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The NOW Map: Consistent, Dynamic and Contemporary Geospatial Information

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Some see things that are and ask “why?”;

Others dream things that never were and ask “why not?”

George Bernard Shaw

Candidates Certification

I certify that the ideas, designs and experimental work, results, analysis, software and conclusions set out in this dissertation are entirely my own efforts, except where otherwise indicated and acknowledged.

I further certify that the work is original and has not been previously submitted for assessment in any other course or institution, except where specifically stated.

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Abstract

Mapping agencies, national and regional, are finding it increasingly difficult to maintain the currency of their suite of map related products and services. These products include topographic maps and the provision of up to date topographic data. The maintenance of this socially important spatial information is at issue through the duplication of effort that presently exists within government agencies at all levels. A dedicated data sharing and topographic maintenance program has the potential to solve all of these issues.

The “NOW Map” gives the “map hungry” public the ability to obtain spatially located data and products in time frames and formats of their choosing. This system is capable of delivering consistent, dynamic and contemporary geospatial information. It will be flexible, in response to a modern ever-changing society, and capable of providing up to date topographic maps and data that not only meets current standards, but also continually exceeds them.

After the development of initial procedures, a pilot study was conducted to expand and further refine data collection and analysis procedures. This was followed by a final data-gathering research phase. The research used relevant local, interstate and international examples in all areas of the study.

The outcomes of the pilot study and analysis of the second research segment demonstrated that maps can be maintained more efficiently through the utilisation of accurate up to date information. These topographically significant updates can be provided incrementally by organisations that maintain data as part of their own core business.

Acknowledgements

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NOMENCLATURE, ACRONYMS AND ABBREVIATIONS

The following acronyms and abbreviations have been used throughout the text and references:-

Acronym	Proper Name
AGD	Australian Geodetic Datum (is shown as AGD66 to represent the 1966 definition of the datum)
AIRSAR	Airborne Synthetic Aperture Radar
ALS	Airborne Laser Scanning
ANZLIC	Australia New Zealand Land Information Council
ASDD	Australian Spatial Data Directory
ASDI	Australian Spatial Data Infrastructure
AURISA	Australasian Urban and Regional Information Systems Association
AUSLIG	Australian Land Information Group
AVHRR	Advanced Very High Resolution Radiometer
AVIRIS	Airborne Visible / Infrared Imaging Spectrometer
CASI	Compact Airborne Spectrographic Imager
CERCO	Comite Europeen des Responsables de la Cartographie Officelle
CTP	Computer To Plate
DAIS	Digital Airborne Imaging Spectrometer
DCDB	Digital Cadastral Data Base
DEM	Digital Elevation Model
DTDB	Digital Topographic Data Base
DTM	Digital Terrain Model
ENC	Electronic Navigation Chart
ERIS	Environmental Resources Information System
ESRI	Environmental Science Research Institute
FIG	Federation Internationale des Geometres

Acronym	**Proper Name**
FME	Feature Manipulation Engine
GDA	Geocentric Datum Australia (is shown as GDA2000 to represent the 2000 definition of the datum)
GIM	Geomatics International Magazine
GIS	Geographical Information System
GITA	Geospatial Information and Technology Association
GNB	NSW Geographical Names Board
GNR	Geographical Names Register
GPS	Global Positioning System
HRSC-A	High Resolution Stereo Camera – Airborne
ICA	International Cartographic Association
ICSM	Intergovernmental Committee on Surveying and Mapping
IMTA	International Map Traders Association
ISO	International Standards Organisation
ISPRS	International Society for Photogrammetry and Remote Sensing
JERS	Japanese Earth Resource Satellite
LGA	Local Government Authority
LIDAR	Light Detection and Ranging
LINZ	Land Information New Zealand
LIST	Land Information System Tasmania
LPI (NSW)	Land and Property Information (New South Wales)
MEGRIN	Commercial Arm of CERCO
MGA	Map Grid of Australia (is shown as MGA56 to represent the grid in zone 56)
NASA	National Aeronautical and Space Administration
NGDI	National Geospatial Data Infrastructure
NOAA	National Oceanic and Atmospheric Administration

Acronym	**Proper Name**
PCGIAP	Permanent Committee for GIS Infrastructure for Asia and the Pacific
PDF	Portable Document Format
PE&RS	Photogrammetric Engineering and Remote Sensing
RTA	NSW Roads and Traffic Authority
SABE	Seamless Administrative Boundaries of Europe
SAR	Synthetic Aperture Radar
SES	NSW State Emergency Service
SPOT	Systeme Probatoire d' Observation de la Terre (Satellite System operated by French National Space Agency)
SQL	Structured Query Language
SRTM	Shuttle Radar Topography Mission
TFW	Tiff World File
TIFF	Tag Image File Format
UAV	Un-manned Airborne Vehicle
URISA	Urban and Regional Information Systems Association
USGS	United States Geological Survey
WALIS	Western Australian Land Information System

GLOSSARY

Definitions of lesser-known terms may be found in appendix A.

The value and social utility of geographic information comes from its use. Sharing of geographic information is important because the more it is shared, the more it is used, and the greater becomes society's ability to evaluate and address the wide range of pressing problems to which such information may be applied. Failure to share geographic information is also economically inefficient and wasteful. The expertise and time it takes to collect and maintain information about the land creates a need to share that information

(Masser 1997)

CHAPTER 1 - INTRODUCTION

There are few results of man's activities that so closely parallel man's interests and intellectual capabilities as the map

(Arthur H. Robinson 1965 in Clancy 1995, p.vi)

1.1 - Outline of the study

With the introduction of Geographic Information Systems (GIS) in the 1970's also came an explosion of spatial information that has steadily progressed over the past 30 years. This has enabled not only the mapmakers but also the map users to progressively alter the focus of map making, thus providing products with the needs of the individual client in mind. This focus however needs to continue to respond to an ever-changing world, where users are requesting accurate up to date information on a daily basis. These requests can only be accommodated with the development of a coordinated change detection system that is suitable for output on demand topographic mapping. This system will ultimately improve spatial position, aspatial attribution and temporal accuracy, using cost effective methodology that makes it possible and sustainable for the broad cross-section of users.

The system is best described as a series of processes that link organisations together through a common goal, which is the provision of up to date topographic information. It is pertinent at this point to introduce the "Now Map" concept. The "Now Map" uses data that is dynamic and constantly improving and evolving. The concept's ideal application is one that allows a customer to walk in off the street and order an up to date map product of their area of interest. The map sales staff would in turn be able to output the customer's map on a medium of their choosing, showing what the situation is "now", that is, what the real world looks like as of today. Due to the temporal nature of this data, it would be possible to supply the customer with previous time variant data as well; but the ultimate is to provide today's information today.

The purpose of this study was to substantiate the hypothesis that:

> ***"Topographic maps can be maintained more efficiently by utilising accurate up to date information provided incrementally by organisations that maintain data as part of their own core business."***

Constraints were placed on the study with the scope being limited to, when undertaking data comparisons, only considering that data deemed to be topographically significant and relevant to the production of topographic maps. Further limitations, with respect to the type and quantity of data obtained from the organisations involved, were also defined to suitably simulate the "Now Map" concept. A suitable selection was chosen from the data population to prove that the process is transferable to all data sources. Numerous background issues have been identified world wide and in the area for this study, the Australian state of New South Wales, together with the selective involvement of several state and local government organisations (refer sections 2.3, 2.4 and 2.5). The project's undertaking has provided a number of key outcomes including the demonstration of a successful data sharing program that has substantiated the hypothesis and enabled the further development of the "Now Map" concept.

1.2 - Background

The Land and Property Information (LPI) Division of the New South Wales (NSW) Department of Lands, the mapping arm of the NSW Government, is responsible for the production and maintenance of both cadastral and topographic maps within NSW. This responsibility includes both the traditional hardcopy map form as well as the digital spatial databases that exist as part of the NSW Government's Geospatial Information System (GIS).

LPI undertook a major data collection project in 1988 with the aim of transferring the NSW cadastral fabric from hardcopy to electronic form. This task was undertaken by approximately 50 staff and was completed in 1994 with the transfer of about four million cadastral parcels. Currently the maintenance (update) of the cadastral fabric is jointly administered by both the Bathurst and Sydney offices of the LPI. The Bathurst office is responsible for mapping with the Sydney office controlling title information and plan registration.

This update process is usually initiated at local government level with most new developments requiring local government approval prior to any subdivision work being undertaken. On approval, this information is forwarded to the Sydney office for processing. Once the plans have been registered, they are sent to Bathurst for inclusion in the State's cadastral layer. This information, once incorporated with the surrounding cadastral fabric, is then available for supply in digital format. Data integration is usually undertaken within 14 days of the plan being registered. With no such process presently in place for the state's topographic fabric, the capability to provide contemporary spatially accurate information of a topographic nature on demand is unfortunately non-existent.

Topographic maps (1114) cover NSW at a range of scales from 1:25000 to 1:100000. The state is divided into three divisions with each of these generally equating to the three different scales used. Initially (pre 1991) each scale area was treated with a separate photographic based revision timetable, due to each division experiencing geographic developments at different rates.

- Eastern division - 1:25000 – revised every 3 to 5 years,
- Central division - 1:50000 – revised every 5 to 10 years, and
- Western division - 1:100000 – revised every 10 to 15 years.

Topographic map production ceased temporarily in 1990 with staff being re-deployed for cadastral data collection. With the collection of cadastral data finalised, the staff commenced data collection for the topographic fabric and, after the production of several trial products in 1996, hardcopy map revision and production recommenced in 1998. This traditional mapping process and re-allocation of resources has resulted in information becoming “out of date”, increasing the information currency concern defined by users (refer sections 1.3 and 2.5).

An amended revision program is now in place and, based on a variety of factors, rates particular regions of the state in order of mapping priority. These factors include economic significance, emergency service requirements, the age of the previous mapping, and the amount of regional change. Based on existing production numbers the state’s 1100 maps will require a revision cycle of just less than 14 years, which unfortunately means that some of the existing stock of topographic maps currently in hand will be over 25 years old when they are due for revision. A “whole of government” maintenance strategy is required to prevent the recently revised maps also experiencing this fate.

1.3 - The Problem

Maps become out of date due to the natural and built environments changing faster than maps are being revised. Whilst there is a steady demand for up to date natural resource information by government and the private sector (refer chapter 2), there are not enough (coordinated) resources available to enable the mapmakers to keep abreast of the changes. This point is further highlighted with McRae and Walker (2000, p. 22) stating that whilst topographic maps were “an invaluable planning and operational support tool” they had some serious shortcomings relating to currency and relevance. These shortcomings include the temporal accuracy of the information and the level of usability that the user wanted.

LPI’s current production process in the eastern and central divisions uses a ‘heads up’ digitising approach with ortho-rectified imagery rather than the traditional photogrammetric model approach used in the original production process. The organisation has taken the opportunity to enhance the previous map product through the addition of an orthorectified image to the reverse side of the map sheet. These images are, however, only likely to be produced with each full-scale map revision. This means that while the map side is capable of being updated and spatially upgraded without the acquisition of additional imagery, the image side cannot.

Obtaining mapping quality aerial photography or high-resolution satellite imagery of the map revision area on a regular basis would be cost prohibitive (refer section 2.2.2). It has also been identified as being resource intensive (refer sections 2.3 and 2.4) and does not offer adequate benefits within the current production structure.

Therefore, to maintain data currency, a method of data acquisition is required that is not image based.

Users not only request up to date data but also the ability to have this data integrated and displayed in traditional map format. For example, the user:

- o Identifies an update,
- o Comes to the map sales office with their 'mistake', and a request for a change in the map detail,
- o Requests a new 'corrected' map or plot, and
- o Will question why it can't be done while they wait.

The National Geographic Society (2001a) offers output on demand services in the United States on their web site. They also openly advertise that 'patches' are available in electronic form for the previous edition's atlas that may have become 'out of date'. Users merely download the file and output these on a colour printer of their choice at the scale appropriate for the patch. To accommodate this style of request, a new output procedure would be required, which would not only be transferable, but would also be capable of accommodating the various systems used in map production within LPI (NSW). All new update mechanisms would also need to take these functions into account.

The current procedures do not address individual client's needs or expectations (refer the above example), with respect to data currency or content, and needs to be improved. A duplication of effort, which also needs to be prevented, already exists within government data updating and revision processes (refer chapter 2). The flow on effect will be a more efficient use of time and money that will in turn produce savings in turnaround time, thus increasing production.

1.4 - Research Objectives

The aim of the research project was to:

- Identify up to date topographic map production problems and trends,
- Formulate hypothesis based on identification outcomes,
- Develop appropriate methodology and recording mechanisms applicable to changes in geospatial data,
- Test the hypothesis, and
- Provide a mapping process and implications applicable to industry and scientific community needs.

The research was conducted in six stages specifically designed to realise these aims.

Stage One. Identify the problem and its extent.

Stage Two. Review existing industry literature.

Stage Three. Conduct a pilot study and establish appropriate research methodology. This stage included associated investigations to establish:

- Which data is topographically significant; which organisations / groups hold such data, and who should be responsible for maintaining it?
- Appropriate methodology to facilitate timely incremental updating for all data regardless of type, theme or production scale.

Stage Four. Undertake a full data gathering process. This included the collection of sufficient evidence to substantiate the proposition.

Stage Five. Analyse data collected and establish study outcomes.

Stage Six. Develop conclusions and recommendations including the presentation of a working model that can be incorporated into existing production environments.

1.5 - Conclusions: Chapter 1

The current topographic mapping procedures do not address clients needs or expectations with respect to data currency or content. This situation can be improved by avoiding duplication of effort within the revision and updating processes. The flow on effect will be a more efficient use of time and money that will, in turn, produce savings in turnaround time and increases in production. The end result will be a process capable of producing a quality product that exceeds client expectation. These expectations include the maintenance of currency, which contains data relevant to their needs, and through the adoption of an accurate spatial position.

Through the conduct of a comprehensive review of current practices, operations and procedures, the research will be able to establish that appropriate methodology is presently available for undertaking map maintenance. These elements, whilst available, need to be collated, managed, and adapted to allow the formation of a new system to solve the problem. These investigations included a literature review of existing industry publications and journals, a pilot study to establish appropriate methodology, and a data collection and analysis program to test the methodology. The research activities will lead to substantiating the hypothesis, that is, the “Now Map” concept.

The research outcomes will also demonstrate that the developed model can be used in this and a number of like situations to track real world changes and dynamically record these in a spatial environment. The research is also intended to demonstrate that the model is applicable and transferable to other environments and data sources.

CHAPTER 2 - LITERATURE REVIEW

> *Every novel idea in science passes through three stages. First people say it isn't true. Then they say it's true but not important. And finally, they say it's true and important, but not new.*
>
> (Anonymous in Harold 1986, p. 57)

The production of up to date topographic maps relies on the ability to record, within the accuracies of the map, the position of all significant features and, where appropriate, associated attribution. Leading producers of topographic maps store these details in large databases that must be capable of accommodating many millions of records. Continual maintenance of these data is required to maintain database currency.

In relation to the maintenance of topographic databases, current mapping methodologies present several issues with respect to both spatial and temporal accuracy. There is a need to address these by establishing a dynamic system that automatically reflects changes in the real world environment. The system links organisations together through their commitment to the provision of up to date topographic data and map related information. These organisations utilise this data as part of their own core business whilst also providing additional data users with contemporary, up to date data. Maintaining the temporal and spatial accuracy of map related topographic information is the key to the system and requires the utilisation of appropriate tools and methodology.

Hence, this chapter will review existing literature to establish:

- The need for a coordinated approach to data collection, maintenance and revision for the purpose of maintaining digital topographic data, and
- The need for a systematic approach to updating and output to ensure accurate display of spatial information.

This chapter will also outline previously used, present and emerging spatial related technology and methodology. Each point is discussed using relevant industry references and case studies, and provides an accurate representation of the current industry situation.

2.1 - What is a Map?

The hypothesis (refer section 1.1) is dependent on the definition, structure and content of a map, in addition to the processes to maintain its relevance. Several definitions exist for the question of "what is a map?", one of which is:

> *A graphic depiction of all or part of a geographic realm in which the real world features have been replaced by symbols in their correct spatial location at a reduced scale.*
>
> (*What is a map?* 1999)

Different varieties of maps have been produced, each with a specific use and purpose in mind (refer section 2.3). These may all be categorised as being either:

- A topographic map, or
- A thematic map.

(Meine 1984, pp. 17-19)

A topographic map is defined as "a map whose principal purpose is to portray and identify features of the earth's surface as faithfully as possible within the limitations imposed by scale" (Multilingual Dictionary of Cartography, 1973 in Bohme 1988, p. 1). Priority is given to those features that are topographically significant. A feature is topographically significant if, at a particular display scale, it is unique by location, attribution and association (author's observations).

Both of these definitions include scale, which is a major criteria that separate maps from sketches and diagrams. Others include generalisation, symbolisation, and the use of a mathematical projection (Meine 1984, p. 17). The generalisation and use of symbology can be seen (refer figure 2.1) with the map containing symbols to represent the features on the earth's surface. Text or annotation can also be seen for the town, pipeline and river name.

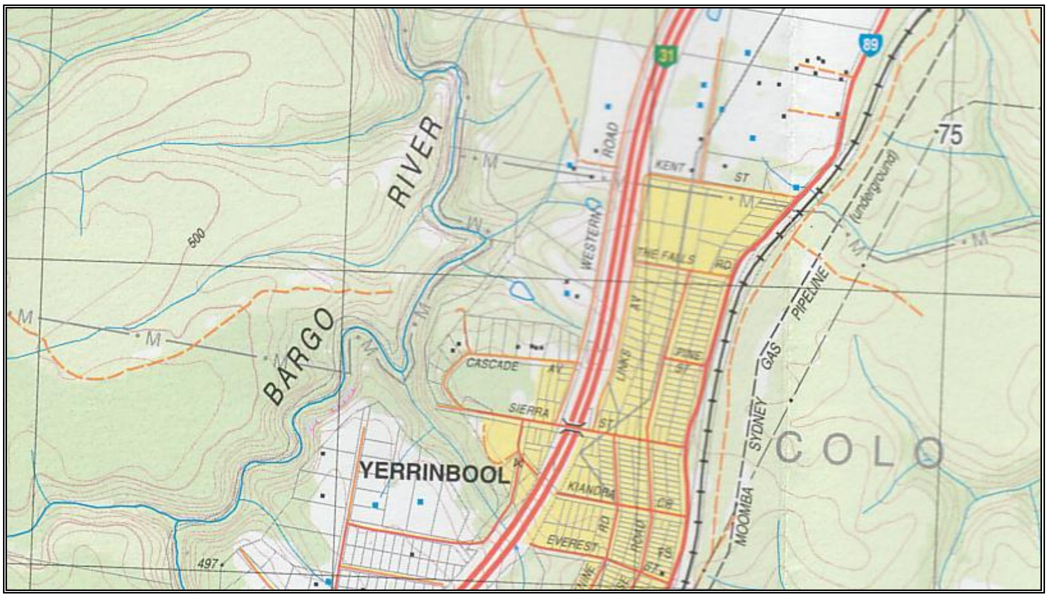


Figure 2.1: Bargo 1:25000 Topographic Map (NSW Government 2000)

The basic construction of topographic maps has evolved over the years with a gradual transformation from the sketches and diagrams of the past to the scale drawings of today. Improvements over this time have seen the inclusion of various elements that may now be found on maps and charts. These include, title, orientation (north point), date, author, legend, scale, index, grid, and source. Even though each of these aids the overall usability of the final product, the essential items are generally scale, grid and orientation.

2.2 – Maps, Maintenance and Production

This section outlines the history of topographic map production as well as summarising presently used techniques. Specific reference is made to the methods used in recording the position and attribution of map related information and in providing data currency through continual revision and database maintenance. The continual production of topographic maps demonstrates the on-going usefulness that the products provide to society.

2.2.1 - History of Topographic Map Production

Aerial photography is a relatively recent invention, as photography was not discovered until 1839. Despite being used in balloons almost immediately, it was not utilised in aircraft until 1909. Aerial photography retained a monopoly for imaging the earth's surface for the next fifty years until the acquisition of the first images from space. Prior to the availability of these images, maps were often drawn in the field from information collected using one of a variety of techniques. These included surveyors traversing with theodolite and chain, and through the use of plane tables. Prior to the introduction of modern computers, the map production process can be summarised as described in the following paragraphs.

Map related features can be classified into the general themes of hydrography, land cover, cultural, and transport. Aerial imagery was used to collect these features photogrammetrically from stereoscopic pairs of aerial photographs. The information collected was then checked by surveyors / field staff, with particular attention paid to verifying the features spatial position, attribution and authenticity. The accuracy of all nomenclature and map annotation was also confirmed, in addition to the use of particular geographic names, often through liaison with major landholders (Paxton 1999). Associated scribe sheets, names overlays, and peel coat masks (refer figure 2.2) were created or updated from the particular photogrammetric line data.

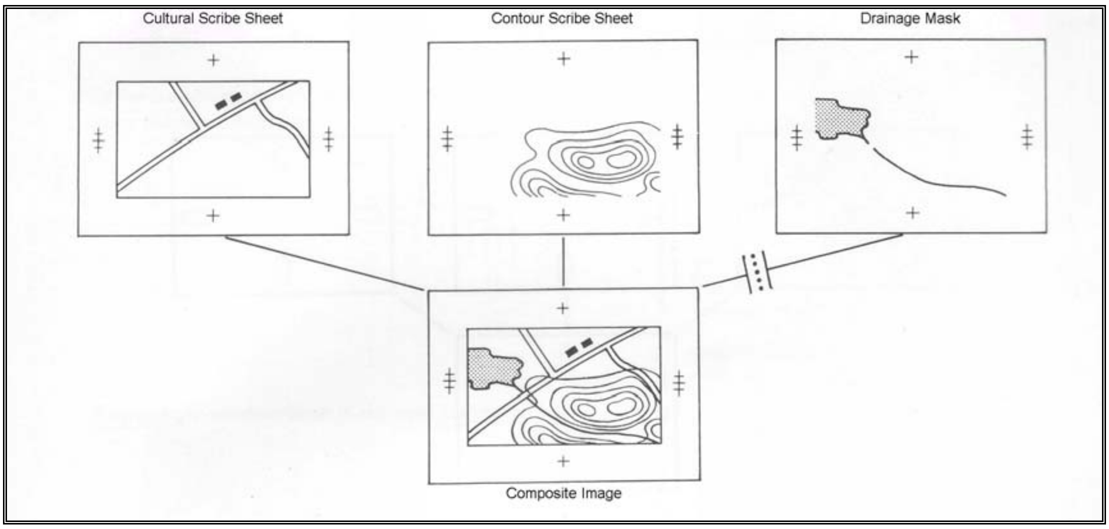


Figure 2.2: Scribe sheets and masks for map related feature themes (Christer 1984, p. 193)

The various map themes were developed into printing plates in preparation for printing, after a thorough check for completeness and quality.

The areas of data collection, data manipulation, and output are explained in more detail in the following sections.

2.2.1.1 - Data Collection

The image based data collection phase included several individual stages.

- o Image Generation,
- o Photogrammetric Collection, and
- o Field Verification.

Despite two alternative platforms being available for imagery from the late 1970's, only the airborne platform offered imagery in the scale ranges suitable for large to medium scale topographic mapping. Imagery obtained from satellites offered users additional capability in the areas of vegetation and land cover analysis (Campbell 1987, p. 366).

Individual processes conducted whilst undertaking aerial photography include:

- o Coverage Determination and Flight Planning,
- o Establishing photogrammetric control, and
- o Flying the mission.

Before the photography could be flown, the area to be covered was determined and the flight planned to establish the most efficient method of undertaking the mission. This included planning the layout of runs within the area to be photographed (refer figure 2.3). Once this is planned the photogrammetric control, which is used to orientate the photography to the ground, was placed on the ground. Each photographic run is flown in turn with the photographs taken to maximise the coverage for the photographs flown.

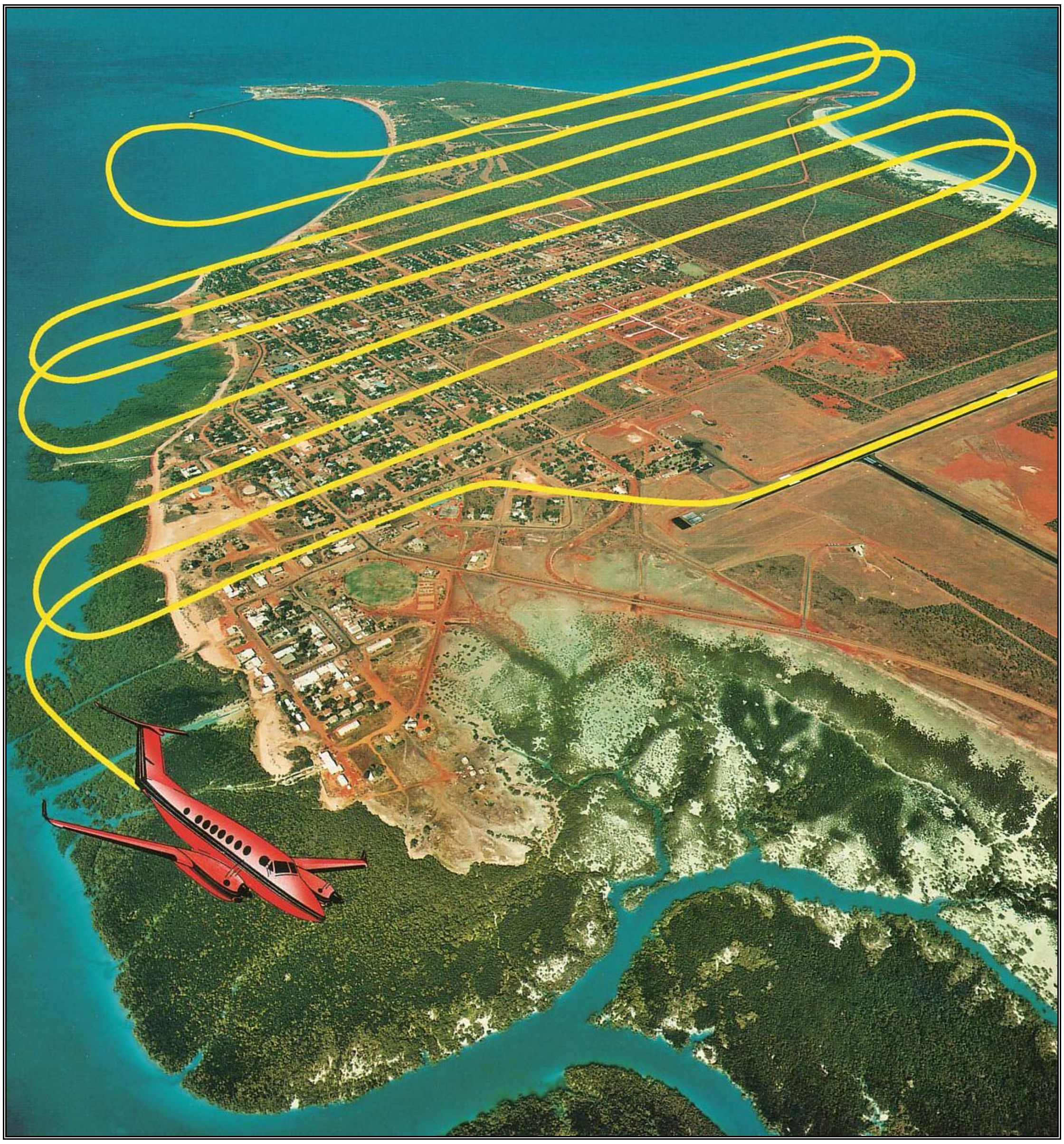


Figure 2.3: Photo Flight Path (Leica 1994)

Without navigational support, there is the possibility of gaps and unnecessary overlaps occurring between the runs of photography (refer figure 2.4). The result adds to the acquisition time and money, as additional photographs are required to either fill the holes or repeat a complete run.

The photogrammetric collection consists of two phases. The first being aerial triangulation, and the second, line map collection. The triangulation phase sees the control points for each photograph transferred from each stereographic model to the next as each additional photograph is viewed in turn. This process assists with the absolute orientation phase and through the removal of parallax for accurate 3D positional mapping of photographic detail.

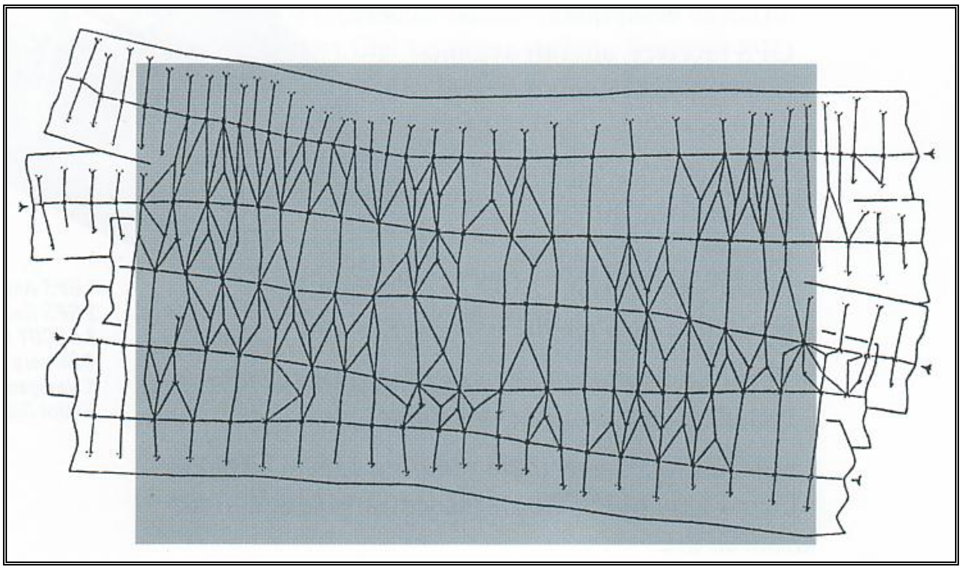


Figure 2.4: Photo Coverage Without Navigation Support (Leica, 1994)

During the line collection phase, topographically significant features (refer section 2.1) were collected from stereographic pairs using photogrammetric instruments. These features included for example roads, rivers, cliffs, contours, and buildings. The photogrammetrist also noted when features needed to be checked in the field. These may have been obscured from view due to cloud or shadow, and included those that were significant but were too small to be adequately identified with existing instruments.

During the field verification stage, surveyors and field staff checked and verified the spatial position of the features already collected while gathering a variety of additional associated attribute information. They also liaised with local landholders to confirm the present-day and historical use of any geographic names and features.

2.2.1.2 - Data Manipulation

The data manipulation phase consisted of the three stages: data transfer, annotation, and generalisation. During the transfer stage, the photogrammetric information was transferred from the photogrammetric line sheets to the associated scribe sheets and peel coat masks (refer Christer 1984). For the first edition maps, this was a photographic process with each subsequent edition having the change only or revision information transferred manually.

This is demonstrated in figure 2.5 where the information from the previous edition (left) is updated using a recently flown aerial photograph (center). These changes, once detected, are used to modify the original information, which is used to produce the updated edition of the topographic map (right).

A names overlay was created on clear film for all annotation required for the map sheet. The lettering in later years came in a choice of “letraset” or rub down lettering, and “photon” where greater variety was available with respect to fonts and styles. Where there were issues regarding a clash in either annotation or symbology, modifications were made to the mask or sheet concerned with the information being generalised during this stage.

Figure 2.5: Topographic Update Process (Meine 1984, p. 23)

Due to the labour intensive nature of the manual data manipulation process, change detection and revision was a time consuming process as well, and did not adequately enable modern change on demand concepts to occur.

2.2.1.3 - Output

The scribe sheets, peel coat masks and text overlays were used to produce the printed map through a four-stage process. These were negative creation, proof making, plate making, and printing.

The scribe sheets, peel coat masks and text overlays were used to create photographic negatives for each printing plate. This means that if a four-colour process was being used, then four negatives would be created. These negatives were used to create a photographic proof on film, which resembled the printed map. These were used in the quality assurance process to check the relationship between the scribe sheets, masks and names overlays. Corrections were made where mismatches were found.

The final negatives were then used to create printing plates, which are in turn used to print the new map sheet. The four-colour printing process uses cyan, magenta, yellow and black coloured inks to produce the printed product (refer figure 2.6).

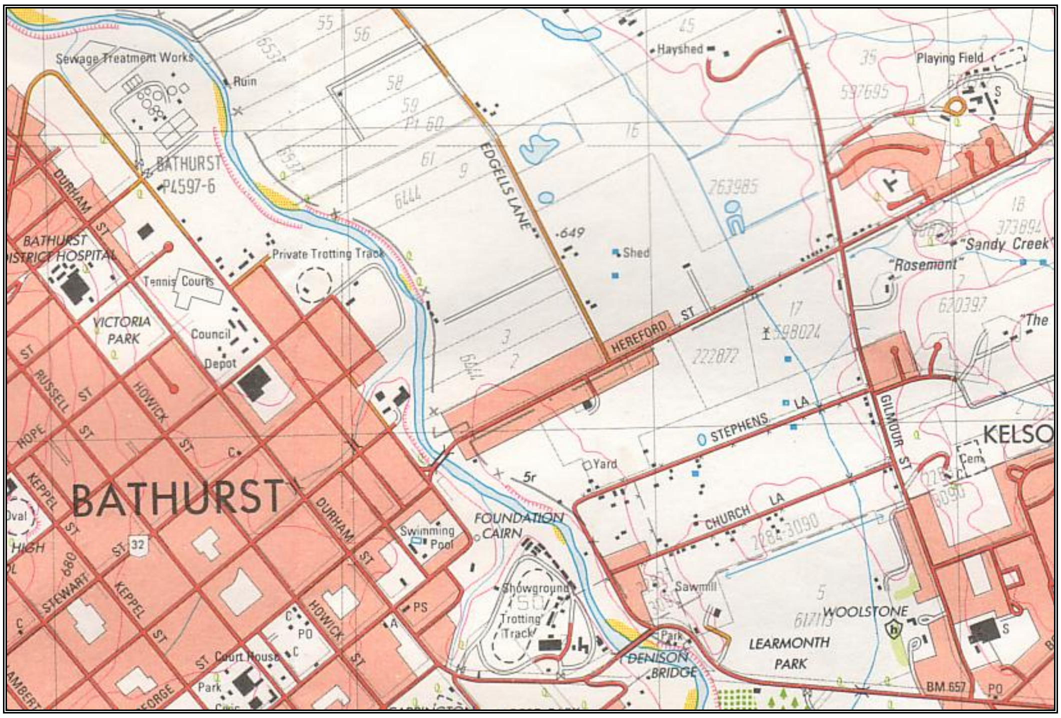


Figure 2.6: Bathurst 1:25000 Topographic Map (NSW Government 1985)

Other colours are created by printing the process inks in specific ratios through the use of photographic screens. Until the introduction of four-colour printing, registration problems existed through the printing of colours with individual inks.

Woodward (1975) provides details of the history of map printing and highlights the evolution of this resource intensive approach which had until recently remained largely unchanged.

2.2.2 - Modern Production Techniques

Analysing modern mapping production techniques is best done within the topics of, data collection, data manipulation, and output. While advances have been made on immediate past methods (refer section 2.2.1) they remain extremely resource intensive with respect to time and money.

2.2.2.1 - Data Collection

> *Collection is cheaper when costs and effort are shared*
>
> (Bashfield 1997).

Large area projects often require the use of imagery and appropriate capture methodology, as outlined by Dawson & Maughan (1998). There are a variety of other factors that influence the positional accuracy of a particular dataset that must be taken into account as well. These factors are interrelated and have an accumulative effect (Geoinnovations 1999).

a. Acquisition

The various platforms used for the acquisition of spatial data can be categorised as either:

- Extra terrestrial / Satellite,
- Airborne, or
- Terrestrial.

Each of these utilise updated techniques of previous methodology and are discussed in the following sections.

(i) Extra Terrestrial / Satellite Systems

Since Landsat 1 was launched in 1972 there have been over 130 satellites (*Satellite Missions: Remote Sensing Satellites* 2003) placed in orbit specifically for the purpose of earth observation. These satellites contain instruments designed to collect earth resource information using both active and passive means and provide users with the ability to choose the information most appropriate for the task selected. Imagery from weather satellites presently maintained by National Oceanographic and Atmospheric Administration (NOAA), has been downloaded and with "several minutes" post processing, provides near real time imagery (Jelenak, Shaw & Steyn-Ross 1998).

It is envisaged that as the number of satellites increase so will the available satellite resolutions (refer table 2.1). Fritz (1998, in Li 1998) previously predicted that as many as 24 remote sensing satellites may be operational by the end of 2003. Ten of these would provide high-resolution imagery with a further twelve being able to provide medium resolution. In mid 2004, there were nine satellite-based sensors capable of providing high-resolution imagery with a further 21 providing medium (*ITC's Database of Satellites and Sensors* 2004).

Table 2.1: Classification of Spatial Resolutions (Fritz 1998, p. 2)

Spatial Resolutions	Pixel Size (m)
Very High	< 0.5
High	0.5 - 3
Medium	3 - 30
Low	30 - 300
Very Low	300 <

SIR-C radar data from the Shuttle Radar Topography Mission (SRTM) has supplemented that available from radar capable satellites (refer table 2.2) (Salge 2000). It can be seen that except for the Almaz satellite (which ceased service in 1992), the standard resolution is around 25 to 30 metres. It can also be seen that the current revisit time ranges from three to 44 days.

Table 2.2: Radar Capable Satellites (*EOS Satellite Handbook* 2003; *The Satellite Encyclopaedia* 2003; Australian Centre for Remote Sensing 2001; Metternicht 1999, pp. 1-17)

Name	Launched	Std Resolution	Revisit Time
Almaz 1A	1991	10 to 15 m	5 – 7 days
ERS 1	1991	26 m	3 + 35 days
JERS 1	1992	25 to 30 m	44 days
ERS 2	1995	26 m	3 + 35 days
Radarsat	1995	24 m	24 days
Envisat	2002	27 m	35 days

These characteristics offer excellent opportunities for detecting changes in the built environment and may be used for projects such as coastal zone monitoring (Mahmood & Giguere 1998) and estimating topographic change (Okatani, Watanabe & Koarai 2000; Ticehurst, Dong & Forster 1998). Radarsat's fine beam offers just under 10-metre resolution and is well suited to that task. Despite radar providing all weather, day / night monitoring capability (Evans n.d.), there are several limitations with several materials being almost transparent to radar, for example, plastic, dry wood and other materials with a low relative dielectric constant (Kruzins, Dong & Forster 1998).

Passive space borne systems may be categorised as either multispectral or hyperspectral. The multispectral systems include the lesser-known film-based system used by the former Soviet Union and high-resolution radiometers that resemble large digital cameras. These electronic multispectral sensors can be found on a number of the remote sensing satellites presently circling the globe. Resolutions and individual revisit times for selected radiometeric instrument carrying satellites are listed in table 2.3.

Table 2.3: Selected Radiometric Instruments in Orbit (*EOS Satellite Handbook* 2003; *The Satellite Encyclopaedia* 2003)

Name	Launched	Max Resolution	Revisit Time
Landsat 7	1999	15 m	16 days
Ikonos 2	1999	1 m	3 days
EO 1	2000	10 m	16 days
Eros A1	2000	1.8 m	2 days
Quickbird 2	2001	0.61 m	3 days
Spot 5	2002	2.5 m	26 days
Orbview 3	2003	1 m	3 days

Major corporations previously involved in the collection of high resolution imagery included Space Imaging, Earthwatch, and Orbimage (Jones, A. 1997, p. 15). Presently Spot 5 imagery (2.5m panchromatic) is marketed in NSW by Raytheon Corporation at about A$2.25 per km^2 if purchased by the 60km x 60km scene (Raytheon Corporation 2004). Although a discount would no doubt be given due to the size of the order, a starting price for negotiations would probably be in the vicinity of $A1.8M for the entire state of NSW. Digital Globe imagery, with its increased resolution, retails for at least $US18 per km^2 and would be eight times that price, before taking the quantity discount or exchange rate into account (Digital Globe 2004). Imagery obtained from these and similar high-resolution image gathering satellites would be cost prohibitive if regularly collected for large to medium scale topographic mapping.

Experiments on the feature detectability of current satellites have shown them to be suitable for topographic map content at 1:100K–1:250K using a pixel size of 5–10m (Schiewe, 2001 in Forghani, Reddy & Smith 2003). Selected present and scheduled topographic suitable satellites are listed in table 2.4.

Prior to the introduction of the Meteor weather satellites in 1980, the Soviet Union began using large format cameras (335km x 335km) capable of offering multispectral images with a resolution around 30m. This method of remote sensing is still in operation (Baltsavias 2000, p. 38; Fritz 1998) and enables missions to be flown, as per a customers individual requirements, (*Sovinformsputnik* 2004) with the film being returned to earth after exposure and recovered for processing (Campbell 1987, p. 154).

Table 2.4 Launch schedule for high-resolution remote sensing satellites suitable for topographic mapping (Forghani, Reddy & Smith 2003)

Satellite (Operators)	**Brief Description**	**Launch Year**	**More Information**
EROS-B1 (ImageSat International)	0.5m PAN & 2m MS	2003	www.imagesatintl.com
Orbview-3 (Orbital Imaging)	1m PAN & 4m MS	2003	www.orbimage.com
Cartosat-1 (ISRO)	2.5m PAN & 0.5m PAN	2003-4	www.isro.org
ALOS-1 (NASDA)	2.5m PAN, 10m MS, & 10-100m SAR 10	2004	www.nasda.go.jp
KOMPSAT-2 (KARI)	1m PAN & 4m MS	2004	www.kari.re.kr
IKONOS-3 (Space Imaging)	0.50m PAN & 1m MS	2004-5	www.spaceimaging.com
Quickbird-3 (Digital Globe)	0.50m PAN & 1m MS	2004-5	www.digitalglobe.com
RADARSAT-2 (SOAR)	3m PAN SAR	2005	www.space.gc.ca

Hyperspectral systems offer the capability of identifying the material composition for each pixel within the dataset. As each material present exhibits a unique spectral reflectance signature, the materials are identified by comparing the values collected against a library of reference signatures (refer figure 2.7).

The hyperspectral sensor provides near continuous radiometry over the visible, near infrared and short wave infrared regions of the spectrum (Metternicht & Gonzalez 1998). Unfortunately the systems do not offer similar resolutions to that found in the multispectral systems.

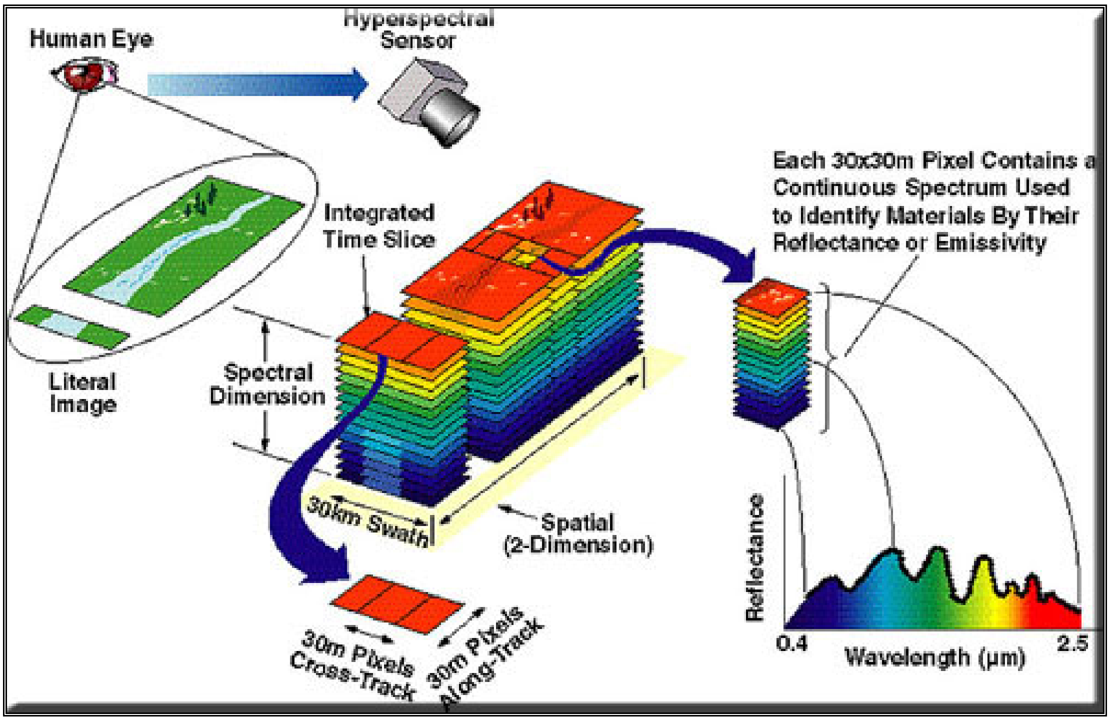


Figure 2.7: Hyperspectral Data Collection (*Round The World In 80 Clicks*)

Research is however making in-roads in this area with the failed Warfighter satellite system, to be operated by the US military offering 8-metre resolution. The nearest civilian equivalent, with 30-metre resolution is the Hyperion instrument on EO-1.

(ii) Airborne Sensors

As with the systems found on satellites, the airborne platform has both active and passive systems. Active systems include LIDAR and Synthetic aperture radar (SAR).

The Airborne Laser Scanning (ALS) system, which uses LIDAR, consists of three components (Jonas & Turton 1999). Firstly the on-board GPS, secondly an accurate inertial reference system (IRS) to determine the aircraft's attitude, and lastly the high frequency laser scanner. Recent examples of LIDAR include its use by NASA and others in high resolution airborne topographic mapping (NASA 2001; Wright, Swift & Manizade 1997) and by NOAA for coastal monitoring (NOAA Coastal Services Centre 2001). Limitations potentially include data overload, with excessive redundancy due to the number of points collected, and secondly with the data being attribute deficient. With post processing, however, it is possible to create accurate contour information that may be integrated with a variety of other sources.

Current trends within airborne radar systems suggest that this system will be utilised more frequently as capabilities increase. Several airborne systems presently offer swath widths greater than 20 km and better than 10 metre pixel resolution (Metternicht 1999, pp. 1-17). Despite some systems having sub metre pixel resolution, this is currently the exception but may soon become the norm as technologies develop. Revisit times are not only dependent on the aircraft availability but also the methodology used for change detection. The P Band within SAR may also be utilised to offer vegetation and ground penetration capabilities.

Intermap Technologies Corporation previously acquired imagery in 1998 over Peurto Rico from a flying height of 10000 metres and achieved a 2.5 metre pixel resolution with 2 metre vertical accuracy (Intermap Technologies Corporation 2001). NASA is also presently exploring the capabilities of airborne radar and undertook the PACRIM 2000 mission using a DC-8 aircraft equipped with AIRSAR side looking radar. The radar, although primarily used for the production of accurate digital terrain models and topographic maps, also has the ability to accurately detect ocean current movements (*NASA's Flying Lab Maps Australian Bush* 2000).

Passive airborne systems include electronic sensors, where there are both multispectral and hyperspectral alternatives, and the traditional film capturing approach. Digital camera systems are becoming portable and, if the various systems become interchangeable, will eventually be more economical than ferrying aircraft around. As systems develop, the flexible nature of the digital system will become apparent with terrestrial, close range and aerial applications using the same digital acquisition source (Stojic & Shannon 1998).

The High Resolution Stereo Camera – Airborne (HRSC-A) was originally developed for the Mars96 space mission and combines high resolution and satellite quality imaging with the flexibility of an airborne platform (Lehmann et al. 2000, pp. 12-17). Included in the advantages over conventional film based airborne cameras is the capability for five stereo bands and four multi-spectral bands from blue to near IR. Future developments will also see a 25cm resolution capability from a 6000 metre flying height. Despite this, digital cameras, regardless of platform, will not replace film cameras due to a number of factors which presently include price, resolution, radiometric calibration and quality, and restricted image acquisition (Baltsavias 2000, p. 38).

Airborne data collection by video is also available using rotary wing aircraft (helicopters) (Gyrovision). There are major advantages in using video mapping technology over conventional mapping techniques which include the stand alone capability of the platform, the accuracy levels attainable, and the reduced time and cost involved (Jones, B. 1999). Satellite data is also being verified through aerial videography (Bastin, Chewings & Pearce 1998) as the classification of video data is easier than satellite images due to the ability to recognise features from pixel to multi pixel size in true colour.

Unmanned aircraft are also capable of providing imagery in emergency situations (Fadaie 2001, p. 36). Codarra's UAVs can be programmed using a laptop computer and offers low cost imagery in real time (*Tactical man portable real time aerial surveillance*).

The hyperspectral field is also emerging and potentially offers greater identification capability than exists with multispectral devices. Instruments presently include Hymap and the Compact Airborne Spectrographic Imager (CASI) (Rollings, Doblin & Light 1998).

Aerial photography is now GPS controlled with both flight path and shutter control able to be programmed into the onboard computer (refer figure 2.8). Other photogrammetric tasks, such as aerial triangulation and DEM collection, have also been streamlined by the introduction of advanced automated systems (Agouris 2000, p. 81).

Orthorectified images also offer additional benefits and are regarded as a cost effective information source for resource mapping and farm management (Chong & Pearson 1998, pp. 63-69). New aerial films offer not only increased film resolution and sharpness but also increased detail in shadows and light saturated areas (Brake & Mango 2000, pp. 70-71). This is due to built in ultraviolet absorption filters improving sharpness by reducing the effects of atmospheric haze.

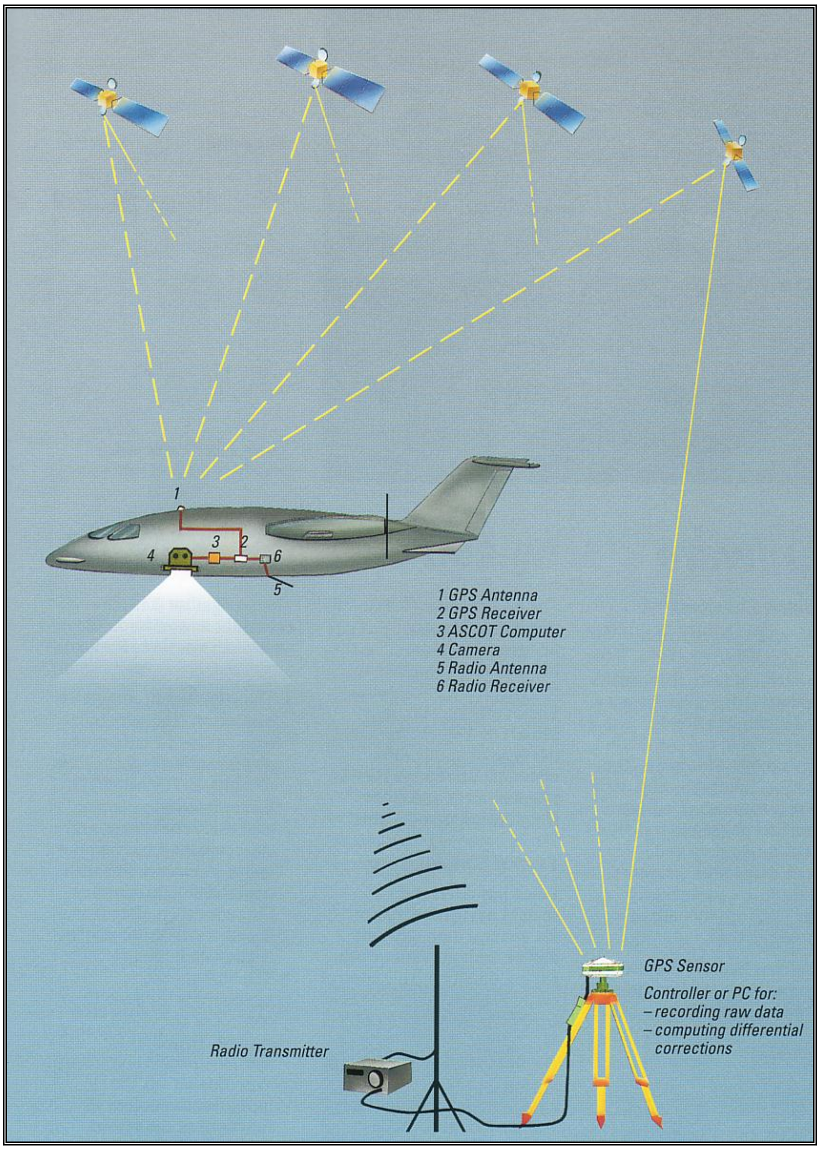


Figure 2.8: GPS Controlled Photography (Leica 1994)

(iii) Terrestrial

Mobile mapping solutions are designed to eliminate the paper based reporting and streamline the efficient collection of features (Brown 2000, pp. 64-65). Vehicle based community mapping (McRae & Walker 2000, pp. 22-27) has been effectively tested and offers not only accurate road centre lines but also the collection of appropriate roadside attribute information. Vehicle mounted data collection using stereo video has been used by the NSW Roads and

Traffic Authority for the collection of roadside assets ('Assets to Go' 1996, p. 45). These digital image sequences can be directly georeferenced through the use of navigation and positioning sensors including GPS, inertial navigation sensors and dead reckoning (Tao & El-Sheimy 2000, pp. 84-87).

Terrestrial laser scanning has been used in building definitions and also offers a wide variety of surveying and mapping applications. Different accuracy requirements exist for the individual users within each of these applications (Georgiadou 2000).

b. Attribution

For each feature in the topographic database, attributes are collected that assist in providing the name of the feature, its importance or topographic significance, and the symbology that should be used to represent the feature at a particular scale. These are collected for each feature regardless of type or whether it is present on the map face. They are also collected from a wide variety of sources, which include the white pages (phone directory), the Internet, and published feature directories, especially where the address can be used as the primary locator. Where this is not the case, as with suburbs and localities, further research is required. Additional attribute information, in the case of NSW road names is also sourced from local government.

Standards have been developed for the use of geographic names (United Nations 1999) with these promoting the consistent worldwide use of accurate place names. Also in existence are standards for local variations, with indigenous names being recognised in Australia since 1992 (Geographical Names Board 2001, pp. 1-10). Geographic names databases, like the one maintained by the NSW Geographical Names Board, are increasing in size with the Alexandria Digital Library web prototype having over 5 million entries (Goodchild 1996). Jolicoeur (1998, pp. 10-12) discusses this further and provides additional examples of on-line digital names databases, further highlighting the expanding importance of accurate spatial information to society.

c. Change Detection

> *Detection of change between two remotely sensed images of the same geographic region is not difficult. Finding the significant changes is the challenge. Differences in viewing angle, illumination, seasonal variations in vegetation, cloud cover, and atmospheric conditions for example are real changes that are easily detectable in digital remotely sensed data. In most applications however these are insignificant changes. The imaging process can also introduce spurious differences such as changes in sensor calibration, or mis-registration between the two scenes. Even when all these systematic errors are removed, "significance" remains a subjective attribute. New roads may be significant to one user but of no interest to another.*
>
> (Davenport & Sailer 1996)

Changes between geometrically registered images can be identified using image subtraction (Canada Centre for Remote Sensing 2003) with a number of applications of Synthetic Aperture Radar (SAR) also being used for change detection (Ehrismann, Van der Kooij & Hulshof 2001). Using a heads up digitising approach, a more accurate definition of coastline features has also been achieved with Radarsat data (Wyllie et al. 1998).

The accuracy of Government attribute databases can also be maintained using online change of address services ('Changing Address Made Easy' 2002).

(i) Computer Assisted Feature Extraction

Despite being designed to minimise the level of human effort for automatic feature extraction, the sheer volume of collected imagery will quickly overwhelm the image community's capacity to carry out timely analysis and feature extraction tasks (Doucette et al. 1999; Doucette et al. 2001, pp. 347-358). This is because manual methods for the extraction and determination of features are labour intensive and time consuming (Anderson, Williams & Crowther 1999), further highlighting the need for a less resource intensive system.

Automated systems require a 'trade-off' between reliability and precision (Agouris, Mountrakis & Stefanidis 2000), which equates to a compromise between identification and tracking, or the ability to follow a feature. One particular method includes the use of a spatiotemporal gazetteer to assist in detecting real world changes (Agouris et al. 2000, pp. 1241-1250). Other automated methods also exist for road extraction (Trinder & Wang 1998), and automatic feature extraction (Zheng, Coppa & Gang-Jun 1998).

Knowledge based rules have also been used to automate linear feature extraction from scanned maps (Graff 1997). Synthetic Aperture Radar (SAR) has also been used for the automatic detection of road intersections (Canadian Centre for Remote Sensing 2001), however one limitation is that SAR images require better ground point definition and are resolution dependant with respect to extraction methodology. Methodology for evaluating automatically extracted road axes (Wiedemann et al. 1998) and for analysing the uncertainty in automated change detection models are presently being developed (Agouris, Gryftakis & Stefanidis 2000).

(ii) Operator Assisted Feature Extraction

Imagery is regularly used for updating maps by detecting the change (refer figure 2.9) between data of differing temporal accuracies (Skender, Lovric & Lampek 1996).

Figure 2.9: North Haven Comparison 1979 and 1997 (Resource Information 1999)

Mangroves have been mapped using hyperspectral and radar sensors (Held & Williams 1998), with high resolution CASI data also being used for the automatic recognition and counting of tree crowns (Held & Billings 1998). High-resolution imagery can also be used for the collection of water features, using density slicing within band ratios, (Dare 2002, pp. 21-23) and for 3D building acquisition (Shao & Fraser 1998). These types of automated classifications are not without error, as the terrain, in rugged areas, can cause variations in the reflected radiation received by the sensor (Jacobson 1999). These variations can be avoided by adopting a change detection system that is not image based.

(iii) Data Verification

This is a process of data validation and verification, and checks the authenticity of the collected data. Methods include, field checking and ground truthing, and validation against existing internal and external databases.

2.2.2.2 - Data Manipulation

(a) Generalisation

The generalisation process is often non deterministic as the particular methods used by one draftsman may be regarded as being of little use or in the worst case unsafe (Brenn 2001, p. 49). As the process of manual generalisation is largely subjective, any system of automated generalisation would require the acquisition and encoding of 'expert knowledge' (Mayer 1998). This is particularly relevant with rasterised vegetation data lacking the smooth generalised outlines present in photogrammetrically collected data. Hart & Gibson (1998) outlines methodology applicable to generalising raster vegetation datasets.

Several advantages become apparent, as spatial models become object rather than geometrically orientated. An object may then hold multiple geometries as well as raster to represent different scale bands. A built up area outline at larger scales becomes a symbol at smaller ones (Laser Scan 2001). After the update is performed in a master database, the updates can be added to a cartographic database. Harrie (1998) suggests that through the use of incremental generalisation, an update in the master database only effects part of the cartographic database. Large scale "master databases" can be created to feed generalised small scale "product databases" (Carlsson & Johnsson 1997). Kilpelainen (2000, pp. 101-107) expands this concept further with the inclusion of "multiple representation databases".

Depending on the scale of the map, features often have symbols that are larger than their real world size. Generalisation of the feature's position is then required especially in situations where the symbology overlaps with other features, annotation or grid lines (Martinec & Faigl 1996). As automated map generalisation systems are created, specific tools will be developed to perform analysis on the data and apply specific generalisation operations (Smith 2000, p. 70). With map publishers inserting copyright traps as a protection measure to detect copyright infringements (Cho & Clark 1998), these operations will, over time, also become automatic.

(b) The Importance of Scale

The resolution of the photograph is dependent on the production scale of the photography and the quality of the photographic film. These both contribute to the final resolution by affecting the size of the photographic grains in ground units. As the photography is being used for data collection, the smallest recognisable feature is determined by pixel size according to scanning resolution, which in turn is also scale dependent.

The field completion phase is scale dependent as well with information only relevant to the particular print scale being checked. Additional information not on the previous edition may be collected during this phase and placed in the database in preparation for the next edition. During the presentation phase only that annotation that can be adequately shown on the new map is created.

This is also dependent on the size and location of scale dependent symbology as this determines the quantity of features of particular types that are shown in a particular area.

2.2.2.3 - Output

Output choices may be categorised as either hard or soft copy (refer section 2.3) and includes database driven map automation. This offers users the advantage of a consistent high quality map that can be constructed from a user-friendly interface. This consistency unfortunately eliminates any possible manual intervention that may be required for individual customisation (Maclaren & Hirst 1999).

Traditional hardcopy output is generally regarded as being produced on a media that is non-digital, such as paper or photographic film (refer figure 2.1), despite the initial data used for its compilation being digital. Digital Press Technology offers an emerging cost effective solution for small print runs whilst eliminating the need for proofing, plate creation and calibration (Cliffcolour).

There will always be a demand for hardcopy maps, despite the number of emerging technologies, and uses of spatial information and map related products (refer section 2.3). Utilising these new technologies to the advantage of the map hungry public will enable the production of a suite of well-maintained topographic maps and products.

2.3 – Map Related Data: Uses and Benefits

> *International market studies indicate that global expenditure on spatial information is in the order of $A34 billion a year and growing at a rate of 20%. The Australian spatial information industry has turnover in excess of $1 billion*.
>
> (Spatial Information Industry Action Agenda 2001, p. 7)

The effectiveness of maps may be discussed firstly, in terms of their role, secondly whether the map has a particular client or market in mind and finally, in terms of their overall communication and how they are designed (Gerber 1984, pp. 115-121). The relationship between these individual elements and the overall map content is closely related to the function of the map and the reasons behind its production.

McLaughlin & Coleman (2000) suggest that the reasons for maps has changed over time. They have moved from defence and public safety, to settlement, resource development and public infrastructure, and finally commercial applications, and a broader societal agenda such as environmental monitoring. Salge (2000) however suggests that the reasons for map production fit into one of two general criteria. The first is "Positional" where the user or producer has questions relating to "Where am I?" and / or "How do I get to where I want to go?". The second relates to "Geographic spread" and "where is a given phenomena at a given time?". Both of these explanations are in effect correct with the latter accounting for those reasons given previously.

Whilst the question of navigation is apparent from both of these suggestions, so is the depiction and location of hazards. Specific examples include hydrographic charts for shipping, air navigation charts for aircraft and specialised large-scale topographic maps for wheelchair users (Beale et al. 2001, pp. 13-18). The defence reason given by McLaughlin & Coleman has also certainly been true over the years. During the Second World War bombing mission maps were made as an oblique view of the target area and were drawn taking flying height and approach bearing into account (Owen & Pilbeam 1992, p. 117). Wildman (2000) and Williams (1999) both outline the defence and military perspective from both Australian and British viewpoints.

2.3.1 - Decision Support Systems

Decision support systems have undertaken a steady evolution from the early days of GIS (Schaefer 2000) and are now actively in use within emergency management organisations. Examples include the Country Fire Authority in Victoria, Australia (Country Fire Authority 1993, pp. 1-8; Garvey, Stephenson & Whelan 1993), the United States of America (Gronlund & Xiang 1993, pp. 102-110), and New Zealand (Majorhazi & Borger 1999).

The national oil spill response atlas is designed to assist in oil spill management (Gilbert, Maslen & Alexander 1999). Other environmental examples including the Murray Darling Basin Commissions Environmental Flows Decision Support Program (Murray Darling Basin Commission) and the use of mapping simulators in the decision making process (Lille, Taladoire & Huynh 1998).

Within the field of hazard management, GIS is regarded as an important set of tools that can be applied primarily to response planning and operations when required. The requirements, which add to its effectiveness, would include the location of:

- Hazards or agents,
- Vulnerable populations,
- Vulnerable assets,
- Infrastructure,
- Relevant physical features, and
- Resources such as fire stations, dams, and levees.

(Buckle 1993, pp. 12-20)

The information required for these criteria would be collected as part of the topographic map production process and would be further enhanced using additional emergency service specific attribution.

2.3.2 - Softcopy Map Production

> *No longer restricted to paper, maps are now transmitted almost instantly and delivered to the user in a fraction of the time required to distribute maps on paper*
>
> (Peterson 2000)

Kraak & Hootsmans (1999) categorise the types of maps presently used on web sites. They have used the criteria of whether it is static or dynamic, and whether it is interactive or view only. This gives four different types of maps that are web capable with the most advanced of these using virtual environments such as VRML.

There has been an expansion of spatial data deployment mechanisms to the web (Christie & Hill 1999) with early examples including web interfaces for internet mapping (Buckley & Sayers 1996, pp. 17-19). Later examples have included the use of the internet and intranet by local government authorities for searching, viewing, and printing of maps (Alakus 1999).

Online atlases are being created and are available in various forms. An early example was the Environmental Resources Information System (ERIS) which was operated by the Australian National Parks and Wildlife Service (*Environmental Resources Information System* 1993). The Electronic Cultural Atlas Initiative offers a modern example of where development is heading in this area (*Electronic Cultural Atlas Initiative* 2003).

A range of software is now available to create web friendly document types. Ghostview and Adobe Distiller are both capable of converting files to Adobe portable document format (PDF). Other alternatives include the creation of images from vector information to formats such as .gif and .jpeg, with GIS software such as Arc Map also offering image creation tools using a variety of screen capture techniques.

2.3.3 - Output On Demand

> *Using electronic technology, no longer does the map user depend upon what the cartographer decides to put on a map. Today the user is a cartographer.*
>
> (Morrison 1997, p. 17)

These on demand outputs may be either hard or soft copy with unfortunately no guarantee that the information is temporally accurate. USGS presently release maps by one or more of three methods. The first method produces printed maps using traditional printing presses, the second provides files in .pdf format whilst the third uses the maps on demand system (Hoffman 2000). This last alternative is unfortunately not “live” and may result in a plotted version of a scanned map which may not have been updated since it was originally compiled.

National Geographic Society offer updates for their world atlas, which may be downloaded from their web site, in the form of .pdf files (National Geographic Society 2001a). Print on demand methodology is used by Ordnance Survey (refer section 2.4.2.o) (Stokes 2002) and has also been used in the customisation of hydrographic charts and products for particular segments of the maritime market (Enabnit & Silcox 2001, pp. 41-43). Illinois State Geological Survey have also identified the need for cost effective production of on demand maps within the production fields of review and presentation, as well as for public distribution (Stiff, Beaverson & Krumm 1998).

2.3.4 - Visualisations

Realistic 3D models and surfaces can be produced from both photos and videos (Pollefeys & Van Gool 2000, pp. 12-15) and has led to the proposal of a cartographic modelling language (Pullar & Sun 1998). Visualisations are regularly used in environmental planning and design (Danahy 2000, pp. 12-15) and have been developed further to provide working 3D nautical charts (Ford 2000). 3D GIS has also been used for emergency response (Hodges 2000, pp. 47-49), with Crawford (2000, pp. 37-38) discussing this further with the use of 3D GIS to accurately “model our world” through the use of animations in both time and space. Digital terrain models combined with imagery can also be used to aid in land assessment and design development (Bennett 2000, pp. 55-57).

Environmental applications are also relying on the integration of remote sensing, GIS and traditional methods (Stone & Goldney 1998). Vehicle navigation systems rely on several basic topographic features relating to not only where the vehicle can be driven but also road attributes such as road pavement type and the number of lanes (Dmitriev, Stepanov & Koshaev 2000, pp. 69-71). Recent archaeological examples have seen the use of both passive and active remotely sensed data (Sever 1998) with several also being integrated with magnetometry (Ronaldson & Thomas 1999).

2.3.5 – Additional Uses

Further examples of the uses of spatial data may be found in the NSW Government Gazette. The following are selected examples, all of which highlight the benefits of utilising accurate spatial information within the workings of government.

- **NSW Fisheries:** The receipt of applications, granting, renewal, and cancellation of Aquaculture leases.

- **Department of Land and Water Conservation:** The creation, transfer and closure of crown roads; the creation and revocation of reserves; the construction of dams, earthworks, embankments and levees, and the placement of bores or pumps under the Water Act.

- **Department of Mineral Resources:** Exploration licenses, Mining leases, Opal prospecting areas, and license cancellations.

- **Department of Urban Affairs and Planning:** State significant development, Nominated determining authorities, and Local environment plans.

- **Roads and Traffic Authority:** Land acquisition (for future roads), Dedication of land as public road, and B Double routes (determines additional attribution).

- **Sydney Water Corporation:** Sewer and water main notifications.

- **Other Notices:** Aboriginal land - Aboriginal Land Rights Act; Land Acquisition for Easements - Electricity Supply Act; New State forests and Amendments - Forestry Act; Propositions, Amendments to suburb boundaries, New assigned names - Geographical Names Act; Historical significance - Heritage Act; Vesting of land and easements in councils for sewerage - Local Government Act; and Land Acquisition – Public Works Act for example Fish River water supply tunnel

- **Private advertisements:** Local Government - Acquisition and Dedication of land as public road, Naming of Public roads, Closure of public roads, Road Name changes, B Double routes, and Light traffic thoroughfares.

2.4 – Maintaining Spatial Relationships

> *Australia stands out within the global community because of the quality of its government spatial databases. Some land information is collected and stored at the national level, but in the main Australia's core information resource lies within the various state government departments.*
>
> (Mayr 1999)

However Nairn & Holland (2000) also point out that,

> *Experience is showing us that it is no longer the technology that is the impediment for GIS industry growth but the availability of standards compliant, accurate data that meets user requirements. In Australia, where there are a large number of government agencies across the different jurisdictions controlling much of the geographic information, the issue of access arrangements, including pricing and licensing to this data is currently an obstacle.*

2.4.1 - The ever-changing world

This section discusses the maintenance of data by organisations as part of their own core business using both national and international examples and references.

The Queensland Spatial Information Infrastructure Council model has been designed to address some of the previously expressed concerns (for example, Nairn & Holland, pg 46) and its implementation has resulted in a high degree of cooperation between the various sectors. This is especially relevant as "Government is typically the ultimate source of most core or commonly used spatial data" (Rhind 1995). In many countries however, topographic mapping is carried out under military mapping agency control and due to their present political climate is considered "sensitive". As detailed and accurate data becomes increasingly available over their individual regions, some countries have amended their national policies as the benefits of civilian and social uses are being recognised (Sorensen 2000).

These benefits, which have long been recognised, have led to the introduction of a series of agreed responsibilities for the various levels of government in Australia (refer table 2.5). It can be seen that there is a spatial nature to all of the themes represented.

Table 2.5: A broad overview of the responsibilities of the various levels of government in Australia (Nairn & Holland 2000)

Federal	**State**	**Local**
Taxation	Law Enforcement	Town Planning
Defence	Education	Local Roads
Trade and Foreign Affairs	Transport	Rates
Social Security	Health Services	Local Environment
Astronomical Observations and Navigation	Land Management	Essential Local Infrastructure
Statistics	Agriculture	

Based on these various levels of responsibilities, several potential data sources immediately emerge within NSW (refer table 2.6 and appendix B).

Table 2.6: Potential Data Sources within NSW

Theme	**Potential Source**
Framework (Sub theme - Rectified Imagery)	RTA, LPI (NSW), Department of Agriculture, Department of Land and Water Conservation
Vegetation	Department of Land and Water Conservation, National Parks and Wildlife Service, Forests NSW, Department of Lands, Department of Defence (Commonwealth)
Cultural	170+ councils and other planning authorities including utilities, NSW Fisheries (Aquaculture Leases) Planning NSW (Developments on line), Acquisition and Disposal of Government Land.
Transport	Local council / RTA (roads), Rail Estate (rail), Federal Dept of Transport (air), Waterways Authority (water)
Relief	Local council / RTA (cuttings and embankments associated with roads), Local council (development that alters contours / DEM / DTM)
Hydrography	Department of Land and Water Conservation
Annotation	NSW Government Gazette (Geographical Names Board, councils / or government agencies, Road Names)

The potential for additional sources is further highlighted by comparing the level of government representation within Australia (refer table 2.7).

Table 2.7: Level of Government Representation (*National Guide to Government* 1999)

	Federal	NSW	Vic	WA	Qld	SA	Tasmania	NT	ACT	Total
Local Government	0	172	79	142	125	50	29	65	0	**662**
Lower House	148	93	88	57	89	47	25	25	17	**589**
Upper House	76	42	44	34	0	22	15	0	0	**233**
Listings	427	271	244	148	129	133	97	78	71	**1598**
										3082

The 1598 listings relate to the number of departments, boards, commissions and other government bodies found to be in existence. The amount of data held by these bodies is in addition to the 662 Australian Local Government Authorities who each store topographically related data as well. In Australia, the major data custodians are listed in the Australian Spatial Data Directory (ASDD). There is, however, no guaranteed way of finding out which data is available for a particular theme, or that which relates to a particular region, or who the custodian may be, if any. One reason for this may be that there are a large number of private and local government organisations that maintain data but do not openly advertise that fact or make it available for sale. At local government level, privacy and security of attribute information is definitely also an associated issue. Each Member of Parliament is also known to have large mail-out databases containing details of their constituents from the electoral roll. The maintenance of each of these databases relies on the accurate notification of change where applicable.

When isolating the changes, it must be realised that maps make the world seem simpler, due to their generalised nature, than it really is. The National Geographic Society has adopted a change policy that reinforces this: De facto rather than de jure.

> *It is simplest and best to show the world as it is – de facto – rather than as we or anyone else wishes it to be*
>
> (National Geographic Society 2001b)

Existing approaches to updating topographic databases include supplying change only information, or a total resupply of existing data. Beyen & Henrion (1998, p. 59) suggest that there is a growing need to preserve the historical perspective of the data. This is further supported by Brand (1998) who suggests that little consideration has been given during database design to maintenance in terms of currency, presentation and archiving. Beyen & Henrion (1998) also suggest that the change only alternative has the potential to suffer from both human errors and software problems.

Dangermond (1999) offers a different and very interesting view with “The Geography Channel” monitoring the daily change in the world. This would operate similar to the nightly news that exists currently. This supports the views of the Open Space Forum at AURISA 1996 that discussed what customers want in data with respect to the four C's (Veenendaal, Taylor & Gahegan 1997). These being consistent, complete, current, and correct.

GIS generally has had trouble handling temporally referenced data and has previously only used two dimensional spatial data to reflect a snapshot in time (Crabbe 1999). It is a recent development for software to be capable of supporting a spatial / temporal data model. Bathurst City Council in the financial year 2002-03 received a record 1004 development applications with an estimated value of $84.5 million (Bathurst City Council 2004). This example highlights the dynamic nature of developmental change. Further examples of this change may be found in the NSW Government Gazette (refer section 2.3.5).

A variety of other sources are available and contain information that can also be used to maintain a database's temporal accuracy. Specific examples include notification type articles ('Removal of Barriers to Fish Passage' 1999, p. 2), which outline industry specific topographical changes. These are often available electronically similar to the "notice to mariners" from the Hydrographic Office and "notice to airmen" from Airservices Australia.

2.4.2 – National and International Mapping Programs

The following case studies and country reports highlight those organisations that are actively involved in conventional revision programs, incremental update and output on demand services.

a. National Geographic Society (World Wide Interest)

The National Geographic Society, for at least the last two years, has been providing on-line updates to their seventh edition world atlas through their map machine web site. The updates page contained 12 updates (11 July 2001) with a further four already posted to archives (National Geographic Society 2001a). The same web site also provides users with on line access to create maps of their own individual area of interest at, within the limits of the program, a scale of their choosing. These maps may be customised, and then printed or saved to disk.

National Geographic also offer output of seamless topographic maps (produced by USGS) through their map kiosks. The user can customise the output through paper rotation, the display of shaded relief and through the choice of map centre. The maps print in less than four minutes on waterproof, tear resistant paper (National Geographic Society 2003) and are available in a range of scales.

The standard output uses 13 x 18 inch paper with the scale of the standard USGS quadrangle altered to fit (USGS 2001b).

b. Geoscience Australia (National Mapping Organisation)

Geosciences Australia has produced topographic maps for more than 40 years with the current standard series covering the entire country at a scale of 1:250000 with 513 map tiles. The current program is scheduled for completion in 2004 and is being produced with the aid of the latest satellite imagery, information sourced from local and state authorities, as well as other informed sources. The topographic data is also used to produce a range of hardcopy products at a variety of other scales including 1:100000, 1:1 million, 1:2.5 million, 1:5 million, and 1:10 million and smaller.

Geoscience Australia also offers online mapping systems for user defined map creation. The system uses Global Map Australia 1:1 million data. A variety of other National Geoscience Datasets are also available online including, Australian earthquakes, Australian estuaries, and 1:250000 Geology maps. Links are also available to other online mapping systems, with particular reference to community risk mapping, power stations, online image processing, and 3D models (Geoscience Australia 2003).

c. Canada

Considerable duplication of effort has occurred due to Geomatics Canada, the Canadian Hydrographic service and the provincial mapping organisations producing and maintaining datasets for both Pacific and Atlantic coastlines (Coleman 2000). Data sharing arrangements are now in place between the agencies and include both coastlines and the federal use of provincially prepared road network datasets.

The National atlas is available on Schoolnet and offers users the opportunity to examine various information on the Canadian economy and natural resources, as well as creating customised maps with a variety of interactive tools (Scholten & LoCascio 1997).

d. Columbia

In 1993 Columbia moved from an analogue to a digital mapping environment. Although cadastral mapping is undertaken down to 1:2000 the topographic fabric is mapped within the National Digital Data Base at 1:100000. Despite 55% of the program being complete in 2000, 94% of the information was more than 10 years old (Borrero 2000).

e. Denmark

The National Survey and Cadastre (KMS) is building a topographic database with 1:10000 accuracy (Ryttersgaard 1998) and is responsible for coordinating mapping and charting within both public and private sectors. To avoid unproductive and inefficient production, KMS is negotiating with the municipality associations to gain agreement on common object definitions. Many municipalities have their own well-established mapping systems and without agreement, Denmark runs the risk of having two rival systems.

f. Eurographics (CERCO-MEGRIN)

The 'Comite Europeen des Responsables de la Cartographie Officelle' (CERCO) was created in 1980 and consists of (in principle), the heads of the European National Mapping Agencies (NMA's) and range from Russia to Portugal, and from Iceland to Cyprus.

MEGRIN is the commercial arm of CERCO and was created in 1992. Since then, the Seamless Administrative Boundaries of Europe (SABE) product has been the priority of MEGRIN and involves the stitching together of the digital administrative boundary datasets provided by 26 different NMA's. MEGRIN is also working towards a fully consistent 1:250000 pan-European topographical dataset (Luzet 2000).

CERCO was renamed EUROGRAPHICS in 2001.

g. Finland

Both printed and digital map products are available for the topographic map series at scales ranging from 1:20000 – 1:50000. They are adapted from the national topographic database which was collected with a positional accuracy of approximately 1:10000. Information relating to buildings, transmission networks and roads are updated annually with a comprehensive update completed every five years (National Land Survey of Finland 1998).

h. Hong Kong

Prior to the early 1960's, Hong Kong was mapped at scales of 1:600 and 1:1200 with no height or contour information and resembled a “planimetric record”. Between 1962 and 1971, 1:600 scale maps were produced covering Hong Kong Island, Kowloon and New Kowloon with 5-foot contours and 1:1200 scale maps covering the new territories. With the adoption of a metric system in the early 1970’s, a standard 1:1000 scale was adopted requiring the conversion of approximately 3000 sheets.

Continuous revision is carried out with priority given to areas of greatest commercial activity and development. A survey intelligence system has been set up to collect information on proposed construction projects and other major works, with the system recording the project’s anticipated completion dates. As this information is used to plan the map revision programmes, major changes can be updated on site within a short period of the projects completion. The implementation of computer-based mapping has assisted in the planning of the country’s revision program and has made up-to-date plans readily available (Hong Kong Government 2002). Through continuous improvement, the 1:20000 Topographic Map Series may strategically capture every real world change as soon as the information becomes available (Gan & Shi 2000, pp. 44-47).

i. Israel

Over the last 15 years, topographic mapping in Israel has been completed using GPS controlled 1:40000 black and white photography. Data collection was initially contracted to private organisations and carried out using both analytical and digital stereoplotters. Photographic collection was completed in 1999-2000 and has enabled the production of a countrywide orthophoto series and a 50-metre digital elevation model.

With a data accuracy of 2 meters, the database permits outputs in the range of 1:25000 to 1:5000 and with the development of generalisation programs, it is also possible to output 1:50000 and 1:100000 maps directly from the database. These outputs are in the form of plotted sheets with full cartographic methodology only being applied to certain areas or being limited to parts of the current series.

The topographic map series has now entered a four-year map revision program using orthophotos, for well defined purposes, and three-dimensional models provided by the Survey of Israel for selective revision (Golod 2003).

j. Kenya

The Survey of Kenya is responsible for the production and revision of 1:50000 and 1:250000 topographic maps. These are prepared from photogrammetrically collected large-scale map bases. In 2000, it was reported that all cadastral, topographic, and survey information still required digitisation (Njuki 2000), further highlighting the diversity that exists within national mapping organisations.

k. LINZ (New Zealand)

Early topographic mapping began in the late eighteenth century with several of these early maps only recently being replaced. The first official series began in 1939 and was completed in 1975 at a scale of 1:63360. The current metric series began soon after and was completed in 1996 at 1:50000 using a conformal projection on a single grid.

Just prior to the completion of the metric series, LINZ introduced the Laser Scan LAMPS2 system, and undertook a conversion program to collect the topographic data presently shown on the metric series. One of the design requirements of the system was the “on demand” or “while you wait” output of a topographic map sheet to the national standard in terms of colour, symbology, content and text. Output can be delivered in under five minutes (Howard, Pickering & Woodsford 2000, pp. 38-41) with printing plates for conventional offset printing available in under 24 hours.

The NZ Government has set the department a number of core outcomes including,

> “the ongoing maintenance of publicly available core geographic information that supports the constitutional framework, national security and emergency services’ responses” (Ballard 2000).

This is further supplemented by two of the strategic goals for LINZ,

- o A national spatial referencing system that meets New Zealand’s core land and seabed information needs, and
- o Current topographic, hydrographic and bathymetric information that covers New Zealand’s area of jurisdiction and is required for public interest purposes.

Despite service delivery functions for topography being largely undertaken by external suppliers, the future sees the availability of all products via the internet with many of these available interactively on-line (Ballard 2000).

I. South Africa

South Africa has a complete 1:50000 topographic map coverage comprising 1916 sheets. Although these were originally completed in 1971, they were not converted to metric format until 1991 (Lester 2000).

m. Spain

The Institute of Cartography of Catalonia, Spain has an active program for assessing available resources, environmental problems and issues, as well as evaluating natural risks and hazards (Canals 2000). The updated databases, as well as offering updated symbology, are maintained to provide multiple levels of generalisation.

n. Sweden

The majority of Sweden is covered at 1:10000 by the "Economic Map" produced by the National Land Survey (Sjovall 2000). Less populated areas are covered at 1:20000 with the map series, since completion in 1978, entering a revision and update phase using photogrammetric data acquisition techniques. The database content is similar to the map series with elements excluded, such as contours, footpaths and minor ditches, that were of less importance to database users.

o. Ordnance Survey (United Kingdom)

In 1995, Ordnance Survey digitised the last of some 230,000 maps, making Britain the first country in the world to complete a programme of large-scale electronic mapping. Computers have transformed the map-making process, and electronic data is now routinely available to customers within 24 hours of being surveyed (Ordnance Survey 2005).

Ordnance Survey also offers the public a print on demand service called OS Select. Orders are placed over the Internet on the OS Select web page where the user merely selects the point for the map centre. As the system uses a seamless database, there are no map edges to worry about. Depending on the queue, maps can be plotted within twelve minutes and usually dispatched to the client within two days (Stokes 2002). The system relies on dedicated print servers for the fast client turnaround.

p. USGS (United States of America)

USGS coordinates the national photography program to acquire aerial photography over the 48 conterminous states of the USA every five years (USGS 2001a). This program has been in place since 1980 and was revised in 1987 to accommodate changing user requirements and flight specifications. The archive presently contains over 10000 rolls of cartographic quality aerial photography and increases by about 700 rolls each year.

The USGS is also charged with coordinating the United States' national mapping program. This consists of approximately 53000 1:24000 and 1:25000 topographic maps over continental United States. Hawaii, Alaska and Puerto Rico are also covered using a mixture of other scales. The first editions were completed in 1992 after a program of some 50 years. With the revision cycle started, maps are revised using either complete or basic methodology.

Those in the complete revision cycle saw 100% of the map features revised. With a complete revision of all contour information being included in the process, only four sheets were completely revised in the period 1995 – 2000. Several other agencies assisted with the field completion for these sheets (USGS 1998).

In the same period about 1500 sheets per year were revised using the basic methodology. This differed from the complete with contours not being revised. This increased number was probably only possible due to the work undertaken by the Earth Science Corps (2400 volunteers) who assisted with the field completion activities. The US Forest Service has also assisted with revision of USGS map sheets. This interagency agreement sees the revision of the areas containing only forest service land. There are some 10000 sheets potentially affected by this agreement (Moore 2000).

Over the years the methodology used for map revision has changed with the development of specific software (USGS 1999). The current method was developed to reduce production costs and the amount of time taken for revision whilst still meeting the needs of the customer (Lemen 1999).

The “National Map” project is currently underway. This project, which sees the creation of a single seamless dataset, was started in January 2001 and should be finished in about 2011 ('The National Map From The USGS' 2003). The projects undertaking is timely given that most first editions are still in circulation. This is probably not surprising given that the average age of the maps is 23 years and that adjoining sheets are often more than a decade apart (USGS 2000).

Existing USGS topographic maps range in age from one to 57 years (as at May 2001).

2.4.3 - Australian State Mapping Programs

The following selected reports suitably demonstrate the current government based mapping situation in all Australian states and territories.

a. NSW Department of Lands

Just over 1100 topographic maps cover NSW in three different scale groups. Each of these approximately equate to the three administrative divisions that divide NSW. Initially each scale area was treated with a separate revision timetable.

- Eastern division - 1:25000 – every 3 to 5 years
- Central division - 1:50000 – every 5 to 10 years
- Western division - 1:100000 – every 10 to 15 years

Topographic map production started in the 1950s and continued until 1990. Priorities saw the organisation finalise the collection of the NSW cadastral data and begin the capture of the topographic fabric. After several trial products in 1996, hardcopy production recommenced in 1998.

Until 1991 the production of topographic maps involved the use of traditional techniques, which included the use of scribe sheets, masks, and names overlays. Using this traditional approach, the NSW Department's series of topographic maps were singled sided with only the symbolised map detail shown. Using a more efficient set of tools, the products of today are double sided with traditional topographic detail printed on the front and an orthorectified mosaic image on the back. With the recent introduction of the GDA all recently produced maps have adopted this datum.

During the change detection process for each sheet, the current photography is compared with the existing data and changes made to the state data set. The department has embarked upon a 14-year statewide revision cycle with each sheet undertaking a partial revision not including contours. The topographic datasets are revised with the production of each printed topographic map.

The revised datasets have been used to build TopoWeb. This is an application that allows the mapped physical landscape features to be viewed over the Internet. The data used by the application is a snapshot of the Digital Topographic Data Base (DTDB) and covers all of NSW. In addition to the Topographic data layers, several other reference layers have been added to the map service including State, Local Government and Suburb Boundaries, Towns and Map Sheet Indexes. There are 33 different layers in total used in this prototype.

NSW Department of Lands also offers the ability to view, order and pay for aerial photography and a large number of maps and other products online over the web as well (Bentley, pp. 17-18). The NSW Government is also developing the Intelligent Planning Framework which will allow the electronic lodgement of development applications with Planning NSW and participating local government authorities (NSW Government 2002a).

b. Tasmania

The Tasmanian Government produces 1:100000 and 1:25000 topographic maps over the state and adjoining islands. The Government established the Land Information System Tasmania (LIST) in 1998 using the existing maps as a base and now maintains this as a whole of government land information system (Mahar 1999).

c. Western Australia

The Department of Land Information provides a range of topographic maps for Western Australia.

- Topographic Maps - 1:25000
- Combined Topographic and Cadastral Data - 1:50000
- CALM Land Management Series - 1:50000
- General State Reference Map Series - 1:1 million

(*Topographic Maps* 2004)

Topographic mapping is available in two themes, planimetric showing cultural features such as roads and buildings, and relief displaying the shape of the land. A combination of themes can be requested and are available in both hard copy and digital formats. The information along with WA coastline vector data is also available in scales from 1:2000 to 1:250000.

The Western Australian Land information System (WALIS) was established in the late 1970's (Grant 2000). It is a consortium rather than a single database and has been developed to provide all users with access to the total combined data held by all 27 WALIS agencies.

d. Victoria

Victoria's Standard Topographic Series of maps were produced as a statewide coverage on ADG66 in UTM and are available at 1:25000 and selectively, at 1:50000 scales (*Vicmap Published Standard Topographic Series* 2004). The standard series has been digitally collected and is now available as the Vicmap 1:30000 Topographic series. This online service is an enhancement over current hardcopy maps as the series maps are generated utilising the most current Vicmap data available at the time of order. The maps can be created by choosing locality, municipality, park name, mapsheet number or name. Each map covers about 5km x 7km and is available in A4 mapsheets online as PDF.

(*Vicmap Topographic Maps 1:30000* 2004)

e. South Australia

The aerial photography for the State is maintained through an active program with Metropolitan Adelaide, Fleurieu Peninsula and the River Murray being flown every two years. In addition to these areas, the agricultural regions are flown every four years, the entire coastline every five years and the remote outback every 10 to 15 years. This aerial photography program ensures complete and regular coverage and supplements the topographic map program. The settled areas of South Australia have medium scale coverage (1:50000) while the more densely settled areas are covered by 1:2500 and 1:10000 maps.

An active mapping revision program ensures that the 1:50000 maps are kept up-to-date. Even though the 1:2500 and 1:10000 maps are no longer revised, digital data of the medium and large-scale maps is available if required.

(*Land & Maps* 2004)

f. Queensland

Topographic maps produced by the Queensland Government are available in the following forms:

- Image Maps - use aerial photography, which is corrected to scale, as a base and selectively enhanced with topographic information.
- Line Maps - are the traditional topographic map, where all the features have been interpreted from aerial photography for the map user.
- Orthophoto Maps - similar to image maps, but depict relief, selected enhanced roads and railways on an ortho-rectified image base. Generally available only in hard copy form.
- Double-sided Maps - incorporate the image maps on one side with the line map on the reverse.

Depending on the map scale, features have been symbolised to provide additional information. The topographic maps produced are currently available in printed form with a significant amount of topographic information also being collected and stored in digital form. Selections of topographic digital images that have been corrected to scale are also available (*Topographic Maps - Queensland* 2004). Digital representations of the topographic line or image maps can be provided as non-georeferenced PDF files. Paper maps can be produced from this data, or provided as digital topographic data.

g. Northern Territory

Topographic maps are produced by the Northern Territory Government at the following scales:

1:1000 - 1:2500	Series mapping of all Major Towns and Major Aboriginal Communities.
1:5000	Darwin Region (contours only) and special project area around some Towns.
1:10000	Series mapping of Darwin Region, Alice Springs, Katherine, Tennant Creek and Nhulunbuy.
1:25000	Series mapping Darwin - Katherine Region and Alice Springs.

In addition to these products, the topographic detail is also used to produce maps of Aboriginal Communities and Pastoral Leases.

(*DLPE - Maps and Data* 2004)

h. Australian Capital Territory (ACT)

ACT Land Information Centre develops, coordinates and manages mapping programs for the production and maintenance of cadastral, topographic, orthophotographic and thematic maps to support the planning, development, construction and management of land in the ACT.

Mapping programs include:

- Canberra by Suburbs - showing the blocks of land in each suburb of Canberra and rural districts in the ACT;
- cadastral maps at scales of 1:500, 1:2500 (urban) and 1:25000 (rural);
- topographic maps at various scales including 1:10000 and 1:25000; and
- detailed maps at 1:500, 1:1000 and 1:2500.

(*Mapping Program* 2004)

All sixteen of the recently produced topographic maps (1:25000) covering the ACT were produced by the NSW Department of Lands in a cooperative arrangement utilising ACT government data where applicable.

i. Cooperative mapping - State Government Organisations

The NSW Department of Lands has negotiated a series of cooperative mapping arrangements for the topographic map sheets along the state borders with Victoria, South Australia and Queensland. These arrangements detail the production of individual topographic maps along the state borders by the various state mapping agencies. The updates for all agencies are, however, only requested at the time of map production.

2.5 – Production System Shortcomings

Map production data (Douglas 2002) summarises the NSW topographic production capability over the period from 1949 to 2002, and clearly demonstrates that whilst the timeframe from aerial photography to printing has been reduced over that time, it is still substantial (up to 6 years) and requires further reduction (refer tables 2.8, 2.9, and 2.10; and appendix C). The timeframe for all first editions can be explained due to the extremely labour intensive collection of initial contour information. Subsequent editions undertook a less intensive revision process, with improvements in methodology also accounting for these timeframe reductions.

The period from field revision to printing ultimately dictates the temporal accuracy of the map data which, with advances in technology, will improve with each revision cycle. A clear trend can be seen in the latest editions of 1:25000, 1:50000 and 1:100000 topographic maps with the timeframe being reduced and hence providing an increase in temporal accuracy (refer table 2.9).

The tables (2.8, 2.9, and 2.10) relate to the 1826 map sheets printed between 1958 and late 2002 using aerial photography flown between 1949 and 2001. In 1980, production peaked with 499 map sheets held at various stages of output. The highest number of current map sheets (as at Oct 2002) were also produced in that year. Unfortunately the current available map series spans from 1972 to the present, with about half of the current holding being over 20 years old (refer figure 2.10). The current reduction trend needs to continue to enable the provision of temporally accurate topographic information.

Table 2.8: NSW Map Production Statistics 1949 to October 2002 - Edition / Scale Combinations (Adapted from Douglas 2002)

Aerial Photography to Field Completion								
1st / 25	**2nd / 25**	**3rd / 25**	**1st / 31**	**1st / 50**	**2nd / 50**	**1st / 100**	**2nd / 100**	**Year range**
16	2	4	2	3	-	1	-	Less than 1
93	57	60	-	26	-	26	-	1 - 2
163	100	41	3	35	3	17	-	2 - 3
181	113	26	17	39	2	15	6	3 - 4
63	78	-	11	61	-	11	24	4 - 5
57	70	-	32	31	-	17	30	5 - 6
16	37	-	34	15	-	14	-	6 - 7
5	9	-	36	5	-	7	-	7 - 8
-	-	-	25	-	-	3	-	8 - 9
-	-	-	11	11	-	7	-	9 - 10
-	2	-	9	2	-	8	-	10 - 11
-	-	-	9	4	-	-	-	11 - 12
-	2	-	4	6	-	-	-	12 - 13
-	-	-	-	1	-	3	-	13 - 14
-	-	-	-	-	-	1	-	14 - 15
-	-	-	-	-	-	1	-	Over 15

Table 2.9: NSW Map Production Statistics 1949 to October 2002 - Edition / Scale Combinations (Adapted from Douglas 2002)

Field Completion to Printing								
1st / 25	**2nd / 25**	**3rd / 25**	**1st / 31**	**1st / 50**	**2nd / 50**	**1st / 100**	**2nd / 100**	**Year range**
23	38	56	3	4	2	2	25	Less than 1
212	212	57	94	56	2	41	35	1 - 2
278	143	19	75	105	1	60	-	2 - 3
69	66	-	10	52	-	17	-	3 - 4
6	11	-	2	17	-	3	-	4 - 5
5	-	-	3	3	-	4	-	5 - 6
-	-	-	4	2	-	4	-	6 - 7
-	-	-	-	-	-	-	-	7 - 8
-	-	-	1	-	-	-	-	8 - 9
-	-	-	-	-	-	-	-	9 - 10
-	-	-	-	-	-	-	-	10 - 11
1	1	-	-	-	-	-	-	11 - 12
-	-	-	-	-	-	-	-	12 - 13
-	-	-	1	-	-	-	-	13 - 14
-	-	-	-	-	-	-	-	14 - 15
-	-	-	-	-	-	-	-	Over 15

Table 2.10: NSW Map Production Statistics 1949 to October 2002 - Edition / Scale Combinations (Adapted from Douglas 2002)

Aerial Photography to Printing								
1st / 25	**2nd / 25**	**3rd / 25**	**1st / 31**	**1st / 50**	**2nd / 50**	**1st / 100**	**2nd / 100**	**year range**
-	-	-	-	-	-	-	-	Less than 1
4	13	17	1	-	-	2	-	1 - 2
33	36	59	1	10	1	5	-	2 - 3
104	46	45	1	28	3	16	-	3 - 4
193	73	10	3	18	-	12	10	4 - 5
125	132	1	23	41	1	23	41	5 - 6
90	88	-	18	53	-	16	9	6 - 7
31	56	-	24	31	-	9	-	7 - 8
8	22	-	47	21	-	15	-	8 - 9
1	1	-	20	10	-	6	-	9 - 10
4	-	-	21	7	-	9	-	10 - 11
-	1	-	13	6	-	9	-	11 - 12
-	1	-	11	1	-	4	-	12 - 13
-	2	-	4	5	-	-	-	13 - 14
-	-	-	3	7	-	1	-	14 - 15
1	-	-	3	1	-	4	-	Over 15

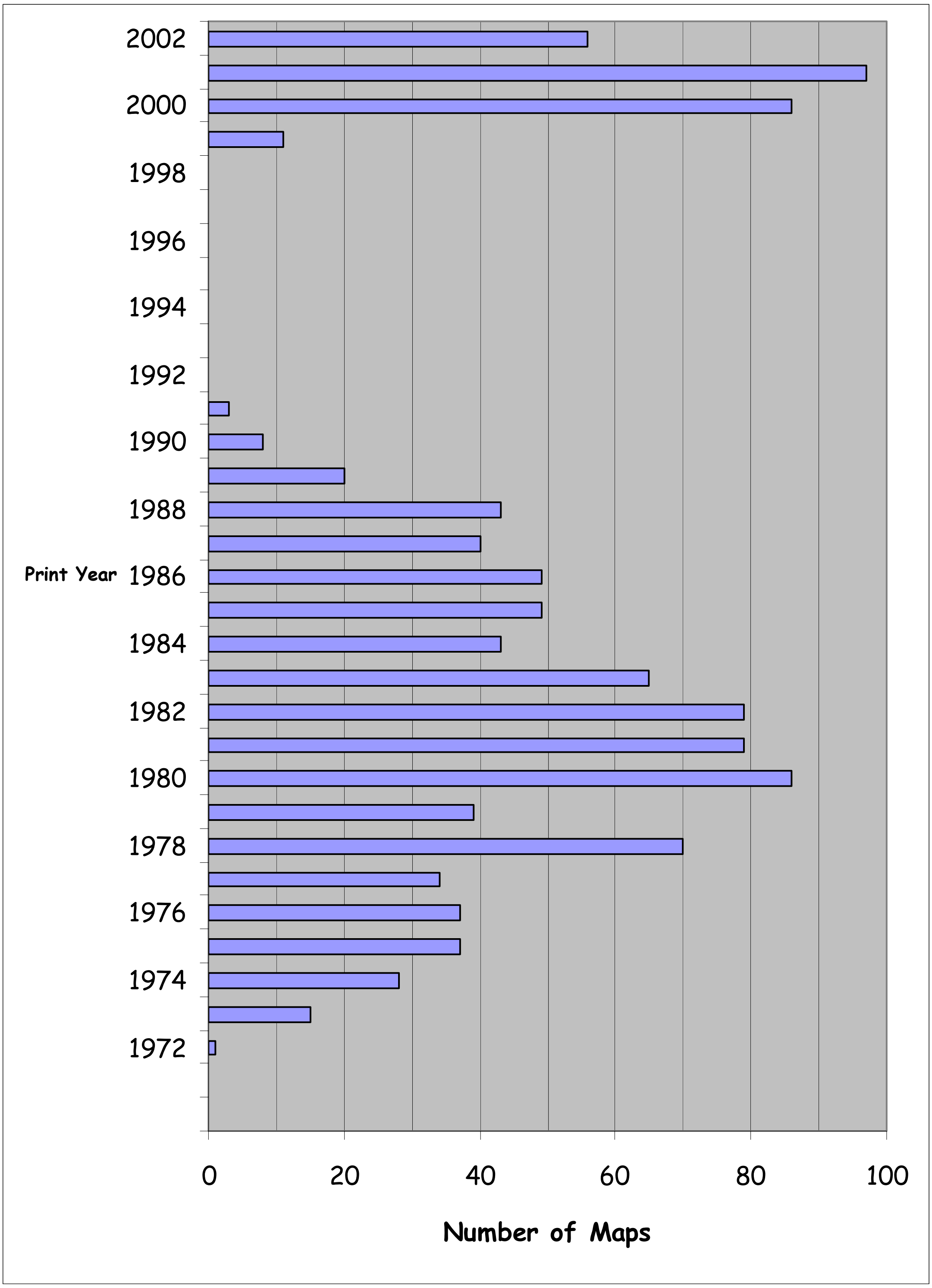


Figure 2.10: Age of Current Topographic Map Stock

2.5.1 - Associated Data Maintenance Issues

The use of DEM's allows semi automated contour line generation, however, the result is not error free (Duperet 2000, pp. 45-49) and the uncertainty found in the collection methods also transfers these inaccuracies to the DEM's produced (Reeves, Friend & Lu 1998; Wechsler 1999). This example is just one of many that highlight the implications of utilising spatially and temporally inaccurate data. This section discusses the associated elements of the hypothesis dealing with data accuracy, data supply and incremental updates.

a. Data Accuracy

> *.... all topographic data are imperfect versions of reality and vary from the earth's surface. The degree of accuracy associated with topographic data sources depends upon methods of acquisition and translation, which include factors such as scale and agency policy. Thematic representations imply uniformity for the entire collection zone. This may not be the case.*
>
> (Rybaczuk 1993)

A variety of software tools for reporting and communicating spatial data quality are being developed, with the tracking of edits being one such approach (Hunter 1999). Without cooperation and consistency there is a risk that data will not be available or compatible, there will be costly duplication of effort, and opportunities will be missed (Fenwick 1999). Efficient utilisation of data relies on the ability to share and integrate.

In many respects it is not the lack of data that is the problem but the need to anchor different data sets (relating to both physical and human environment) to a common framework.

(Burrough et al. 1997)

This is also highlighted by Delsere et al. (2000, pp. 66-67) who describe that the lack of homogeneous maps required the standardisation of decentralised mapping activities. Rhind (in Masser 1997) also reinforces the importance of data integration with,

All GIS experience thus far strongly suggests that the ultimate value is heavily dependant on the association of one data set with one or more others, ..., the bulk of the success and value came from linking data sets together.

In defining the information society, Petch (2000) also focuses on the aspects of data sharing.

One aspect of this is a society in which decisions and the information on which decisions are made are more and more in the public domain. Individuals increasingly want to share in those processes that they see as effecting their well being and destiny.

Current data integration issues include formats, conventions, spatial extent, projection, spatial accuracy and scale, quality, lineage, access, currency, and completeness (Australian National Groundwater 1999). Jensen et al. (1999) also explores these issues and offers that a spatial hierarchy should consist of foundation datasets, a thematic framework, and finally the individual themes. This will however not guarantee that problems due to the gaps in the spatial network or issues created by imprecise data sets will be solved.

Byrom & Pascoe (2000, pp. 42-43) suggest that to avoid data misuse a set of integration rules need to be developed. These rules should state, for example, that data sets;

- o Should not have large differences in scale,
- o Have the required accuracy over the area of interest,
- o Have the required precision, and
- o Not be out of date for their intended use.

The inappropriate use of data is due largely to an under educated user community (Salge 2000). Appropriate usage safeguards would ensure that the data is not misused, thus preventing inappropriate overlays. Data must, however, be related in an understandable way as geographic data is of little use until it can be related to other locations (Longhorn 1997), thus highlighting important geospatial relationships and topographic significance. Online gazetteers can be used to resolve some of the geo-referencing and geospatial relationship issues that may occur through data integration. The GEOnet names server (GNS) provides access to the US Department of Defence's database of foreign geographic names (Gerland 1996, p. 24).

b. Data Supply

Whilst data sharing is well established in Victoria for cadastral information, the same could not be said about NSW (circa 2000). Spatial consistency was in doubt in terms of position and correctness (GITA 2000) due to the number of organisations maintaining their own databases. While this was done for a variety of reasons, including securing early access to data, the multiple maintenance requires a duplication of effort.

The PCGIAP believes that resources should not be wasted on duplicated effort (Permanent Committee for GIS Infrastructure for Asia and the Pacific 1998) as the ability to share information will be crucial for future informed decision-making (Brand 1998). This is reinforced with,

> *Information, particularly spatial information, can provide a range of benefits, including increased economic development capacity, improved social development and responsible and informed environmental decisions*
>
> (Mawn & Stanton 1999).

To maximise these benefits, a range of standards will be required, within each individual discipline, when utilising the various tools within each particular type of software. Without the development of these universally accepted standards, time and effort will be spent converting data between various formats and data types. These will be especially so as outlined in Clarke et al. (2000) with respect to the Global Map.

It was expected (1998) that International standard ISO 15046 would become the world wide standard for geomatics and geographic information (Macauley & Bullock 1998). This has since been replaced by the ISO/TC211 series of standards, further highlighting the dynamic nature of change within the spatial information industry. Existing Australian practices also highlight this change with 62% of 379 organisations surveyed in 1998 regarded as being both data users and data suppliers (Mason & Masters 1999).

This is reinforced with,

> *the trend is now toward even wider use and sharing of data at the enterprise level*
>
> (Maguire 2000, p. 73),

and,

> *Spatial data is an important resource for almost all areas of government so no single agency has a monopoly over its management*
>
> (Holland, Peter et al. 1998).

To accommodate this increase in data management, the method of storage must allow an efficient updating and maintenance mechanism. Efficient data maintenance solutions must address at a minimum, data content, timeliness, data transfer, administration, and pricing. These aspects are equally important when coupled with updating alternatives such as incremental update, a block data update, and bulk file updates (Jacoby 1996).

> *The digital earth is seen as a multi resolution three-dimensional representation of the planet into which we can embed vast quantities of geo-referenced data*
>
> (Holland, P. 2000)

Current Spatial Data Infrastructures are a complex digital version of what has existed within most developed nations for the last 50 years (Williamson 1999). It is important to recognise that the infrastructure models now contain people, standards, clearinghouses and frameworks. Kidokoro (2000) reinforces these in discussing the principles surrounding the Global Map which include global coverage, consistent specifications, and that the data is open to the public and distributed worldwide at marginal cost. Burrough et al. (1997) also proposed that certain datasets should be available at low cost and free of intellectual property rights when extracted at 1:500000 or less.

Harris (2000, pp. 38-41) also discusses the supply of geospatial information and the question of "Should data be free?". Although there is a free exchange of meteorological data already, no cost may be perceived to mean no value. This assumption is questionable as Taylor (2000) suggests that two of the changes the internet has created are a demand by people for readily accessible and digestible information and a belief that there should be no place for artificial barriers.

With accessibility also comes the challenge of distribution with an organisation's overall capability encompassing acquisition, production, management and dissemination (Williams 1999). Brokerage arrangements, once in place, are designed to allow the data custodian to concentrate on the task at hand, namely the creation and maintenance of the dataset whilst relieving non-core activities and associated administration (Ower 1997).

Data delivery, an important aspect of these arrangements, will benefit from the web being regarded as "the ultimate delivery mechanism" (Magan & Finniear 1997). These thoughts are reinforced by Zangari (2000) through, its increasing widespread use, the utilisation of standard data transfer protocols, and the ability to send data with a high level of security. With the typical data warehouse being updated periodically (usually daily), file size can be controlled through the use of incremental updates (Firns

1997). Transfer and storage technology (for example Mr SID) using data compression algorithms are also available to significantly reduce the size of high resolution images to a fraction of their original size (Foley 2000, pp. 52-53). These advances also maintain the quality and integrity of the original image.

Distribution and data transfer via a national clearinghouse is one alternative available for the Australian Spatial Data Infrastructure (ASDI). Whilst this approach adequately covers national datasets, problems may arise where there is a need to compile a dataset that overlaps existing dataset boundaries. In this situation, data and systems must be interoperable (Macauley 2000).

c. Incremental Updates

The Intergovernmental Committee on Surveying and Mapping (ICSM) has drawn up guidelines for data to be included in the Australian Spatial Data Infrastructure (ASDI). Incremental update capability is a component of the model for data compliant with the ASDI.

> *A data transfer system that enables suppliers to supply only information that has been affected by change between two versions of a dataset and for users to be able to incorporate those changes into their data*
>
> (ICSM 2003).

Jacoby & Marwick (1997) discuss versioning and temporal management within the Victorian DCDB. This model uses time date stamping and features are retired rather than deleted when they are no longer required. Incremental updates are an essential component in the hydrographic mapping field and the production of electronic navigation charts (ENC). Hardy & Woodsford (2000) outline the importance of database maintenance through the use of versioning toolkits within object orientated spatial databases.

The International Cartographic Association (ICA) has also established an international working group related to incremental updating and versioning of digital databases (refer http://geo.heifa.ac.il/~icaupdt/wgtor.htm) (ICA 1999). Temporal aspects and incremental update are also covered by the International Society of Photogrammetry and Remote Sensing (ISPRS) working group IV/3 (ISPRS 1998).

Parallels can be drawn between digital cadastral databases (DCDB) and topographic databases in terms of incremental updates and data resupply.

> *To maintain the currency of the DCDB continual subdivision activity must be captured by the custodians*
>
> (Effenberg & Williamson 1996)

Previous research has also explored the suitability of the Internet for updating cadastral databases (Polley, Williamson & Effenberg 1997). With the technological advances of recent years, this theory may become a reality and provide sufficient capability for topographic updates as well. One such innovation includes the introduction of unique topographic identifiers (TOIDs) by Ordnance Survey in Great Britain thus easing the task of associating different datasets to Ordnance Survey base material (Laser Scan n.d.).

2.6 - Conclusions: Chapter 2

It can be seen in the examples discussed (refer section 2.4.2 USGS, Columbia, and section 2.4.3 NSW Department of Lands) that, due to the rate of ongoing change, there is a need for better map maintenance. It is well known that geographic changes occur on a daily basis within the real world environment. Recording these changes requires an understanding of not only the changes that occur but also of the people and organisations that make them. These changes can be broadly categorised as initiated by either, private individuals or corporations; or local, state, or federal tiers of government.

In mapping terms, these changes may be recorded using a variety of tools and agreed procedures. These can include the use of active and passive remote sensing systems and mobile mapping techniques using GPS or vehicle based videography. The recorded information can be further enhanced with accurate attribution gained via locally obtained ground truthing. These are all, as with mapping in general, resource intensive activities and further demonstrate the need for a coordinated approach to map revision and maintenance.

The majority of organisations involved in traditional map revision programs struggle to maintain the data currency of their current suite of printed topographic products. As the capabilities of these organisations increase, there will be a further push towards online user defined publishing and ordering (refer section 2.4.2.o, the Ordnance Survey Model). The topographic databases used to produce these products, regardless of the media used for output, will still only be as up to date as the information used to maintain them.

Over the last decade, due to an increase in available systems, there has been a reduction in satellite revisit times and an increase in capability and resolution. Additional tools have also been developed for change detection and feature identification and for customer driven print on demand database access. Despite these advances, topographic maps are still not being maintained with adequate temporal accuracy when revised as part of a conventional revision program. Suitable data collection methodology urgently needs to be sought.

Currency presentation and revision alternatives include the maintenance of state held topographic databases with individual incremental updates. These topographically significant updates are often recorded by key organisations within at least one tier of government, however, duplication of effort within these tiers (for example, topographic mapping) promotes inaccuracy in both spatial and aspatial components and attributes. An active data sharing program driven and coordinated by individual data custodians would provide both output on demand and standard program topographic map production.

The arrangements (similar to those in place in Canada and within the WALIS consortium - refer sections 2.4.2.c and 2.4.3.c) would be further enhanced within the various tiers of government through online data entry and reporting mechanisms similar to that used by Hydrographic Office for their Notice to Mariners. There is additional scope for cooperative incremental data sharing agreements due to the increasing number of available online names databases.

The Australian public, driven by planners and developers, environmental managers, and the emergency services community requires up to date topographic maps and products. These can be provided through the implementation of incremental topographic updates, and the ability to provide these updates in a timely technologically advanced manner.

CHAPTER 3 – RESEARCH DESIGN AND METHODOLOGY

There is no comparison between that which is lost by not succeeding, and that which is lost by not trying.

(*Francis Bacon Famous Quote, Inspirational Story*)

The technologies available for data collection, feature identification and map production have advanced steadily over the last ten years. However, this has also resulted in a duplication of effort and resources that has ultimately increased the cost to government through the inefficient use of equipment and trained staff, and a subsequent reduction in client services. It is also apparent that whilst the technology has advanced, so has the community expectation in relation to maps and map related data and services. These are reinforced through specific industrial examples outlined in chapter two.

This rising expectation and the reduction in client services offer little relief to a "map hungry" public in need of the latest information supplied in formats and in timeframes of their choosing. This presents a number of issues to the mapping community where data collection mechanisms at present are unfortunately not designed with data currency in mind. Production schedules have adopted a schema with "the map" as the central focus rather than its individual components.

In short, maintain the map, by maintaining the data.

3.1 - Design Outcomes

Map production has steadily advanced with GIS and CTP technology replacing the scribe sheets and film negatives of the past. Through the Internet, data construction standards, and the use of data compression software, information sharing is becoming commonplace and lending itself to a wide range of applications.

Chapter two determined, to substantiate the hypothesis (refer section 1.1), that this study must focus on the relationships that exist in determining change within the natural and built environments as applicable to modern topographic mapping. From chapter two the outline of methodology and design (as explained in sections 3.2 and 3.3) was to:

- test the workings of government and government business as related to spatial entities, and
- demonstrate the benefits that would be available to government map production through the implementation of a dedicated data sharing program.

A pilot study was conducted in late 2001 to confirm that, “government bodies know about changes in the built environment”, and to validate the proposed research methodology and design. This study was also able to initially test the proposed data sharing structure and identify subsequent process refinement prior to the main trial. The second stage, structured from the pilot study findings, was a detailed investigation over a 28-week period, concluding in November 2002, in which data was collected from the NSW government gazette and three government authorities. This chapter describes the design and methodology constructed to complete both these stages and accurately record all measurable outcomes.

3.2 - Pilot Study: NSW Government Gazette

The pilot trial analysed the data contained in eight consecutive editions of the NSW Government gazette during the period from 24 August 2001 to 12 October 2001 inclusive. A clear indication of the level of government knowledge, with respect to the changing built environment, was expected from the analysis of this data. These gazettes are a record of all notifiable government business and usually published weekly with each edition divided into four sections:

- Legislation,
- Official notices,
- Other notices, and
- Private advertisements.

The legislation section deals with changes in state government legislation or regulation and includes alterations to particular local environment plans. The official notices section is used for listing official notifications from government departments and other official bodies resulting from official government business. This differs slightly with the third section, other notices, listing notifications that deal with a specific piece of legislation rather than a specific organisation. The private advertisements section is similar to the public notices section of major newspapers and advertisements are classified as either:

- Council Notices. Used by LGAs and county councils (utility providers) for notifying, for example, changes in road names or the acquisition of land,
- Estate Notices. Used by solicitors for the notification of probate and distribution of estates, and

- o Company Notices. Used by companies for announcing voluntary liquidation.

Only the advertisements classified as council notices were included in the study. The other notices were excluded due to their lack of geographic content and overall mapping value. Further examples of the items contained in the gazette are listed in section 2.3.

Each gazette edition was reviewed with particular attention to entries of spatial or aspatial topographic significance (refer section 2.1). Those entries were recorded only when they contained details that had the potential to cause a change in the map face through either,

- o position,
- o text, or
- o symbology.

This information included details relating to topographic changes, attribute changes to real world features, or the specific alteration of administrative boundaries or attributes. Particular examples of these information sources include:

- o the rearrangement of map detail caused by the inclusion of priority features or additional administrative information,
- o the rearrangement of suburb and locality names and other annotation as a result of a boundary modification, and
- o changes caused by the update of a feature’s attribution.

The entries were regarded as potential amendments, regardless of the size of the amendment or its priority, if map face modification would have been required to either topographic or included cadastral features. Further investigation would have been required to ascertain the usefulness of each entry. Rating each entry was outside the scope of this study and would have no impact on the methodology of the proposed process. These changes were often location based and were identified through the use of coordinates, spatial relationships and descriptions, plans, or other unique identifiers. Further investigation was required for those lacking a location-based identifier.

For each of the topographically significant entries found within the gazette, the following was recorded:

- o the organisation,
- o the particular tier of government,
- o the number of potential amendments,
- o the method of spatial identification, and
- o the type of government action or update.

The transaction details were recorded in an Excel spreadsheet to allow continuous access for data entry, manipulation, and analysis. Appendix D is a summary of the spreadsheet and lists the organisations, the number of entries and number of potential amendments submitted by each organisation over the eight-week period. The gazette entries spanned 51 different organisations from both state and local tiers of government. Table 3.1 is a comparison summary of the two tiers of government found to have entries in the gazette.

Table 3.1: Comparison of Tiers of Government

Tier of Government	No of Organisations Submitting Amendments	Potential Amendments
State	24	1018
Local	27	106

Although the majority (53%) of organisations involved came from the local government tier (refer figure 3.1), the state government organisations claimed the majority (91%) of amendments during the pilot study (refer figure 3.2). As the gazette is a record of the state government business, this is an expected outcome.

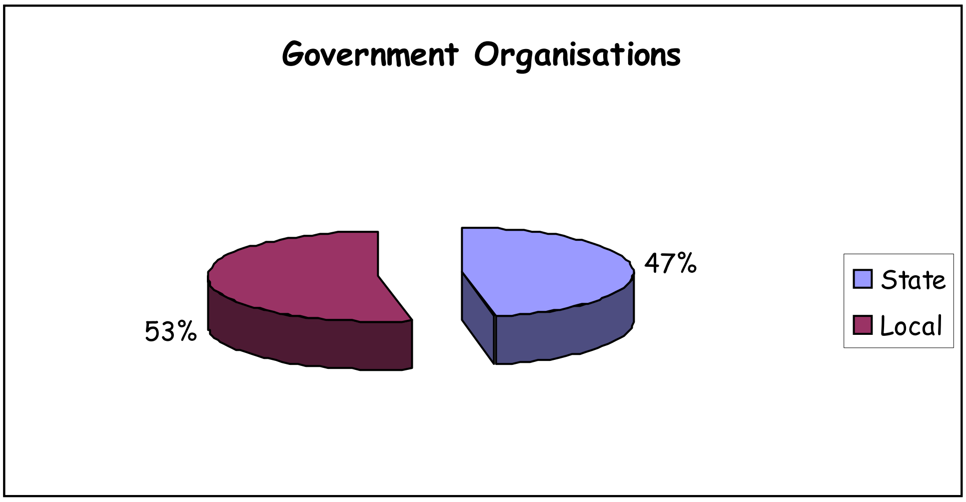


Figure 3.1: Breakdown of Organisations by Tier

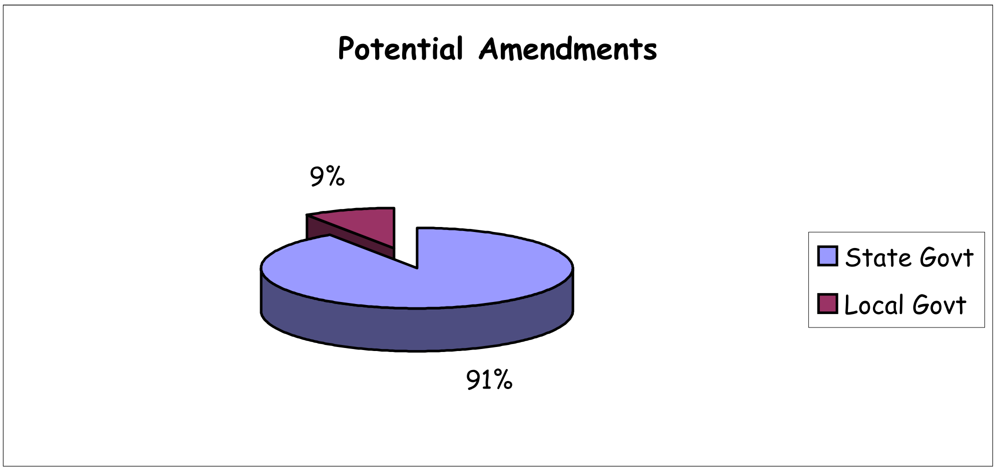


Figure 3.2: Number of Amendments by Government Tier

Table 3.2 summarised this data to display the quantity of potential amendments found in the NSW Government gazette over the eight-week pilot study period.

Table 3.2: Gazette Amendments by Date

Gazette Date	**Entries**	**Potential Amendments**
24-Aug-01	47	192
31-Aug-01	49	240
7-Sep-01	53	142
14-Sep-01	42	93
21-Sep-01	53	100
28-Sep-01	53	75
5-Oct-01	48	136
12-Oct-01	42	146
Total	**387**	**1124**

During the pilot study a total of 1124 potential amendments were noted from 387 gazette entries. This equated to an average of around 49 entries and 140 potential amendments per week.

A longer time frame would be required to ascertain whether these figures were consistent and representative of the entire year, the time period was however, adequate from which to establish the methodology and design parameters for the project.

Figure 3.3 displays the quantity of entries and amendments by date. It can be seen from the graph that no direct correlation existed between entries and amendments during the pilot study.

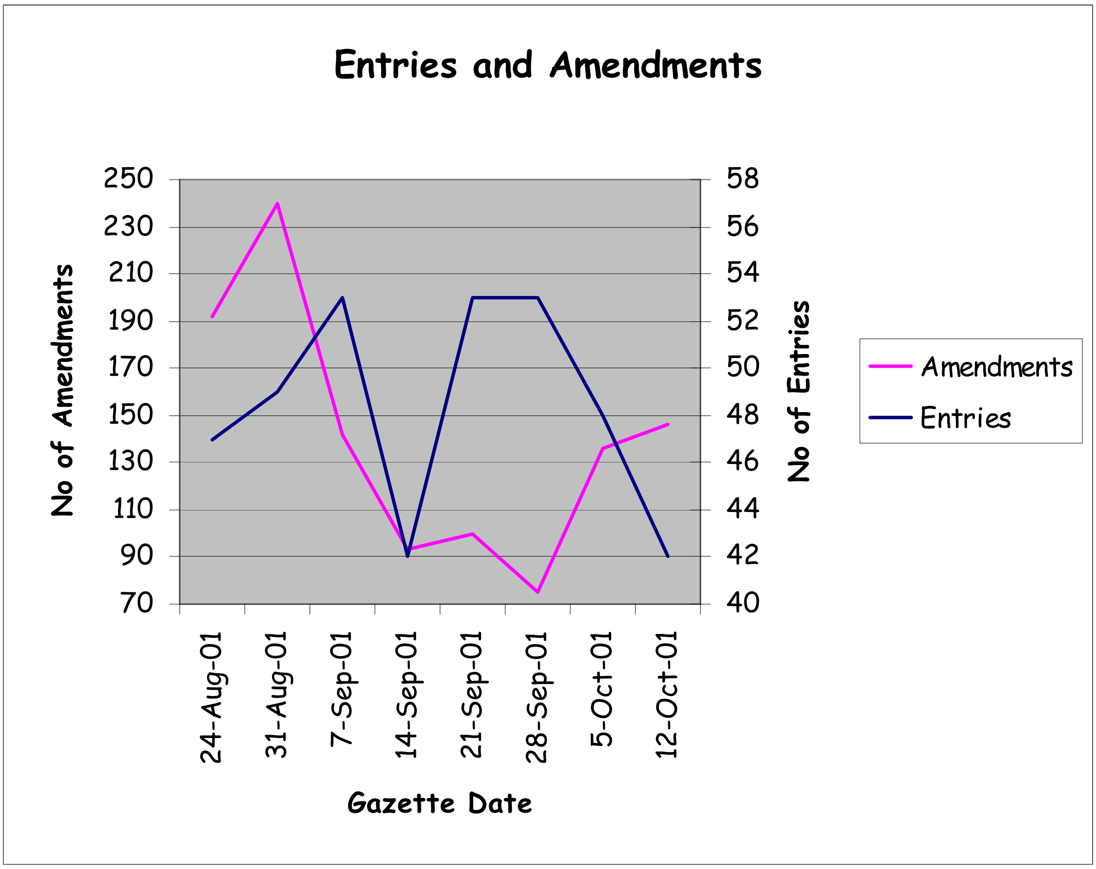


Figure 3.3: Entries and Amendments by Date

Analysis of this data further confirms this with a correlation value of - 0.1269. The lack of correlation between the entries and the amendments is significant and demonstrates the need to record the total number of amendments, as it is not possible to estimate this from the entries alone.

In comparison to figure 3.3, figures 3.4 and 3.5 display the number of amendments by organisation within the two tiers. From these graphs it can be seen that within the local government tier most organisations required only a small number of transactions to be entered in the gazette. In the state government tier the amount of transactions is significantly larger (refer figure 3.5).

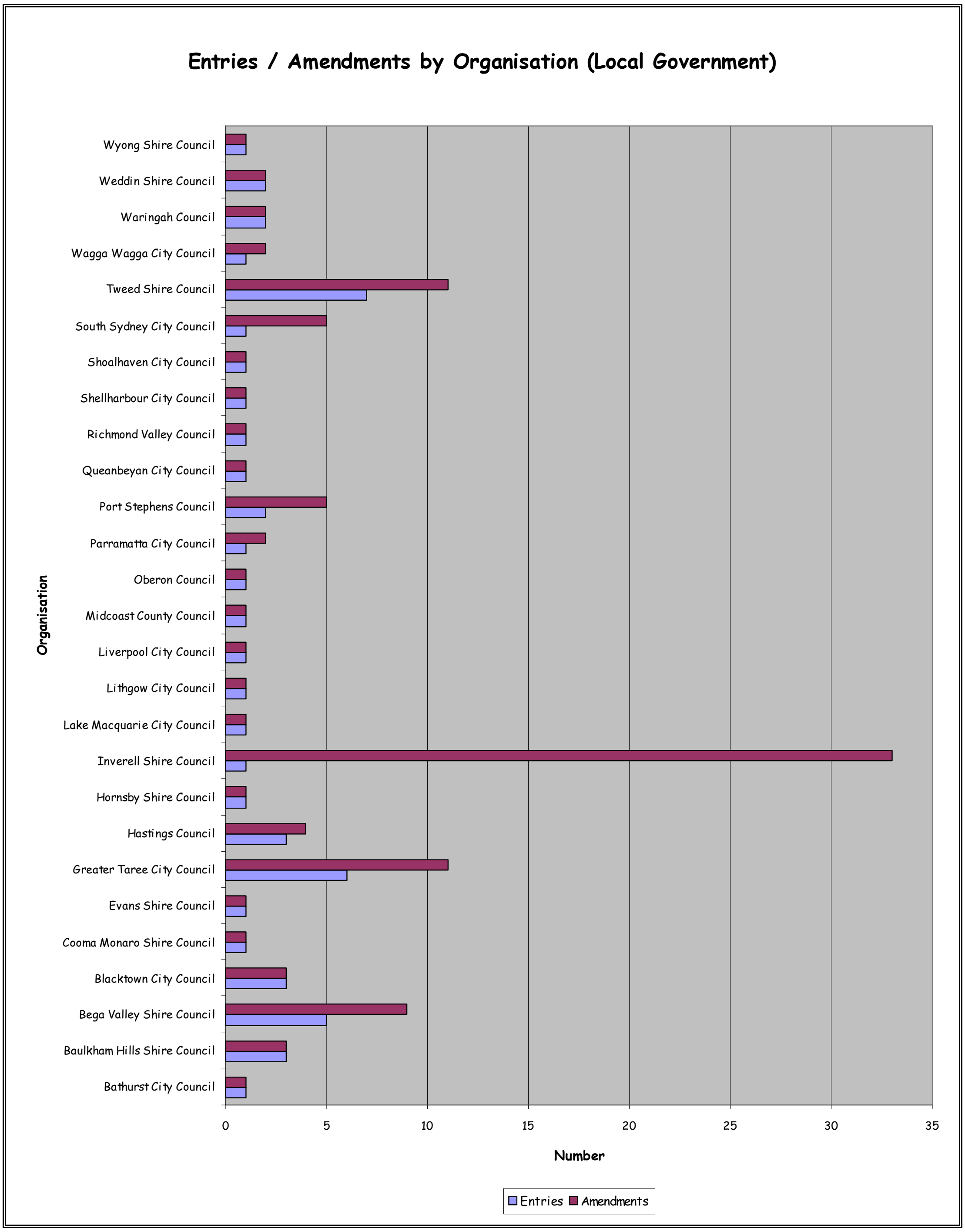


Figure 3.4: Entries / Amendments by Organisation (Local Government)

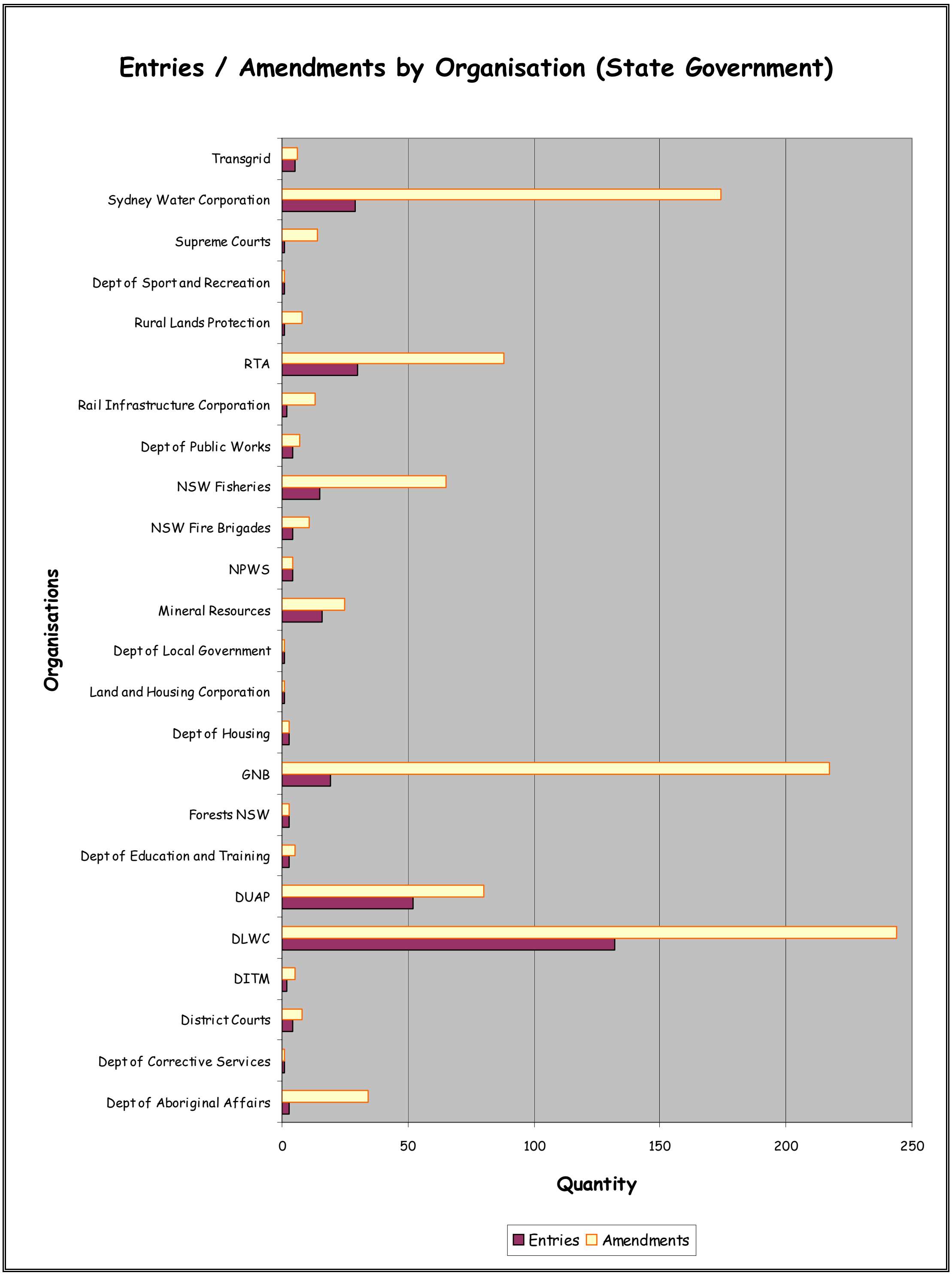


Figure 3.5: Entries / Amendments by Organisation (State Government)

The quantity of transactions substantiates that the various agencies within the two tiers of government are aware of changes to the built environment within their respective fields. Without further investigation into the total change in the built environment it would be difficult to quantify this level of awareness and whether it is representative of the entire tier. The population of the chosen changes is, however, a suitably accurate indicator and provides uniform knowledge. Quantifying this awareness would provide a valuable and more accurate indication of the number of changes likely to occur in a given area, over a chosen period of time. This would then allow for an estimation of resource requirements and enable forward planning for mapping programs. Despite being outside the scope of the study, this would be beneficial in further supporting the functionality of the "Now Map" concept and the temporal accuracy available.

Table 3.3 summarises the method of referencing used within each gazette entry. Figure 3.6 displays the quantity of potential amendments for each referencing type and shows that only 30% (geographic coordinates and addresses) used a spatially orientated method, with the rest relying on aspatial referencing. The deposited plan number as issued by the NSW Land Titles Office was found in 34% of the amendments.

It is also notable that a maximum of 43% of the amendments can be described as having a reference related to the digital topographic data. These being the address, geographic coordinates and the name / description.

Table 3.3: Spatial Referencing

Spatial Reference	**Entries**	**Potential Amendments**
Plan / Diagram / Local or Regional Environmental Plan	38	109
Name / Description	33	142
Lease / Licence / Reserve No	71	149
Geographic Coordinates	9	154
Address	36	184
Deposited Plan (LTO)	200	386

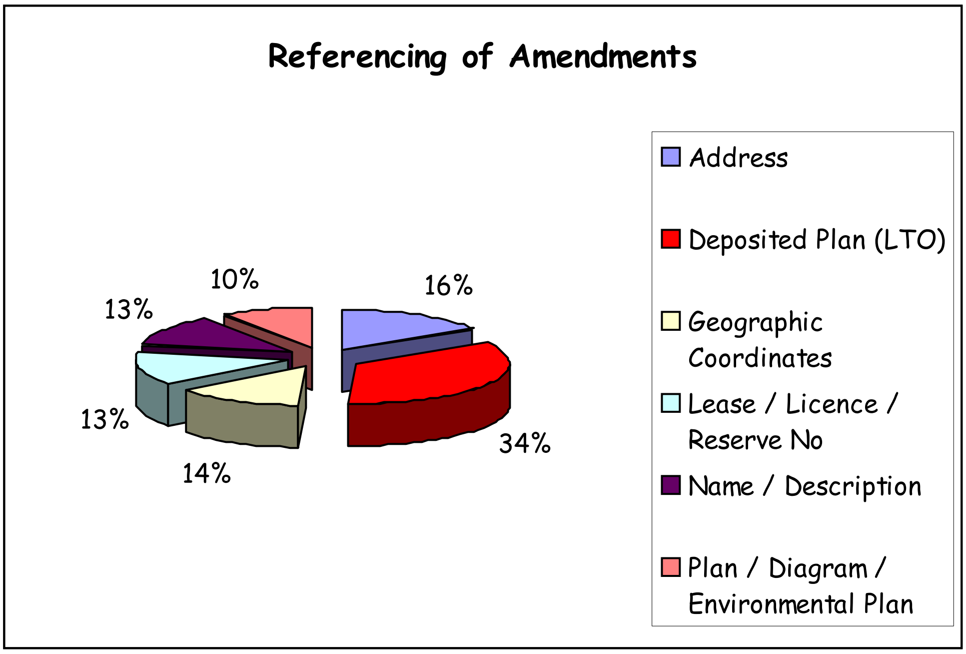


Figure 3.6: Referencing of Amendments

Table 3.4 summarises the actions undertaken by the government departments and related bodies for each entry and amendment. These actions are grouped in terms of the unique modifications required for each topographically significant entry. Further investigation would be required to ascertain the map face modifications required to each amendment and as such is outside the scope of this study.

It can be seen from the table that the changes to topographic linework (30.8%) is only slightly less than the allocation of topographic names (geographic and roads) (32.8%). It cannot be suggested that the remaining items (37.4%) are only of cadastral significance. Several of those government actions, already identified, impact on this study by undertaking dual roles, that is, changes to both cadastral and topographic data.

The actions of the government's departments and related bodies are shown in graphical terms (refer figure 3.7) and clearly demonstrate that while the majority of these are of a topographic nature, there are cadastral symbology and text related implications for map product maintenance as well.

The major indicators can also be categorised in terms of both topographic and cadastral, and as either symbology or text. These include those related to administrative boundaries and area renaming, feature identification and land use classification.

Table 3.4: Gazette Actions

Actions Relating To: **(N**ames **/ L**ines**)**	**Entries**	**Potential Amendments**
Geographic Names (**N**)	16	211
Identification of Pipelines (**L**)	30	175
Changes to Cadastral Roads (**N**)	77	159
Topographic Road Definition / Naming (**L**)	27	98
Acquisition / Vesting of Land / Easements	42	64
Aquaculture Leases (**L**)	12	62
Reserve Trusts	40	61
Local / Regional Environment Plan Definitions	40	58
Changes to Crown Land / Reserve / Public Land	29	49
Water Licence Applications	11	45
Identification of Government Property / Significant Development	13	37
Heritage / Historical Significance	3	35
Mining	16	25
Identification of Timber Plantations	10	20
GNB Boundary Amendments (**L**)	5	13
GNB Erratums	13	13
Reserve of Public Water Land	2	2

The method of referencing used for each amendment further substantiates that the various agencies, within the two tiers of government are aware of changes to the built environment.

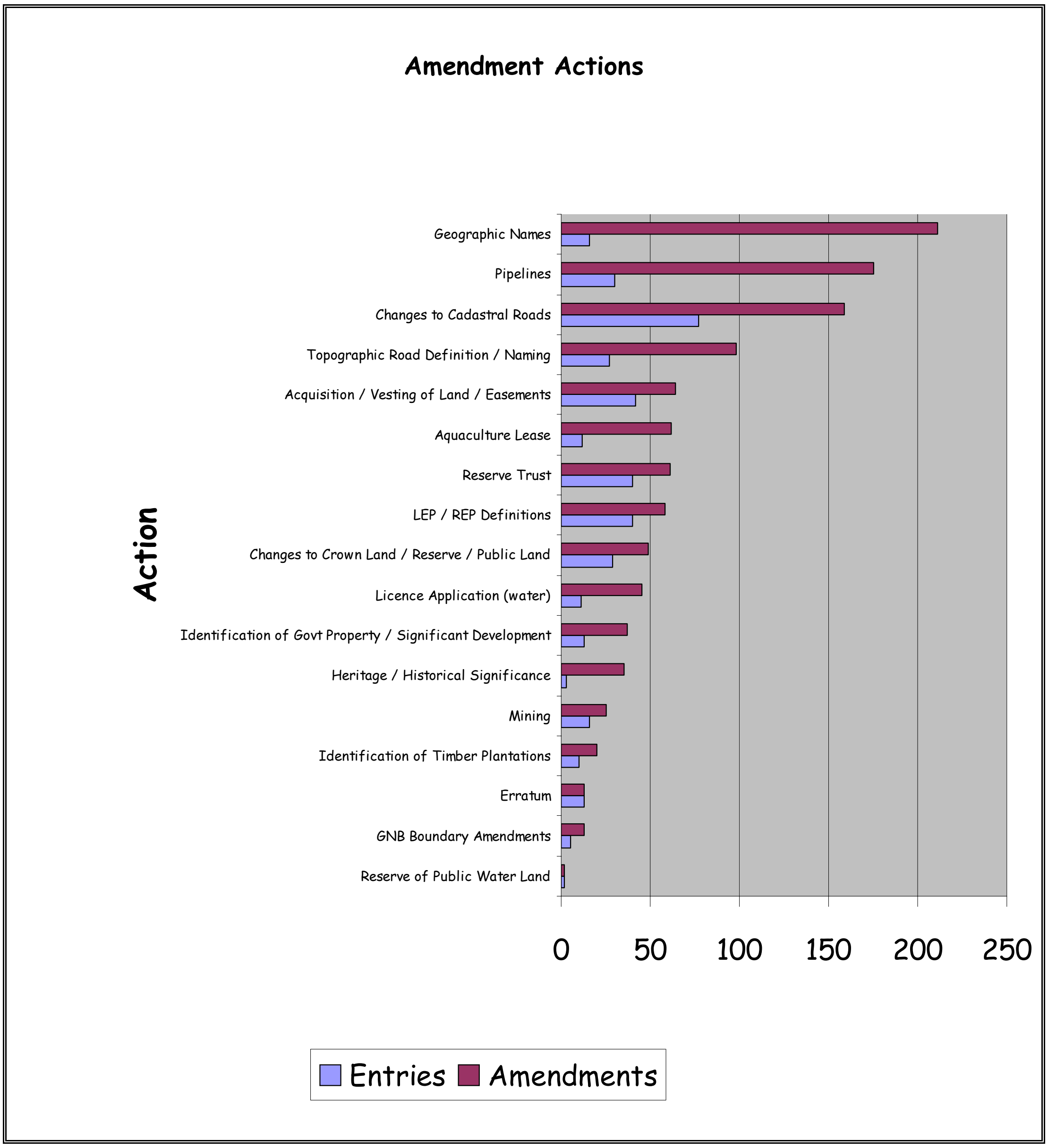


Figure 3.7: Amendment Actions

a. Pilot Study Summary

The pilot study has demonstrated that a significant amount of information is available within both local and state tiers of government. Analysis of this information established that the tiers of government are aware of changes in the built environment and publishes these within the NSW Government Gazette. This information would be further enhanced by the additional information (unpublished) held within the two tiers that also relates to changes to the natural and built environments. The pilot study also successfully demonstrated that this information would produce benefits when supplied through a dedicated data sharing program.

As the results confirm, the methodology and technique of the pilot study demonstrated its suitability for use in a longer investigation. Hence, to fully test the validity and reliability of these findings, a final data collection trial was undertaken, further enhanced by a data sharing program involving three governmental organisations within both tiers.

Several minor changes were implemented in the final data collection procedures, in relation to the collection of data, after analysing the conduct of the pilot study. Within the pilot study the focus was centered on all data regardless of theme and regardless of organisation within a particular time period. The final study used theme as a central focus for the gazette studies and again within the data sharing programs, further enhancing the “Now Map” concept.

To better establish the relationships that exist between the partners in a data sharing arrangement, data was selected to complement that available through the gazette and further demonstrate the “Now Map” concept.

3.3 - Major Study Data Collection

The pilot study outcomes demonstrated the validity of the research methodology, and confirmed that the major study collection of data should be divided into two parts:

- A selective review of the NSW Government Gazette, and
- A data sharing program involving three government organisations spanning an area of 70 topographic map sheets.

3.3.1 - NSW Government Gazette

Whilst reviewing the gazette, the observations were confined to three specific aspects.

- Geographic Names,
- Road Names, and
- Aquaculture Leases.

These three aspects each provided a situation, namely text, symbology with text, and symbology only, which was sufficiently significant (refer sections 2.1 and 3.2) to be valid for this study.

a. Geographic Names

Information in relation to geographic names is covered by the Geographical Names Act 1966. The transaction notifications for geographic names variations, additions and deletions are found within the third section (other notices - refer section 3.2) of the gazette.

Hence, the information collected for each transaction included one or more of the following data;

- o Additions due to names being approved,
- o Deletions due to names becoming discontinued,
- o Administrative boundary alterations, and
- o Changes due to errata.

An example of the advertisements is contained in figure 3.8 with all research transactions details being recorded in an excel spreadsheet (refer appendix E) to allow continuous access for data entry, manipulation, and analysis.

Geographical Names Act 1966

PURSUANT to the provisions of Section 10 of the Geographical Names Act 1966, the Geographical Names Board has this day assigned the geographical name listed hereunder:

Name Assigned	Lowe Creek
Designation	Creek
LGA	Wyong
Parish	Stowe
County	Northumberland
Latitude	33º 08' 10"
Longitude	151º 12' 30"
L.P.I. Map	Kulnura
100,000 Map	Gosford 9131
Reference:	GNB4419

WARWICK WATKINS
Chairman

Geographical Names Board
PO Box 143, Bathurst 2795

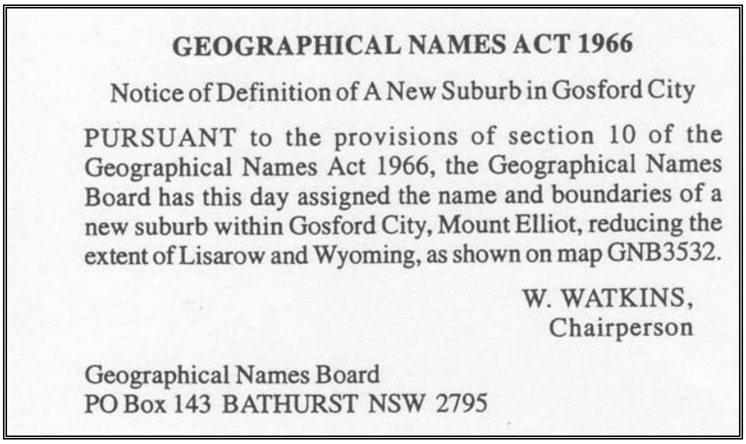
Figure 3.8: Geographic Names Notification (NSW Government 2001b, p. 10761)

It can be seen from the notification that the name is assigned to a feature with a specific designation, which are used to group together features with similar attributes. The notification also lists the feature's parish, county and LGA along with the LPI map and 1:100000 mapping block identifier. The map sheet listed represents, in all cases, a map that contains the feature regardless of whether the feature is symbolized or annotated. Where the feature traverses multiple map sheets, then the map listed will be where the feature is prominent thus assisting the GNR user in locating the feature.

The notification also contains a coordinate rounded to the nearest ten minutes of both latitude and longitude. In the examples noted in this research, the feature is usually found within one geographic minute (about 1.6km) of the coordinate listed. This accounts for area features where the position is the centroid, linear features that show a prominent point or where the feature starts or rises (in the case of drainage, for example, Macquarie River), or is represented by a point, such as Kings Cross.

This also allows for differences in scale and where annotation and symbolisation are positioned offset or not shown. This significance can also be observed when comparing the same feature in similar maps that have been produced for different purposes, for example census collection diagrams and LGA suburb boundaries.

Notifications are also submitted (refer figure 3.9) relating to the alteration of several suburb boundaries in addition to the creation of a new suburb. These changes are shown on the listed GNB map (GNB3532). This amendment would require the alteration of the existing annotation positions as well as the addition of a new piece of text for the newly created suburb name.


GEOGRAPHICAL NAMES ACT 1966

Notice of Definition of A New Suburb in Gosford City

PURSUANT to the provisions of section 10 of the Geographical Names Act 1966, the Geographical Names Board has this day assigned the name and boundaries of a new suburb within Gosford City, Mount Elliot, reducing the extent of Lisarow and Wyoming, as shown on map GNB3532.

W. WATKINS,
Chairperson

Geographical Names Board
PO Box 143 BATHURST NSW 2795

Figure 3.9: New Suburb Notification (NSW Government 2002b, p. 876)

Additional investigation would be required to ascertain the location of the new suburb. Prior to the gazettal, the GNB has already described the affected suburbs. Sharing this information would minimise the effort, thus leading to the overall efficiency of the map production process. Using a dedicated email listing or bulletin board service, this information would be provided to interested parties on the day of the gazettal, thus enabling and further supporting the “Now Map” concept.

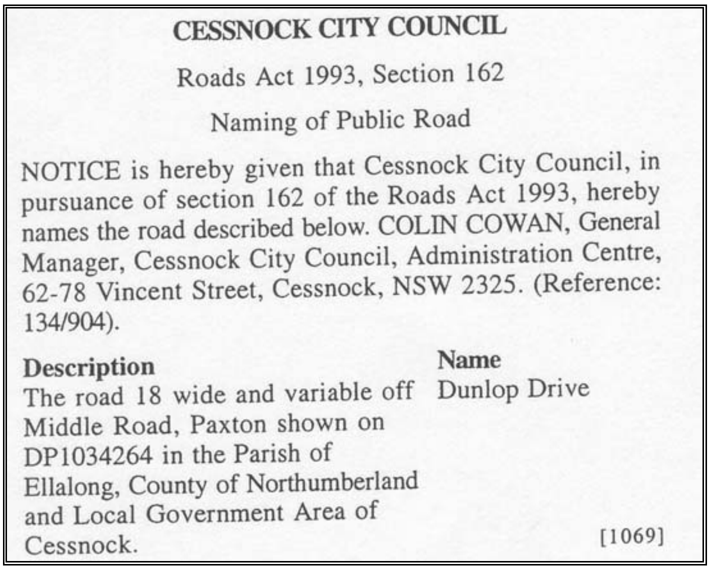
b. Road Names

The transaction notifications for road naming are found within the private notices section (refer section 3.2) of the gazette. The information collected from these notices for each transaction included;

- LGA name, and
- Number of notifications in the advertisement.

Similar to the geographic names transactions, the road name transactions details were recorded in an Excel spreadsheet (refer appendix F) to allow continuous access for data entry, manipulation, and analysis.

It can be seen from the notifications example (refer figure 3.10) that the map sheet details are not included in the notifications. The map sheet names were obtained by cross-referencing the details contained in the advertisements with the existing topographic and cadastral databases maintained by the NSW Department of Lands.



CESSNOCK CITY COUNCIL

Roads Act 1993, Section 162

Naming of Public Road

NOTICE is hereby given that Cessnock City Council, in pursuance of section 162 of the Roads Act 1993, hereby names the road described below. COLIN COWAN, General Manager, Cessnock City Council, Administration Centre, 62-78 Vincent Street, Cessnock, NSW 2325. (Reference: 134/904).

Description	**Name**
The road 18 wide and variable off Middle Road, Paxton shown on DP1034264 in the Parish of Ellalong, County of Northumberland and Local Government Area of Cessnock.	Dunlop Drive

[1069]

Figure 3.10: Road Names Notification (NSW Government 2001a, p. 9821)

Using an SQL query script executed within the Genamap GIS software, the deposited plan (DP1034264) and the adjoining road name (Middle Rd) from the figure 3.10 example advertisement were searched for within the Department of Lands' digital cadastral database (DCDB). When required, additional information from the notification (e.g. LGA, parish, county, and suburb) was used to narrow the search and provide the required map sheet details.

c. Aquaculture Leases

The transaction notifications for aquaculture leases are found within the government business section (refer section 3.2) of the gazette. The information collected from these notices for each transaction included;

- Lease number,
- Estuary, and
- Transaction type, for example, Grants, Renewals, or Withdrawals.

As per the geographic and road names, the transactions details were recorded in an Excel spreadsheet (refer appendix G) to allow continuous access for data entry, manipulation, and analysis.

From the advertisement examples (refer figures 3.11 and 3.12), it can be seen that the map sheet details are not included in the notifications. The tidal area of the estuaries recorded was used in conjunction with the Department of Lands' map catalogue to isolate the mapsheets concerned. The individual map sheet details were noted when it was found that only one map sheet covered the estuary that was applicable to the notification. Where the estuary covered multiple map sheets these were noted as requiring additional investigation.

FISHERIES MANAGEMENT ACT 1994

FISHERIES MANAGEMENT (AQUACULTURE) REGULATIONS 1995

Clause 33 (3) — Notice of Granting of Class 1 Aquaculture Lease

THE Minister has granted the following Class 1 Aquaculture Lease:

OL84/194 within the estuary of Wallis Lake having an area of 0.1614 hectares to Mr Peter WARNER of Nabiac, NSW, for a term of 15 years expiring on 16 August 2016.

The Hon. EDWARD OBEID, OAM, M.L.C.,
Minister for Mineral Resources
and Minister for Fisheries

Figure 3.11: Aquaculture Lease Notification (Grant) (NSW Government 2001c, p. 7391)

FISHERIES MANAGEMENT ACT 1994

FISHERIES MANAGEMENT (AQUACULTURE) REGULATION 1995

Clause 35 (4) — Notice of Aquaculture Lease Renewal

THE Minister has renewed the following Class 1 Aquaculture Leases:

OL55/090 within the estuary of the Bellinger River having an area of 0.2 hectares to Edward Thomas DURIE of Repton, NSW, for a term of 15 years, expiring on 8 May 2016.

OL69/455 within the estuary of the Crookhaven River having an area of 1.9580 hectares to Norman Paul SCHULZ and Gail SCHULZ of Greenwell Point, NSW, for a term of 15 years, expiring on 5 October 2014.

Figure 3.12: Aquaculture Lease Notification (Renewal) (NSW Government 2001c, p. 7391)

With further investigation and cross-referencing with data from NSW Fisheries and the NSW Department of Lands, the individual map sheet details would have been available for all notifications found during the study.

3.3.2 - Data Sharing

The Data Sharing component consisted of three individual programs, which involved the following organisations:

- Gunnedah Shire Council,
- NSW Fisheries, and
- Forests NSW.

This component was required in order to identify the number of amendments that, whilst initiated by the organisations, may not be recorded in the gazette. Whilst their existence should be noted, the reasons (both internal and departmental specific) for their non-inclusion in the gazette is, however, outside the scope of this study. The data supplied also enabled an estimate to be calculated on the number of topographic map sheets that may be updated in a given time frame.

These organisations were chosen after confirmation had been received in relation to their availability to assist with this research. Their capacity to provide additional advice and guidance, as the need arose, in relation to their own particular datasets and data collection methodology was also taken into account. The organisation's individual data types were chosen for this component from their overall capacity to provide a mix of point, line and polygon data.

Four individual study site locations (refer figure 3.13) were chosen with Gunnedah shire and NSW Fisheries having one each and Forests NSW, the remaining two. These were chosen in relation to present (Gunnedah and Fisheries) and future (Forests) data availability with the project time frame taken into account.

Figure 3.13: Data Sharing Locations (*Illustrated Atlas of the World* 1982, p. 229)

Arrangements were made for appropriate data to be supplied by these organisations that related to their individual business arrangements, data collection and maintenance programs.

a. Gunnedah Shire Council

Gunnedah is located in the north east of NSW approximately 80 km west of Tamworth and approximately 400 km north of Sydney (refer figure 3.14) and is sited around the Namoi River near its junction with the Peel and Mooki Rivers.

Figure 3.14: Gunnedah Region (*Illustrated Atlas of the World* 1982, p. 229)

Gunnedah has in the past experienced flooding within the river plain areas surrounding the town. The Council assisted the local branch of the State Emergency Service (SES) with a data collection program aimed towards evacuation information required during time of flooding.

The local SES branch collected inter alia, access track, homestead and farm gate attributes and locations throughout selected parts of the council area. These locations were required to allow access to homesteads during times of flood if the only means was by boat. To operate the flood boats effectively, the SES required detailed knowledge of the area surrounding the homesteads so that obstacles such as fences were not encountered and thus ultimately avoided.

For this reason the data may be regarded as serving a niche purpose and was not all encompassing or representative of the entire shire. The GIS section of Gunnedah council was contacted and after discussing the research proposal, arrangements were made for the supply of data in MGA zone 56 using ESRI shapefile format.

The NSW Department of Lands has created the 'Topoview' digital map product and software to assist its customers in viewing previous edition topographic maps without the need for the paper copies. In addition to viewing these previous editions, AGD66 georeferenced .tiff images of the selected areas were created to enable comparisons to be made against the supplied data.

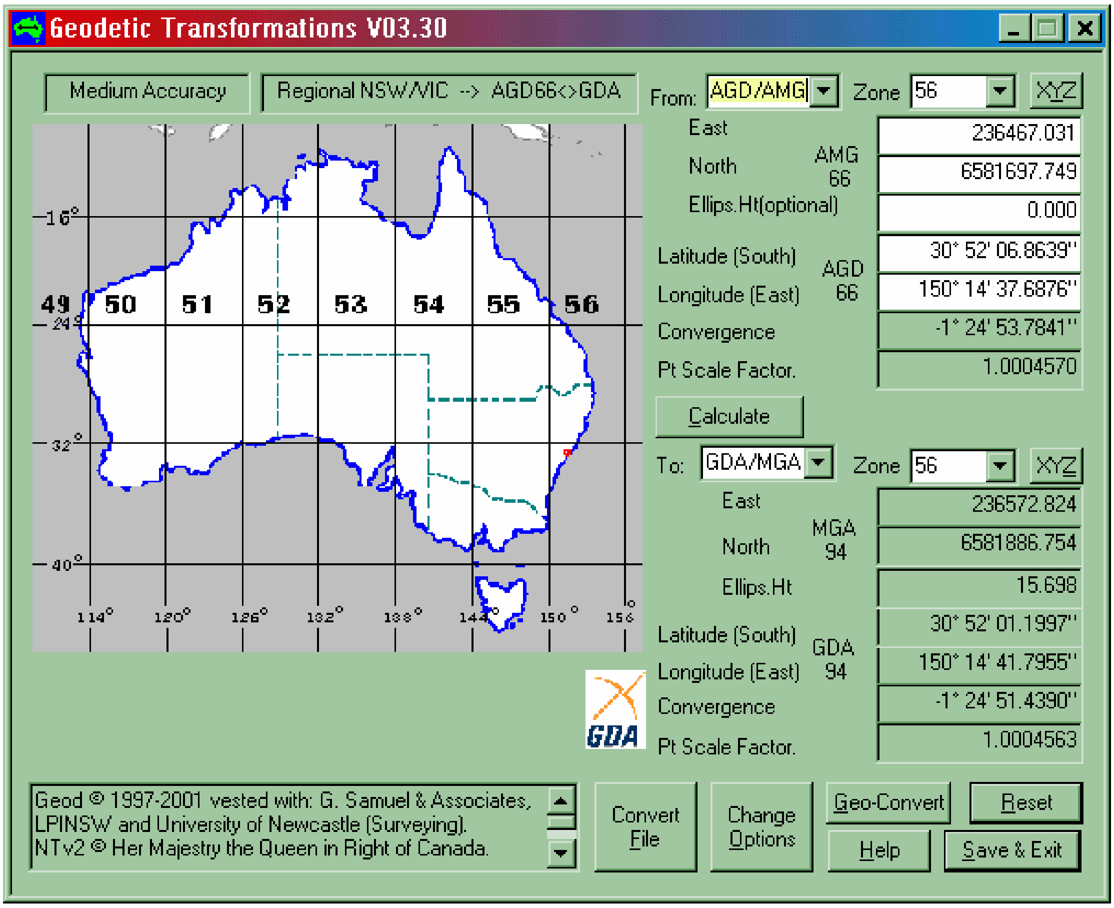


Figure 3.15: Geod Geodetic Transformations Program

To enable the georeferenced tiff images to align to the supplied GDA data, the GEOD Program (refer figure 3.15) was selected to transform the AGD66 corner values to GDA. The software, downloaded from the NSW Department of Lands web site (www.lands.nsw.gov.au), permitted the locally collected data to then be accessed, compared to the original map image and used in the research process.

The tfw files for the tiff images were copied and edited (refer figure 3.16) using the transformed values, obtained from GEOD, to resemble MGA coordinates. The reprojected images enabled a visual comparison to be carried out, in Arc Explorer, between the MGA56 data obtained and the original printed map sheets.

4.00000000000000	4.00000000000000
0.00000000000000	0.00000000000000
0.00000000000000	0.00000000000000
-4.00000000000000	-4.00000000000000
237222.874	237328.576
6554006.881	6554195.986

Figure 3.16: TFW File Editing (before and after)

(i) Data Analysis: Gates

The gates feature class within the NSW Lands Digital Topographic Data Base (DTDB) was visually compared with the images of the previous editions. As no changes were found in the dataset, ArcGis 8.3 (presently used by NSW Lands) was used to obtain statistics on the original gates feature class using the following procedure.

- The Gunnedah LGA was selected from the LGA feature class (from the NSW DCDB).
- Using “Select by location” the traffic control device feature class was selected using the previously selected LGA as a template and saved in the table of contents.
- The gates were selected from this selection using “select by attributes” and then saved in the table of contents.

The following steps were repeated for each map sheet to gain the number of gates present in each of the original maps.

- The map outline feature class was selected and used as a template in “Select by location” to select the number of gates in the map from the previously saved selection.
- The final selection was saved and uniquely named to allow further analysis.

The number of gates collected per map sheet was determined using the SES collected data (refer section 3.3.2.a) and the following procedure.

- The map outline feature class was selected and used as a template in “Select by location” to select the number of gates in the map from the SES collected gates shapefile.
- The final selection was saved and uniquely named to allow further analysis.

This procedure was repeated for each map sheet to gain the number of gates collected by the SES for each map sheet.

Using the final selects for each map sheet, the number of gates found to be in both the data and on the printed sheet was calculated using the following procedure.

- o The saved selection from the SES collected data was used as a template within the “Select by location” tool.
- o A 20 metre buffer was used to select from the saved selection created from the original map sheet. This distance was chosen to allow for the differences between mapping and data collection accuracies.

This procedure was repeated for each map sheet.

(ii) Data Analysis: Access Tracks

ArcGis 8.3 was used to compare the roads feature class, with the data collected by the SES. This comparison was done using the following procedure.

- o The Gunnedah LGA was selected from the LGA feature class.
- o Using “Select by location” the roads feature class was selected using the LGA as a template and saved in the table of contents.

This procedure provided the roads located only within the LGA. The following steps were repeated for each map sheet to gain the number of relevant farm access tracks present in each of the original maps.

- o The map outline feature class was selected and used as a template in “Select by location” to select the number of roads in the map from the previously saved selection. The new selection was then saved in the table of contents.

- Using the collected data as a template, the previously saved selection was selected using a buffer distance of 20 metres. This procedure selected features if any part of the two feature classes came within 20 metres. This distance was chosen to allow for the differences between mapping and data collection accuracies.

(iii) Data Analysis: Homesteads

A series of A0 size plots were produced at map scale for each topographic map sheet. The location of each homestead feature collected by the SES was displayed along with the allocated homestead name. These were overlayed with the original map sheets and visually checked for similarities and differences in location and attribution. Minor variations in spelling were also noted.

By also analysing the feature class attribute table in ArcGIS 8.3, accurate figures on the quantity of homesteads collected per map sheet were available using the following technique.

- The map outline feature class was selected and used as a template in “Select by location” to select the number of homesteads in the map from the homesteads feature class.
- The attribute table was opened with only the selected homesteads visible.
- The names field was sorted to display the number of unnamed features also collected.

This process was repeated for each map sheet to gain the number of named and unnamed homestead features for each of the map sheets.

The original printed map sheets were visually checked to obtain the number of homesteads printed for each sheet. Including these figures, those collected for each sheet were,

- The total number collected by the SES (named and unnamed),
- The number found to be contained in both the data and on the original printed sheets, and
- The number contained on the original map sheets.

(iv) Data Collection Summary

In summary the figures collected for each sheet with respect to gates, tracks, and homesteads were,

- Number collected by SES,
- Number found to be in both data and on the printed sheet, and
- Number on the original map sheet.

These grouped figures then allow the deduction of,

- The number of gates, homesteads and tracks found only in the data, and
- The number of gates and homesteads present on the printed sheets that have not been recollected.

Using these figures it was possible to predict the number of extra features that would be made available for inclusion in future products if a data sharing program had been in place (refer table 4.12).

b. NSW Fisheries

The study area for the data sharing program with NSW Fisheries was near the northern NSW town of South West Rocks within the Macleay River Estuary (refer figure 3.17).

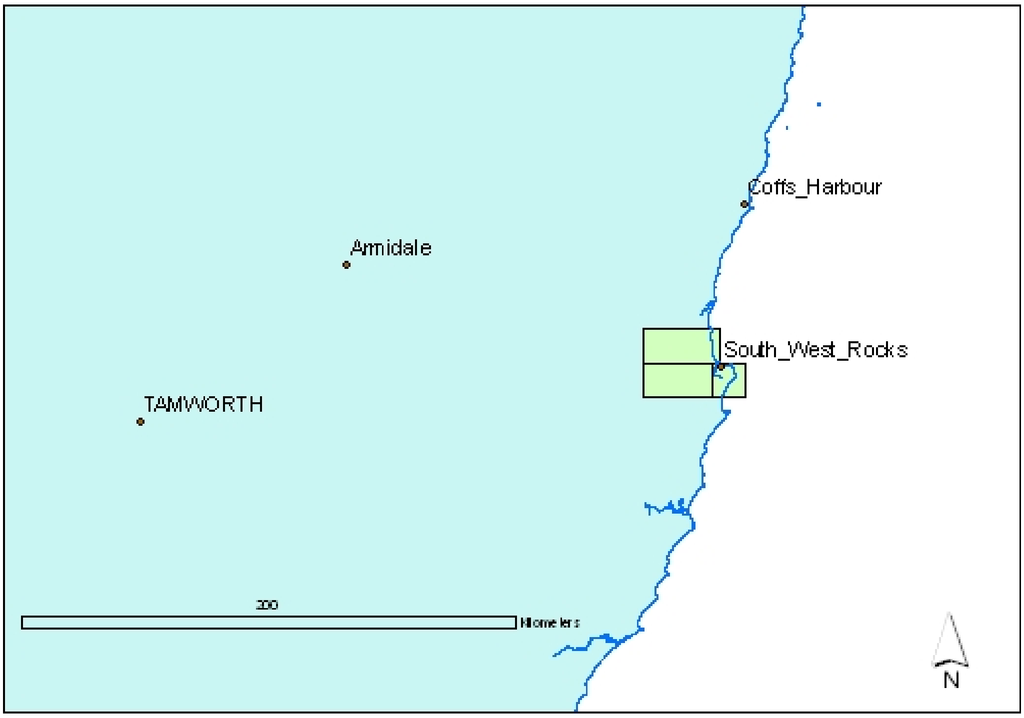


Figure 3.17: Macleay River Study Area

Aquaculture lease information within this estuary was supplied in MGA56 using ESRI shapefile format. Georeferenced tiff images of the previous edition map sheets were created using Topoview, a web based Department of Lands application, and overlayed with the data supplied in ESRI Explorer. A visual comparison established that no lease information was present on the printed map sheets in the vicinity of the supplied data.

ArcGis 8.3 was used for providing analysis of leases per map sheet and the generation of statistical data. The following procedure was undertaken on each of the two shapefiles containing lease data that were supplied by NSW Fisheries and was repeated for each of the printed map sheets:

- o Using the selected map sheet from the topographic map sheet feature class as a template, the “select by location” tool was used to select the number of leases per sheet in each file.
- o The attribute table, once opened, provided a summary of the attributes of each lease. After sorting, the attributes were used to compile the figures on the current and historical nature of the data.

This enabled the collation of figures for:

- o The number of leases present on the printed map sheets,
- o The number of leases present in the data collected, and
- o The number of current leases that would be included in any future maintenance program, as a result of data sharing activities.

c. NSW Forests

Two separate areas (refer figure 3.18) were used for the study with NSW Forests. The first, located on the south coast of NSW, with the second, in the Newcastle area north of Sydney.

Permission was obtained from NSW Forests for the use of infrastructure data collected over State forest areas. Data was supplied in ESRI interchange (.e00) export format files, which were then converted to shapefiles by Department of Lands staff using

FME software. The shapefiles were the preferred format for use in ESRI Explorer.

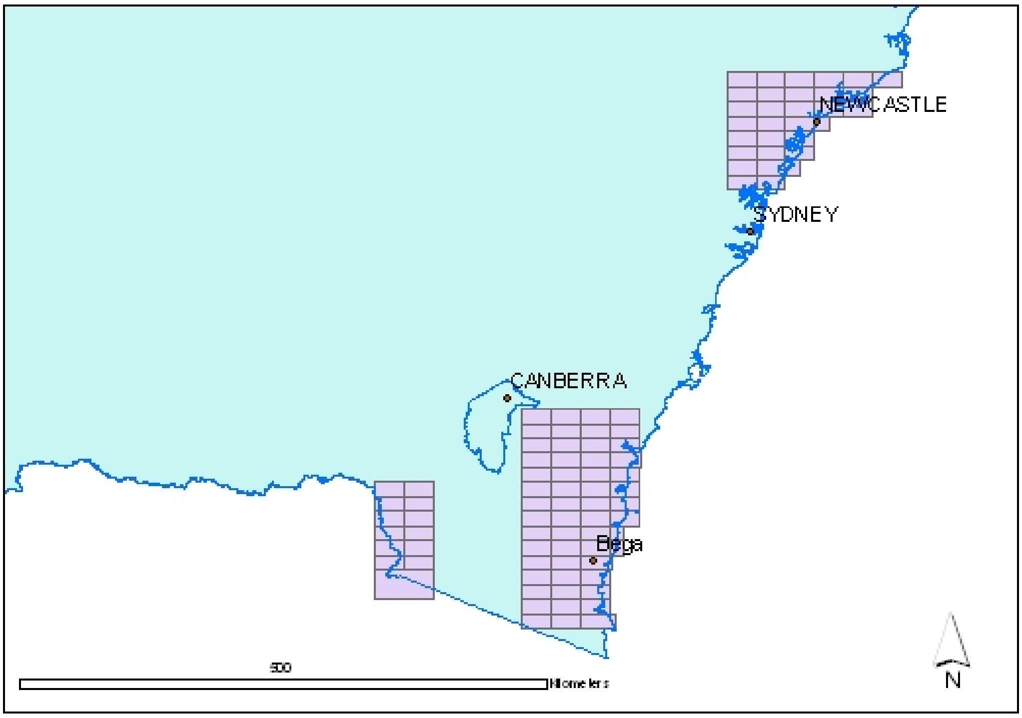


Figure 3.18: Forests NSW Study Area Locations

Using geo-referenced tiff images of the previous edition topographic maps as a backdrop, the shapefiles were viewed using ESRI explorer software. These were used to check road name continuity. This was done using SQL by selecting from the attribute table for lines where the road name was present and again where it was not. The selected items drawn together in contrasting colours gave a visual representation of the road continuity.

Genamap GIS software was available for additional checking where doubt existed in the visual result. Genamap GIS software was chosen due to its ability to highlight automatically all instances where a node does not have two attached edges. This is useful when the named and unnamed lines are imported into two separate map tiles. When these were drawn together in different colours, it was immediately apparent when a continuity mismatch needed to be investigated, as the nodes that did not have two attached edges from the unnamed tile were highlighted.

Unique road name lists were created based on the map sheet extent with the database (dbf) files (which existed as part of the shape files) being imported into Microsoft Excel spreadsheet software. Formulas were written that provided the number of unique road names for each file.

These figures were compared to those obtained from both newly printed and previous editions. In these cases the road names were counted per printed map sheet using a visual comparison. The data collected by the SES was viewed digitally during this stage to clarify the location of the named roads and tracks.

(i) NSW Forests Point Features

In addition to the road names data, it was initially expected that significant point features would be supplied over the state forest areas. Supply of data in this area was inconsistent, with point feature position and attribution being available for only three of the supplied map tiles. The actual cause of this breakdown in supply is unknown with the author suspecting a change in priorities at NSW Forests.

3.4 - Summary: Chapter Three

The pilot study demonstrated that a significant amount of information, relating to changes in the built environment, is present within both state and local tiers of government. Due to the size and complexity of the workings of government organisations within both tiers, only a small amount of this information is published within the NSW Government Gazette. The small amount that is made available would be further enhanced by that held within the two tiers that is not published in the gazette. This additional information would also assist with the enhancement of existing database attribution, thus providing additional usefulness for the system.

The pilot study also found that only 30% of the amendments recorded used a spatially orientated method of referencing. Whilst the remaining amendments (70%) relied on aspatial referencing, the majority of these used cadastral identifiers, for example, deposited plan numbers. By analysing these results further it was also shown that the purely topographic references were in the minority, with the remainder requiring cadastral information and attribution to assist with locating the amendments. In the case of the topographic references, it was found that addresses, geographic coordinates, and the use of names and descriptions provided the primary method of referencing these amendments. The significance of this is that continued monitoring of these amendment referencing types would provide additional attribution enhancement, thus adding to the value of the state topographic dataset.

Additional capability would also be provided within both database maintenance and topographic map production through the increased use of topographic references within the gazette. To test the validity and reliability of these findings, a final data collection trial was undertaken, further enhanced by a data sharing program, which involved three organisations, selected from within both tiers of government. Throughout the final collection trial the government gazette was analysed to further test and record the workings of government and provide further substantiation of the "Now Map" concept. This concept was again demonstrated by selecting data to complement that available through the gazette whilst establishing the relationships that exist between the partners in a data sharing arrangement.

Several minor changes were implemented in the final data collection procedures, in relation to the collection of data, after analysing the conduct of the pilot study. The focus was centered, within the pilot study, on all data regardless of theme and regardless of organisation within a particular time period. The final study used theme as a central focus for the gazette studies and again within the data sharing programs. The outcomes from these were successful, further enhancing the "Now Map" concept and the formation of the working model.

The results from the final data collection confirmed that the methodology and technique, as determined by the pilot study was suitable for use in a longer investigation.

CHAPTER 4 – RESULTS AND DATA ANALYSIS

The research results are presented in two sections with each of these relating to the individual parts of the study. An explanation of the methodology used to enable critical analysis is also included.

The first section focused on the NSW Government gazette study, which over a 28-week period analysed the contents with respect to aquaculture leases, geographic names and boundaries, and road names. The second study complemented the first, with a data sharing trial, and utilised data from three organisations within both state and local tiers of government. This program included data from NSW Fisheries, Gunnedah Shire Council, and Forests NSW, and provided extensive evidence towards substantiating the “Now Map” concept through the use of contemporary, up to date information.

4.1 - NSW Government Gazette

The NSW government gazette contains information relating to government business and the workings of government (refer section 3.2) in addition to notifying the public and other government bodies of pending changes to legislation and regulation. These notifications have provided the results of specific government business applicable to topographic mapping with respect to aquaculture leases, geographic names and the naming of topographic roads. The analysis of each of these situations were related to the “Now Map” concept through concentrating on the maintenance of spatial and temporal accuracy for the production of topographic maps and products.

4.1.1 – NSW Fisheries (Aquaculture Leases)

The grantings and withdrawals of aquaculture leases equate to additions and deletions of topographic features and, potentially, changes to map related text and symbology.

Table 4.1 outlines the potential amendments to map sheets as a result of the granting, withdrawal and renewal of aquaculture leases. It can be seen that the 203 transactions provided 47 lease withdrawals, 39 lease grantings and 117 renewals over 33 estuaries. The renewals provide confirmation of a lease and a continuance of "existing use". This is also relied upon by the cartographer as existence of a continuance of infrastructure, which is displayed using specific topographic symbology.

For the 28 weeks of the study, the listed amendments in table 4.1 show that 42% of the transactions (refer figure 4.1) were topographically significant (grants and withdrawals) and are able to be used as incremental updates. It was also determined that a minimum of 86 database transactions (in addition to generalised annotation as well) would also be undertaken to a topographic database if incremental update procedures were in place.

Table 4.1: NSW Fisheries Aquaculture Lease Transaction Summary

Estuary	Withdrawals	Grants	Renewals	Total
Bellinger River	0	0	4	4
Brisbane Water	1	0	6	7
Camden Haven	1	11	3	15
Camden River	1	0	0	1
Clarence River	0	0	2	2
Clyde River	3	1	16	20
Crookhaven River	2	3	6	11
Georges River - Lime Kiln Bay	0	1	0	1
Georges River - Quibray Bay	0	1	0	1
Georges River - Woolooware Bay	0	1	0	1
Hastings River	0	0	14	14
Hawkesbury River	2	0	1	3
Hunter River	0	0	2	2
Macleay River	1	5	4	10
Manning River	8	0	13	21
Merimbula Lake	0	0	3	3
Moruya River	0	0	2	2
Nambucca River	0	0	3	3
Narrawallee Creek	1	0	0	1
Pambula River	3	1	3	7
Patonga Creek	0	0	2	2
Port Stephens	0	3	4	7
Port Stephens - Karuah	0	0	4	4
Port Stephens - Nelson Bay	2	2	2	6
Port Stephens - Tea Gardens	0	1	0	1
Richmond River	0	0	1	1
Sandon River	1	1	2	4
Towamba River - Kiah Inlet	0	0	1	1
Tuross Lake	0	2	3	5
Wagonga Inlet	10	2	4	16
Wallis Lake	0	2	9	11
Wapengo Lake	4	2	2	8
Wonboyn River	7	0	1	8
Totals (33)	**47 (23%)**	**39 (19%)**	**117 (58%)**	**203**

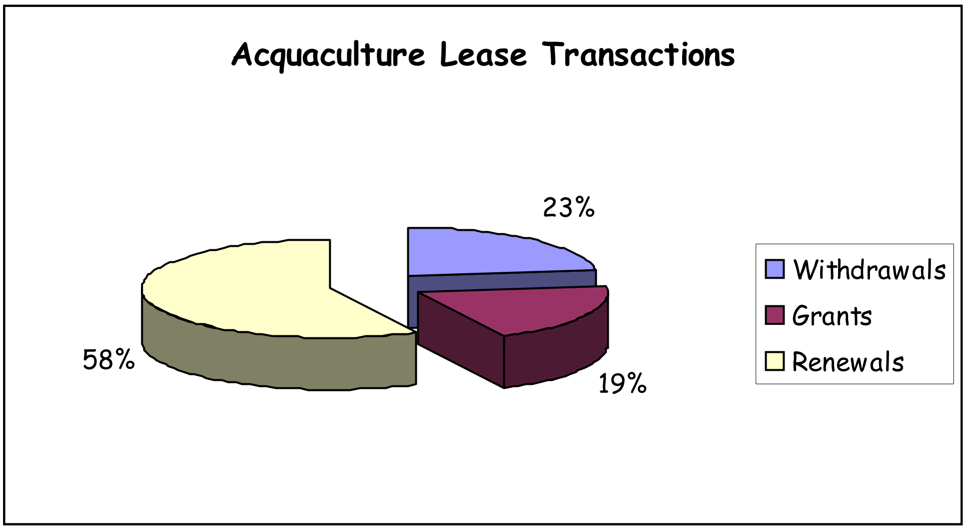


Figure 4.1: Aquaculture Lease Transactions

Table 4.2 outlines the topographic mapsheets for each of the estuaries covered by the lease notifications. As Fisheries NSW use the estuary as the primary reference, it can be seen that due to the size and location of the estuary almost one third have more than one mapsheet listed. This is shown by the Further Investigation Required (FIR) reference (refer table 4.2) and signifies the estuaries requiring further examination with respect to the individual notifications.

It can also be seen that of the 33 estuaries listed, only 11 had recorded notifications that dealt specifically with renewals. The remainder had either a grant or a withdrawal and, as explained in section 3.3.1.c, would require data manipulation of some kind.

Table 4.2: Topographic Map Sheet Identification

Estuary	WG	R	FIR	Map Names
Bellinger River		X		Raleigh
Brisbane Water	X	X	X	Broken Bay, Gosford
Camden Haven	X	X		Laurieton
Camden River	X			Laurieton
Clarence River		X		Yamba
Clyde River	X	X		Nelligen
Crookhaven River	X	X	X	Nowra, Crookhaven
Georges River - Lime Kiln Bay	X			Botany Bay
Georges River - Quibray Bay	X			Port Hacking
Georges River - Woolooware Bay	X			Port Hacking
Hastings River		X		Port Macquarie
Hawkesbury River	X	X	X	Broken Bay, Cowan, Gunderman
Hunter River		X	X	Newcastle, Williamtown
Macleay River	X	X	X	Clybucca, South West Rocks, Eungai, Macleay Entrance
Manning River	X	X	X	Coopernook, Cundletown
Merimbula Lake		X		Pambula
Moruya River		X		Moruya
Nambucca River		X		Macksville
Narrawallee Creek	X			Milton
Pambula River	X	X		Pambula
Patonga Creek		X		Broken Bay
Port Stephens	X	X	X	Port Stephens, Karuah, Clarence Town, Williamtown, Morna Point
Port Stephens - Karuah		X	X	
Port Stephens - Nelson Bay	X	X	X	
Port Stephens - Tea Gardens	X		X	
Richmond River		X	X	Ballina, Empire Vale
Sandon River	X	X		Sandon
Towamba River - Kiah Inlet		X		Eden
Tuross Lake	X	X		Bodalla
Wagonga Inlet	X	X		Narooma
Wallis Lake	X	X	X	Forster, Coolongolook
Wapengo Lake	X	X		Murrah
Wonboyn River	X	X		Kiah
Totals	**22**	**27**	**12**	

WG = Withdrawals and Grantings **R** = Renewals

FIR = Further Investigation Required

The map sheet locations from table 4.2 are represented with the map sheets requiring maintenance shown in blue and those requiring investigation in red (refer figure 4.2).

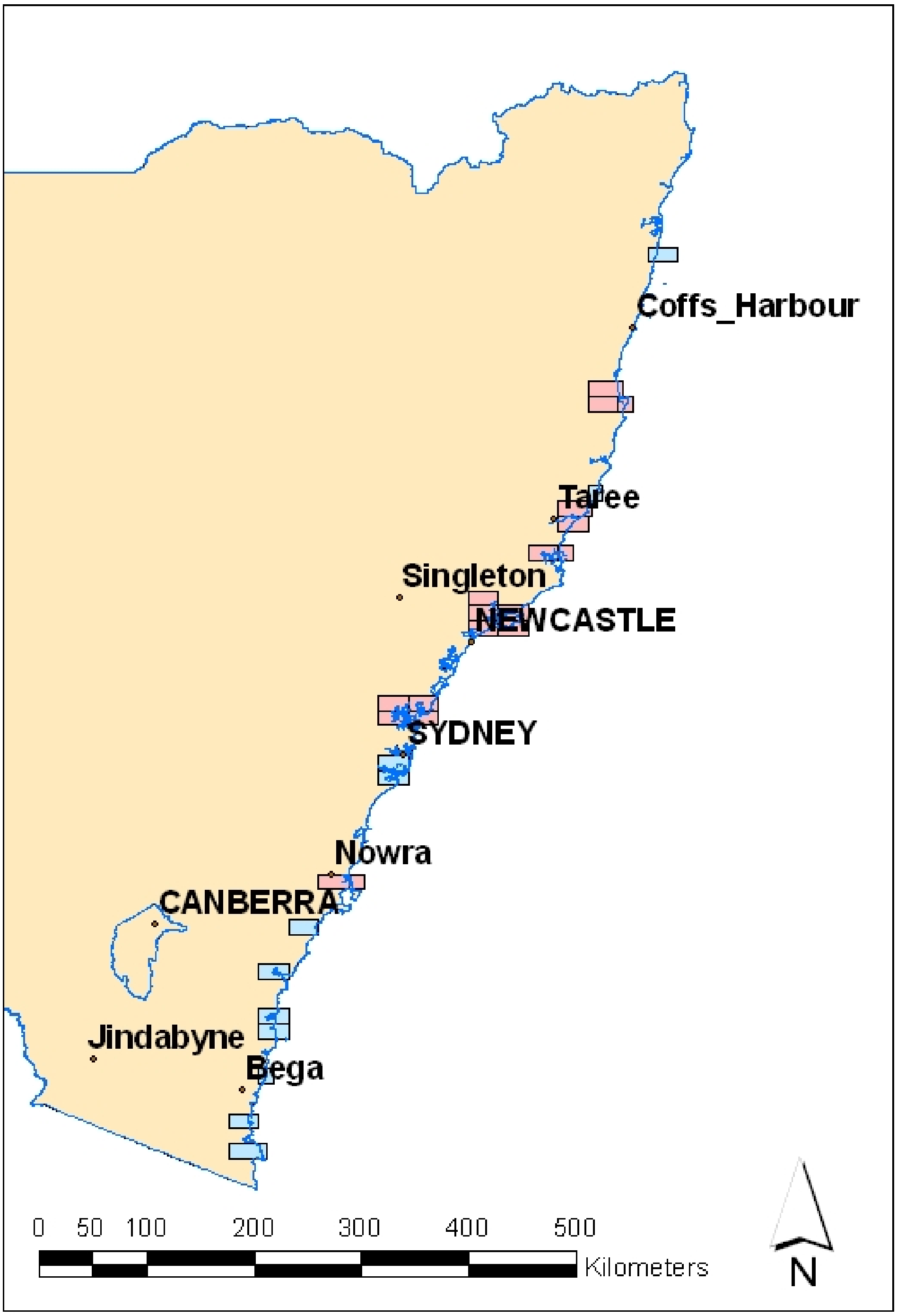


Figure 4.2: Map Sheet Locations - Aquaculture Leases

Of the map sheets requiring maintenance, as a result of the lease change actions, it can be seen that only 11 are listed as definitely requiring maintenance (refer table 4.3). This represents less than 1% (11/1114) of the state's topographic map holding, with the other 19 requiring further investigation on a case-by-case basis (refer table 4.4).

Table 4.3: Map Sheet Maintenance

Map Sheets – Maintenance Required
Bodalla, Botany Bay, Kiah, Laurieton, Milton, Murrah, Narooma, Nelligen, Pambula, Port Hacking, and Sandon

Table 4.4: Further Investigation Required

Map Sheets - Requiring Further Investigation
Broken Bay, Clarence Town, Clybucca, Coolongolook, Coopernook, Cowan, Crookhaven, Cundletown, Eungai, Forster, Gosford, Gunderman, Karuah, Macleay Entrance, Morna Point, Nowra, Port Stephens, South West Rocks, and Williamtown

4.1.2 – Geographical Names Board (Geographic Names)

A list of the transactions from the GNB contained in the government gazette (refer appendix E) for the study period, identified 114 amendments over 58 topographic map sheets. The relationships between the number of maps and amendments per scale group is summarized in table 4.5 and graphically depicted in figure 4.3.

Table 4.5: Scale Summary

Scale	Maps	Names
25000	39	67
50000	11	18
100000	8	29

It can be seen (refer table 4.5) that for the 28 weeks of the study, the 1:100000 scale maps received more amendments per map sheet than the other scales. Whilst The Meadows and Nymagee 1:100000 map sheets required eight and twelve amendments respectively, this is not necessarily significant as not all map sheets are the same geographic size (for example 1º x 1º) even within the same scale group (*NSW Topographic Map Catalogue* 2004). No reasonable comparisons could be made except in relation to predicting the amount of updates a particular scale group could receive over a similar period.

The GNB in association with the local government authorities often allocate names in specific regions of the state to actively accommodate the public consultation process. Further investigation would also be required into the process of how geographic names become gazetted to determine whether a pattern existed with respect to maps, decision making bodies, and individual locations. These criteria are outside the scope of this study and as such have no significant bearing on its outcome.

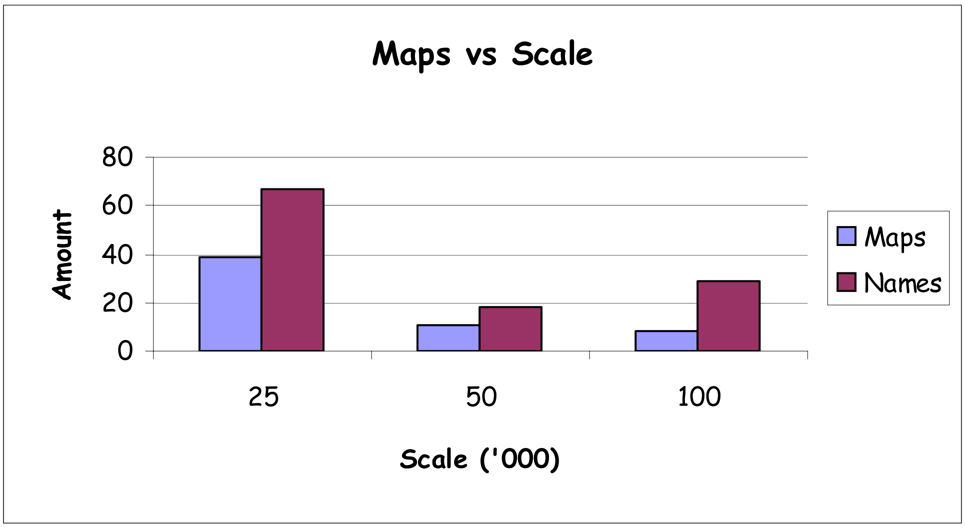


Figure 4.3: Geographic Names

Included in the transactions are 154 amendments where the individual map sheet has not been specified. This is because, after the name is assigned, the map sheet is no longer used as the primary key in the referencing process. There were three types of other amendments found (refer table 4.6), and in each of these the primary reference is the name of the feature with a geographic coordinate being used as an alternative.

Table 4.6: Unspecified Amendments

Amendment	Total
Name Discontinued	109
Erratum	18
Boundary Modification	27
Total	154

Figure 4.4 graphically displays these in percentage terms. From this it can be seen that the discontinued names accounted for 70% of the other amendments.

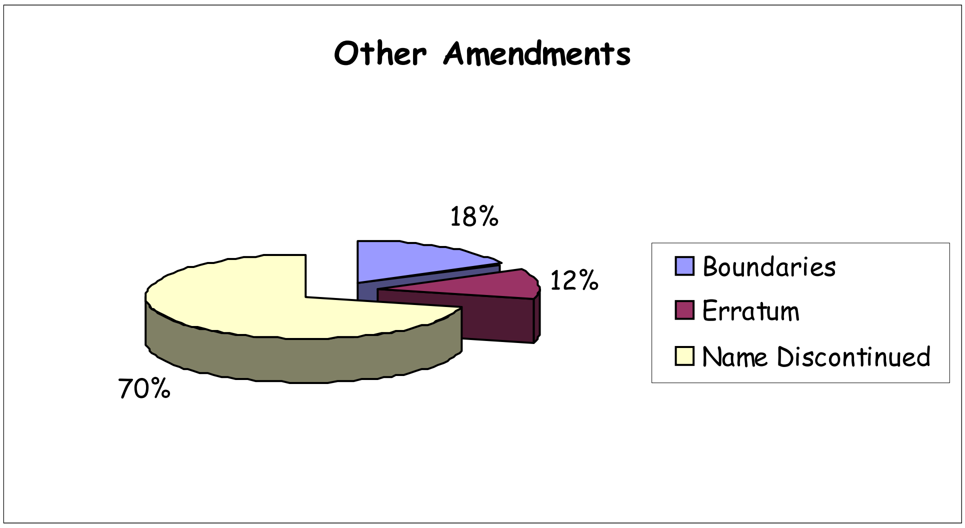


Figure 4.4: Unspecified Amendments

When all of the amendments are shown together (refer figure 4.5) it can also be seen that for the 28-week period the deletions and the additions are almost the same with 40% and 43% respectively. Modifications to administrative boundaries and database corrections identified through errata made up the remaining 17%.

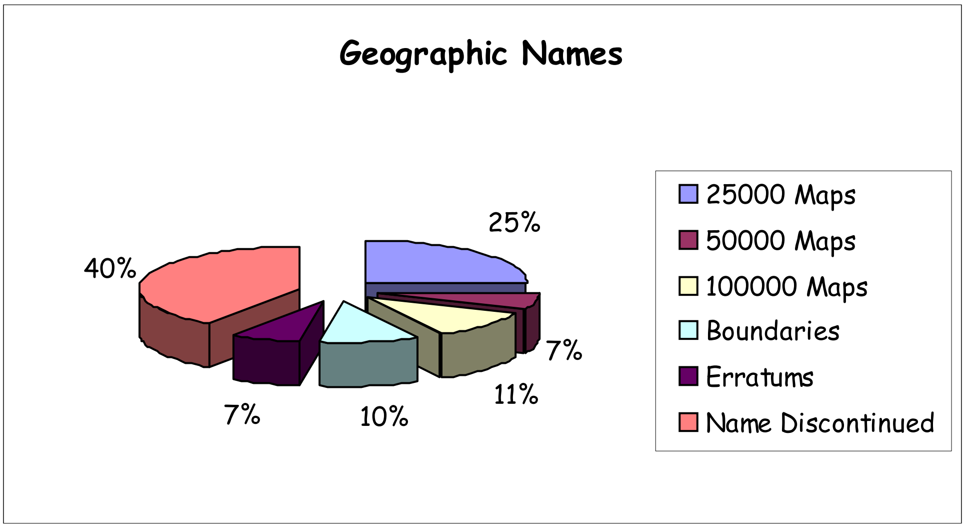


Figure 4.5: Total Geographic Names

Whilst the 28-week study showed a net increase of only five geographic names, a total of 268 database transactions (Geographical Names Register) were undertaken during this time. These transactions affected 58 map sheets (refer appendix E) which equates to 5.2% (58/1114) of the state's topographic map holding. It is possible that where a particular feature is present on more than one map sheet, for example, long linear features such as Great Dividing Range, that more than one map sheet would inevitably be affected.

Categorising the transactions would require additional cross-referencing with the Geographical Names Register. This was both outside the direct scope of this study and has negligible input into the concepts under investigation.

4.1.3 – Private Advertisements (Road Names)

Local government authorities (LGA's) use the private advertisements section of the government gazette to notify the public of road name changes. During the study period, notifications were placed in the gazette by 33 LGA's (refer table 4.7). This gave a total of 48 notifications with an average of less than 1½ per organisation. It can also be seen from table 4.7 that over the 28-week period the maximum number of individual notifications for any one LGA was four.

The number of amendments per local government area is graphically represented in figure 4.6. It can be clearly seen that a small number of shires have a higher number of amendments. In the case of Severn Shire Council this is due to their removal of some of the "from to" style of road name from their council area. Most rural LGA's are replacing these destination type names as part of the state's rural addressing program.

No correlation was found in the data contained in table 4.7 although it is expected that the rural LGA's, through their addressing programs, would submit a greater number of road name changes to their urban counterparts. Urban roads are often named as part of the development process and are more likely to be included with the subdivision details on the deposited plan.

The map sheets (71) that would require database maintenance as a result of implementing the notified name changes are listed in table 4.8. This represents 6.4% (71/1114) of the state's topographic map holding.

Table 4.7: Road Names Result Summary

Shire	Entries	Amendments
Baulkham Hills Shire Council	3	3
Bega Valley Shire Council	1	1
Bellingen Shire Council	1	3
Blacktown City Council	4	4
Bombala Council	1	2
Blue Mountains City Council	1	3
Byron Shire Council	1	4
Cessnock City Council	1	1
Dungog Shire Council	1	1
Gundagai Shire Council	3	3
Hastings Council	1	1
Hume Shire Council	1	2
Kempsey Shire Council	1	1
Ku-ring-gai Council	1	1
Lake Macquarie City Council	2	5
Lane Cove Council	1	1
Leeton Shire Council	1	2
Lithgow City Council	2	3
Lockhart Shire Council	2	7
Narromine Shire Council	1	8
Oberon Council	1	2
Parkes Shire Council	1	5
Penrith City Council	2	2
Quirindi Shire Council	1	1
Severn Shire Council	1	158
Shellharbour City Council	1	10
Shoalhaven City Council	1	2
Singleton Shire Council	1	1
Snowy River Shire Council	1	7
Tumbarumba Shire Council	3	15
Uralla Shire Council	1	50
Waverley Council	1	1
Wyong Shire Council	3	29
Total	48	339

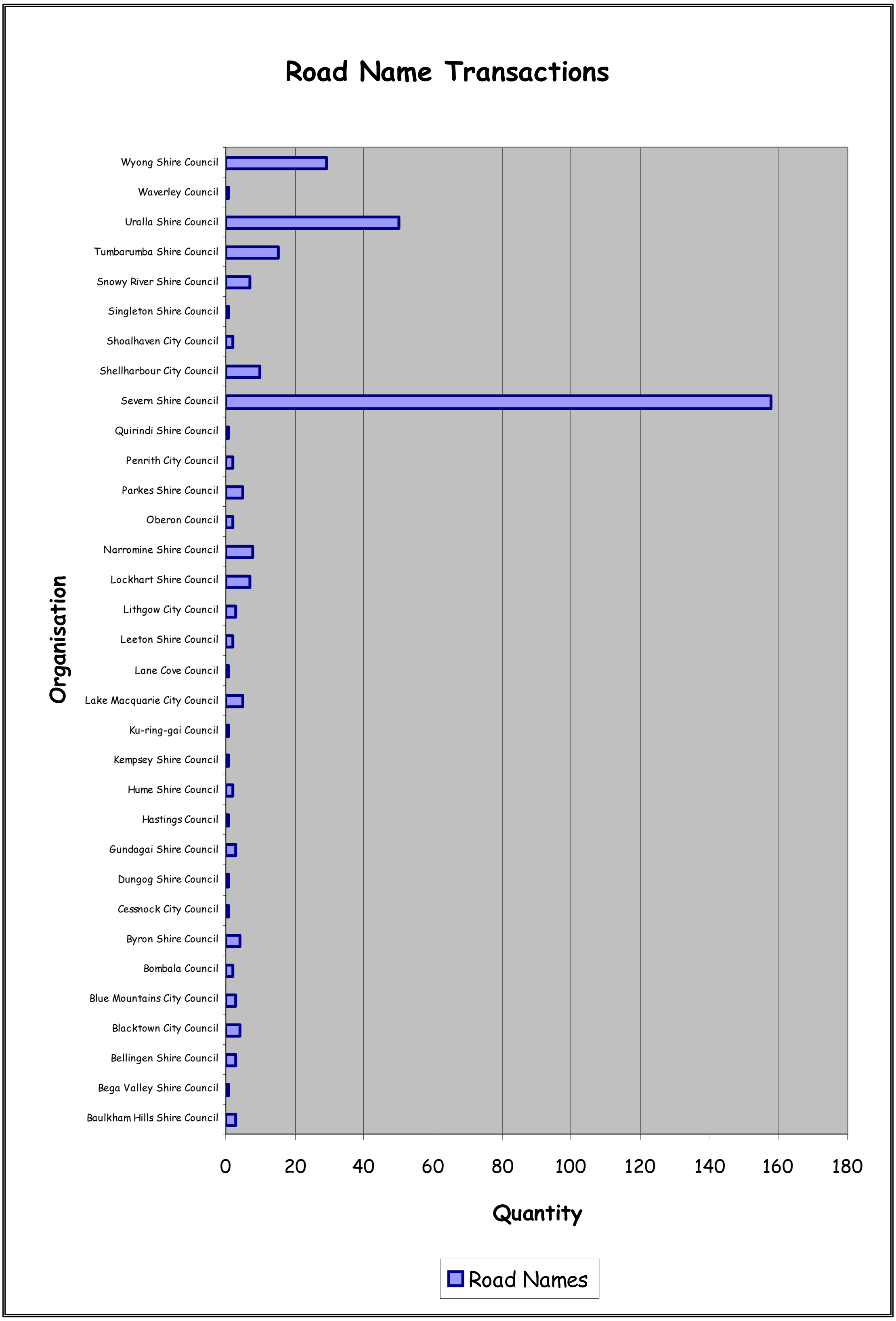


Figure 4.6: Road Name Transaction Summary

Table 4.8: Map Sheet Modifications (Road Names)

Map Sheets Identified	
Abington	Mount Adrah
Albion Park	Munderoo
Armidale	Narromine
Balala	Nevertire
Bellingen	Ourine
Berridale	Pambula
Berry	Parramatta River
Bogan Gate	Penrith
Bombala	Pleasant Hills
Bondi	Prospect
Brunswick Heads	Raleigh
Bundarra	Red Range
Bundemar	Riverstone
Cessnock	Salisbury Plains
Clarence Town	Sappa Bulga
Crookhaven	Shannon Vale
Dandaloo	South West Rocks
Dooralong	Springwood
Dundee	Stonehenge
Emmaville	Tarana
Eucumbene	The Lagoon
Glen Elgin	Tooma
Glen Innes	Torryburn
Gostwyck	Trundle
Gundagai	Tullamore
Hartley	Tumbarumba
Howlong	Uralla
Jingellic	Walbundrie
Junee	Wallsend
Katoomba	Watsons Creek
Kentucky	Wauchope
Kingstown	Weetaliba
Leeton	Wirraba
Lithgow	Wyong
Missabotti	Yarrowyck
Morisset	

4.2 – Data Sharing Results

NSW Fisheries, Gunnedah Shire Council, and NSW Forests provided a representative selection of topographically significant data for use within the data sharing component of the study. This data was provided to demonstrate the suitability of data sharing arrangements in maintaining topographic maps and products.

4.2.1 - NSW Fisheries (Aquaculture Leases)

Two files of data were obtained from NSW Fisheries (refer table 4.9) and contained a mix of current and historical data over the three map sheets in the region of the Macleay estuary (refer figure 3.17). The historical data enabled the research to substantiate the temporal nature of the data from NSW Fisheries. Figure 4.7 graphically displays the data per map sheet and in conjunction with table 4.9 shows that no correlations exist between the data in terms of map sheets or currency.

Table 4.9: NSW Fisheries Data Result Summary

Map Regions	**Eungai**			**Clybucca**			**South West Rocks**		
File 1			12			10			12
Current	7			5			3		
Historical		5			5			9	
File 2			33			44			35
Current	31			36			34		
Historical		2			8			1	
Total	38	7	**45**	41	13	**54**	37	10	**47**

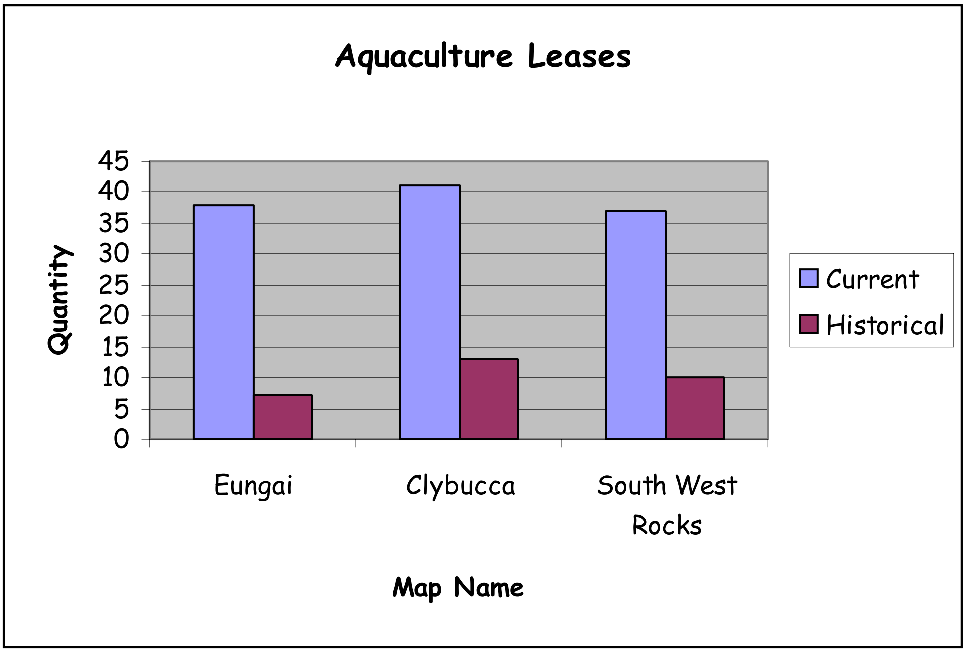


Figure 4.7: Aquaculture Lease Breakdown

It is significant that no aquaculture lease information was previously recorded for the three map sheets (refer appendix H). As shown in table 4.10, 101 additional features have been identified for inclusion.

Table 4.10: Unique Records

File	**Current**	**Historical**	**Records**
File 1	12	19	31
File 2	89	11	100
Total	**101**	30	131

Appendices H1 - H5 (refer appendix H) display the aquaculture lease information integrated with images of the original topographic maps. The different symbology (current data is green, historical is red) accurately represents the temporal attribute in the two files obtained.

4.2.2 - Gunnedah Shire (SES Collected Data)

A total of 781 features were obtained from Gunnedah Shire Council (refer table 4.11). The individual feature classes for the nine map sheets can be seen with the major concentration of data obtained in the 8936 mapping block (refer figure 4.8). This can also be seen in appendices I-1 – I-9 (refer appendix I).

Table 4.11: Gunnedah Shire Council Data Result Summary

Block		Map Sheet	Gates	Homesteads	Tracks
8935	1 N	Curlewis	19	Nil	1
	1 S	Watermark	29	Nil	Nil
	2 N	Breeza	3	Nil	Nil
8936	1 S	Willuri	22	45	23
	2 N	Kelvin	69	70	49
	2 S	Gunnedah	57	70	40
	3 N	Gulligal	25	35	34
	3 S	Emerald Hill	57	79	50
9035	3 N	Werris Creek	4	Nil	Nil
		Total	285	299	197

For the track data obtained, the occurrences listed in table 4.11 represent the individual line strings (as collected) regardless of linear continuity. When undertaking comparisons between the collected data and the original map sheets, it is possible to use only the locations represented by the strings rather than the quantity.

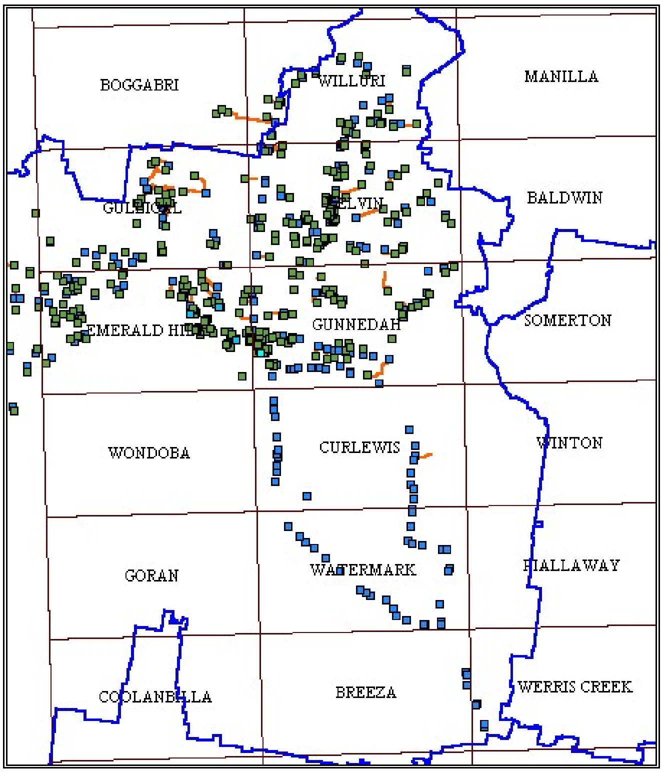


Figure 4.8: Data Distribution within the Eastern Portion of Gunnedah Shire

The graphically represented data (refer figure 4.9), depicts that gates were collected for each map sheet whilst tracks and homesteads were generally not. For each map sheet, the number of homestead features, when they were collected, is greater than the number of gates. A general trend can be seen with respect to the datasets when the locations and topography are taken into account (refer appendices I-1 – I-9). No other correlation exists in the data.

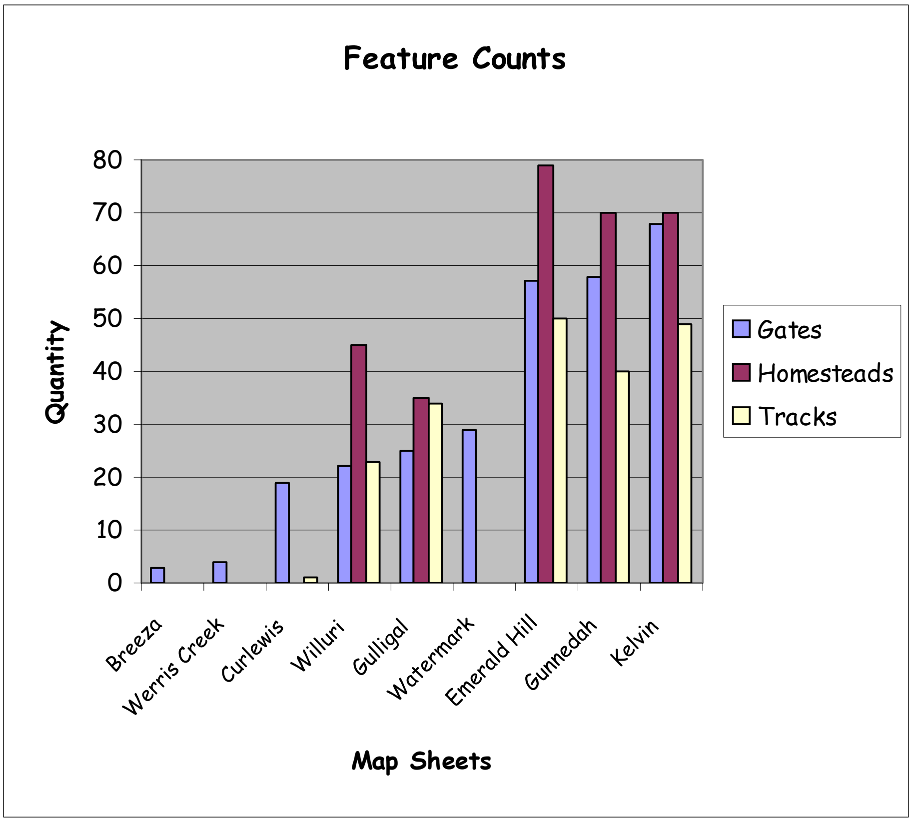


Figure 4.9: Map Sheet Comparisons

Of the homestead points received, 29 were unnamed. To provide an accurate value in relation to named homestead points, these were removed from the feature classes when comparisons were made to the original map sheets. Updated values were recalculated with the unnamed homestead points removed and linear continuity (tracks) taken into account (refer table 4.12). The Net Change is signified by the "Only in Data" column.

Comparisons with the DTDB highlight several inconsistencies in the data received (refer section 4.3.3) as all of the tracks received were without a name attribute.

Table 4.12: Net Change by Map Name

Map Sheet	Data Theme	Qty in Map	Only in Map	In Both	Only in Data	Qty in Data
Curlewis	Gates	0	0	0	19	19
	Homesteads	38	38	0	0	0
	Tracks			1	0	1
Watermark	Gates	0	0	0	29	29
	Homesteads	61	61	0	0	0
	Tracks			0	0	0
Breeza	Gates	1	1	0	3	3
	Homesteads	38	38	0	0	0
	Tracks			0	0	0
Willuri	Gates	41	35	6	16	22
	Homesteads	34	21	13	7	20
	Tracks			19	2	21
Kelvin	Gates	33	29	4	65	69
	Homesteads	58	22	36	29	65
	Tracks			42	8	50
Gunnedah	Gates	4	4	0	57	57
	Homesteads	63	37	26	33	59
	Tracks			29	6	35
Gulligal	Gates	17	16	1	24	25
	Homesteads	40	24	16	16	32
	Tracks			17	6	23
Emerald Hill	Gates	8	7	1	56	57
	Homesteads	95	69	26	45	71
	Tracks			23	14	37
Werris Creek	Gates	13	12	1	3	4
	Homesteads	55	55	0	0	0
	Tracks			0	0	0
	Total				**438**	

Table 4.12 outlines the net change for each map sheet in terms of the three feature types collected. It can be seen that, for the nine map sheets involved in the study, this consisted of 272 gates, 130 homesteads and 36 farm access tracks with the net change being 438 features.

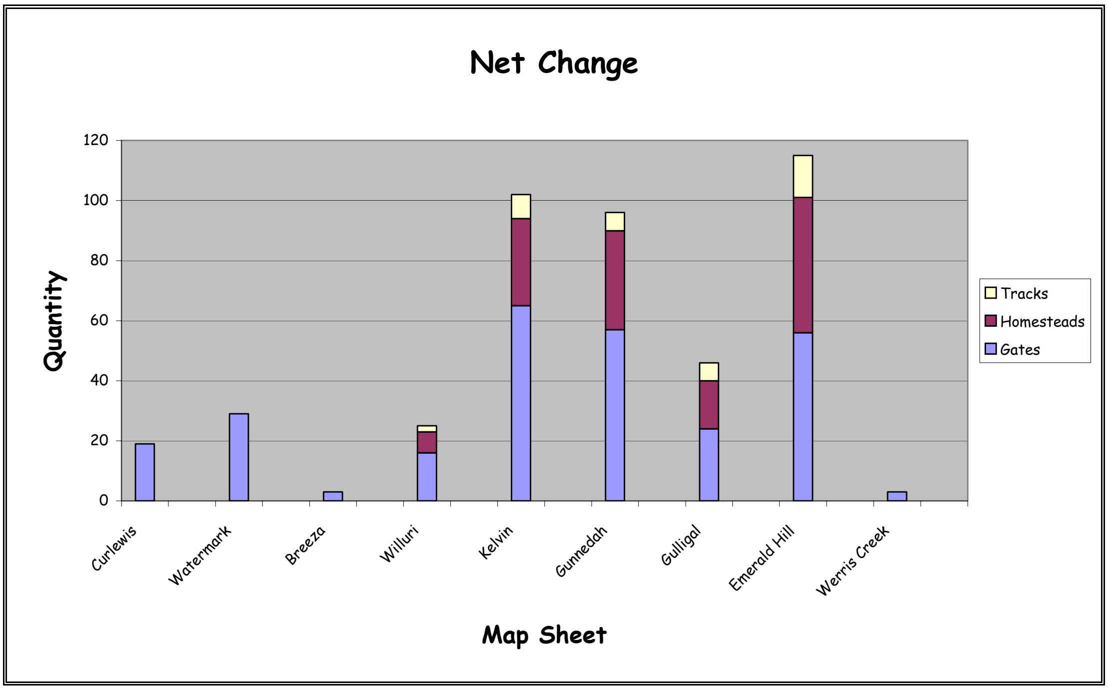


Figure 4.10: Net Change by Map Sheet

Figure 4.10 graphically displays table 4.12 and clearly demonstrates the net gain per feature class for each of the nine map sheets.

4.2.3 – NSW Forests (Road Names)

Data was received from NSW Forests over the areas highlighted in figures 4.11 and 4.12. From the summary of NSW Forest data results (refer appendix J) it can be seen that there were 3000 roads supplied with 1107 being shown on the relevant printed topographic map sheets.

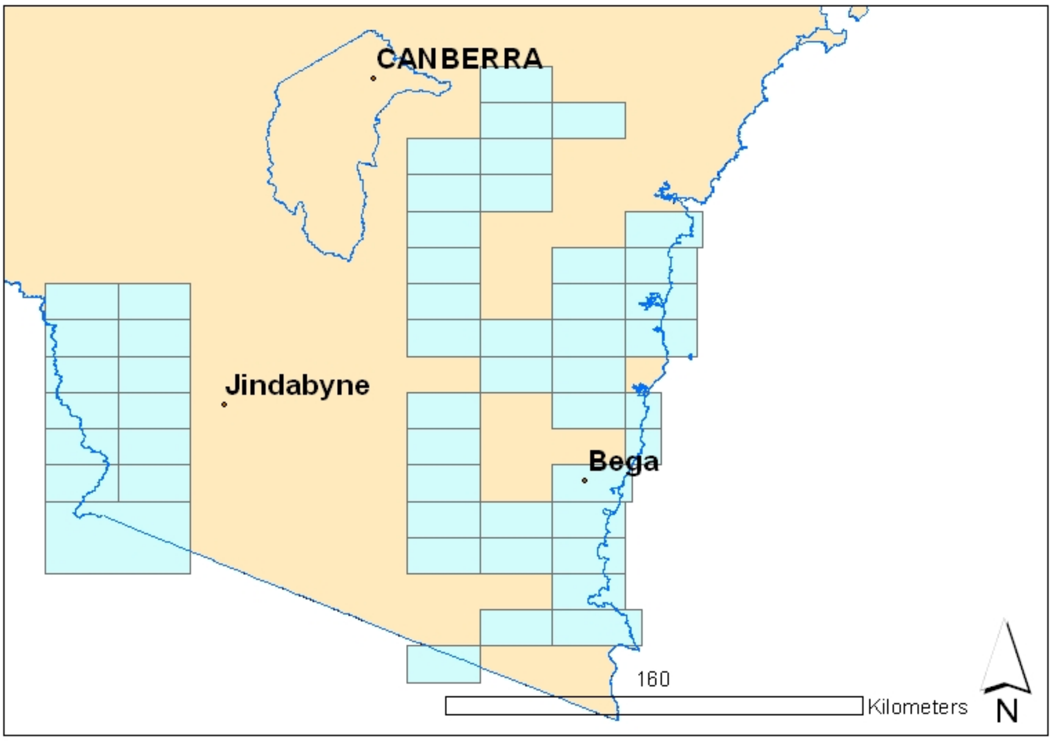


Figure 4.11: Forests NSW Study Area Location - South

This data is represented in figure 4.13 which compares those names supplied by NSW Forests against those names printed on the Department of Lands map sheets. A general trend can be seen from the origin towards the point marked A (refer figure 4.13).

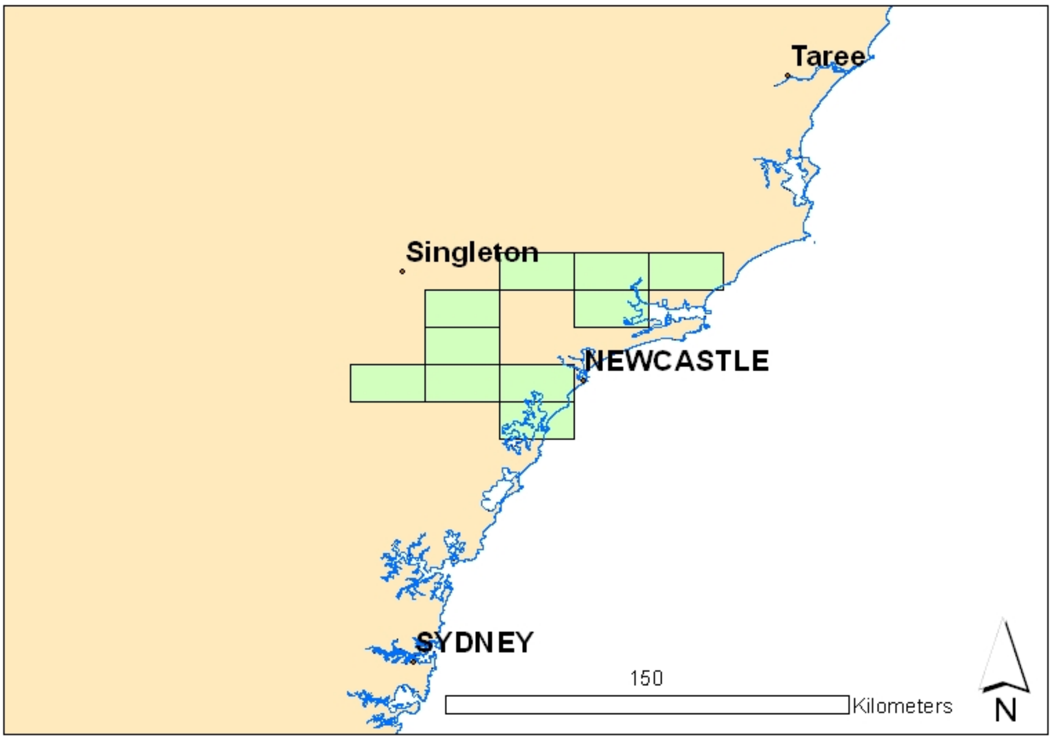


Figure 4.12: Forests NSW Study Area Location - North

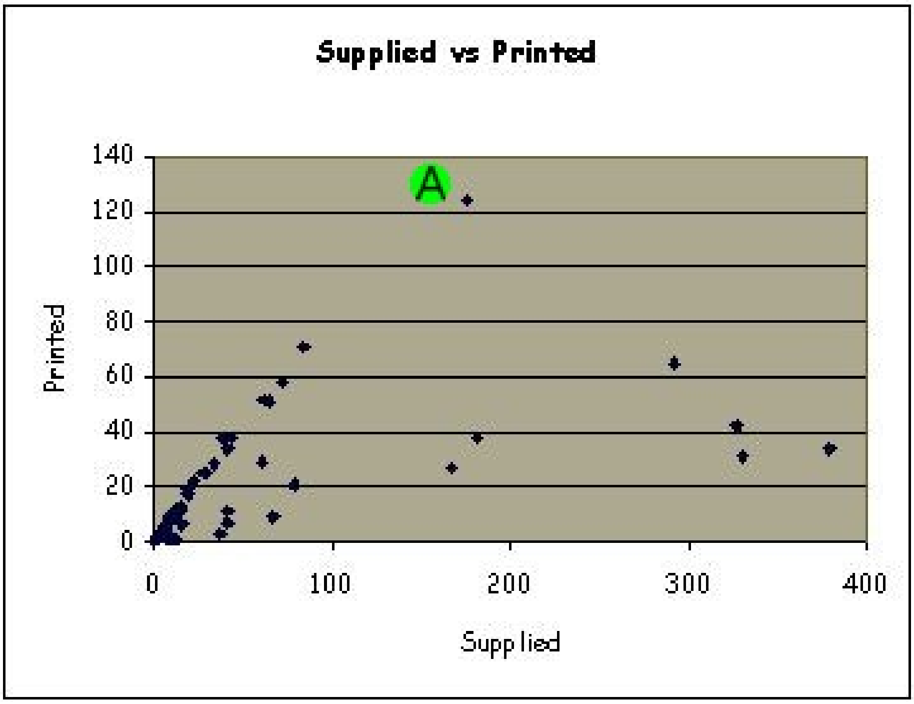


Figure 4.13: Names Supplied and Printed

Comparing all of the supplied to used data reveals a 56% correlation. This increases to 82% by limiting the comparison to those files where the maximum number of names supplied was 100. The 100 names is a significant figure due to the number of rural road names that can be displayed on a topographic map (refer table J-3) and that 87.9 % (51/58) of the map sheets contained less than 100 names. Despite this being the case in 51 out of the 58 files, these situations only equated to 40% of the total data supplied. In urban situations, for example, the 1:25000 map sheet of Botany in Sydney, this figure would be much higher (for example 4500) and is related to the individual suburban area.

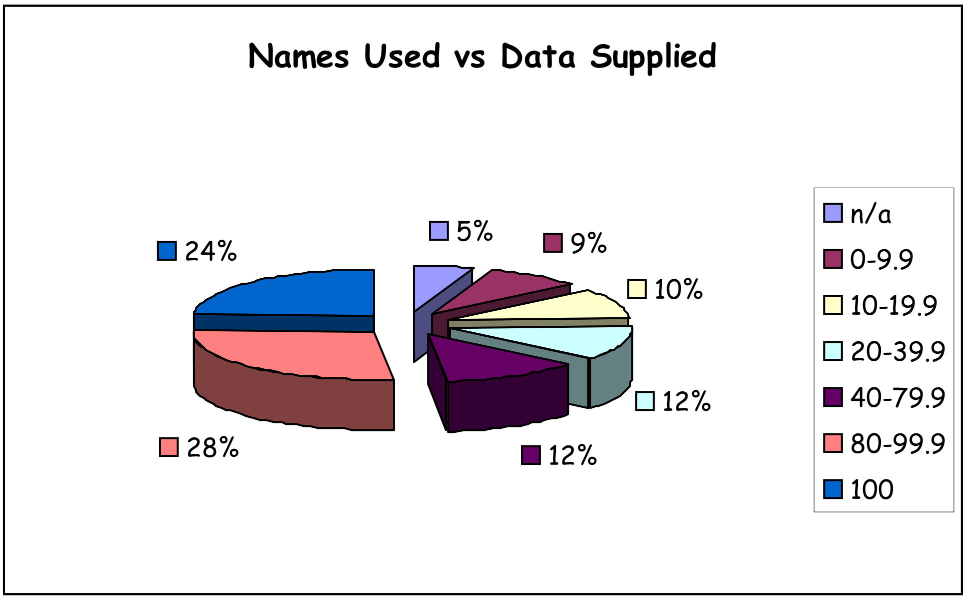


Figure 4.14: Data Used

Figure 4.14 displays the percentage of data used in comparison to that supplied. It can be seen that 52% of the map sheets used more than 80% of the names supplied for the individual sheets.

It is also significant to note that 31% of the map sheets used less than 40% of their individual names supplied. The net gain for the 58 map sheets is displayed in figure 4.15. It can be seen that while six maps had a negative net gain, 40 gained positively with the remaining twelve experiencing no net gain.

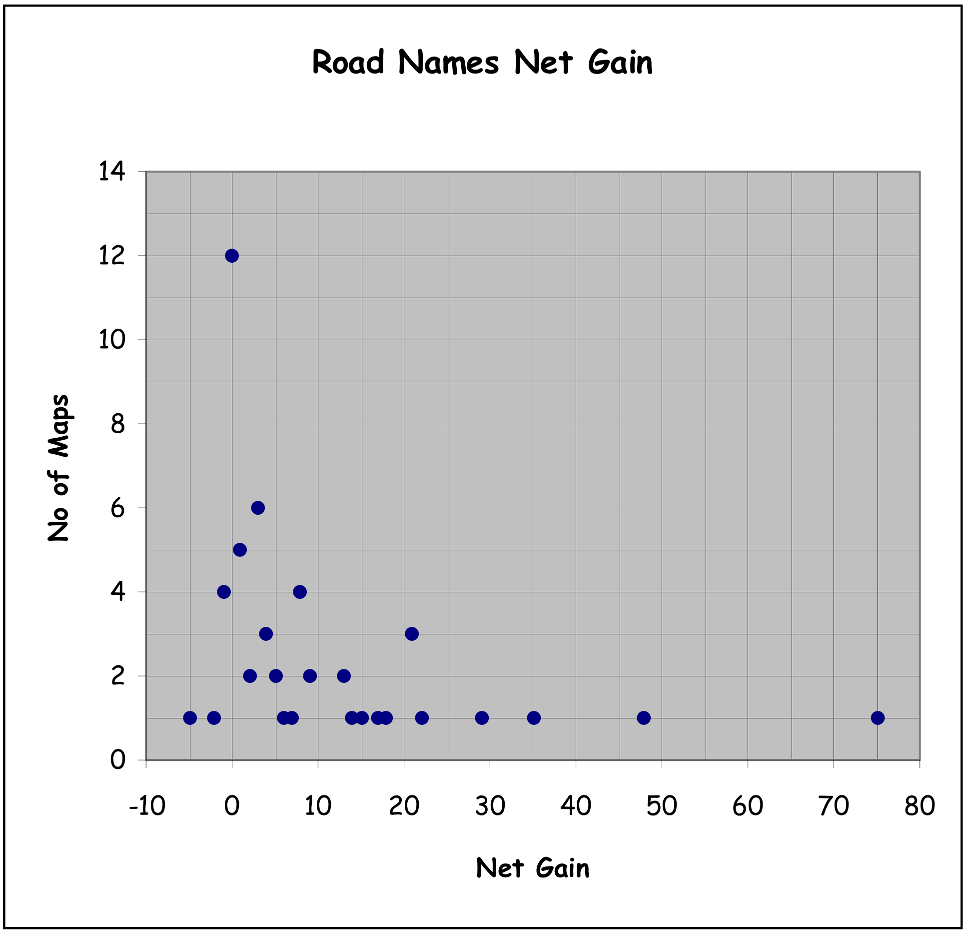


Figure 4.15: Net gain

These figures are displayed in percentage terms in figure 4.16 where it can be seen that only 69% of the maps had a positive net gain.

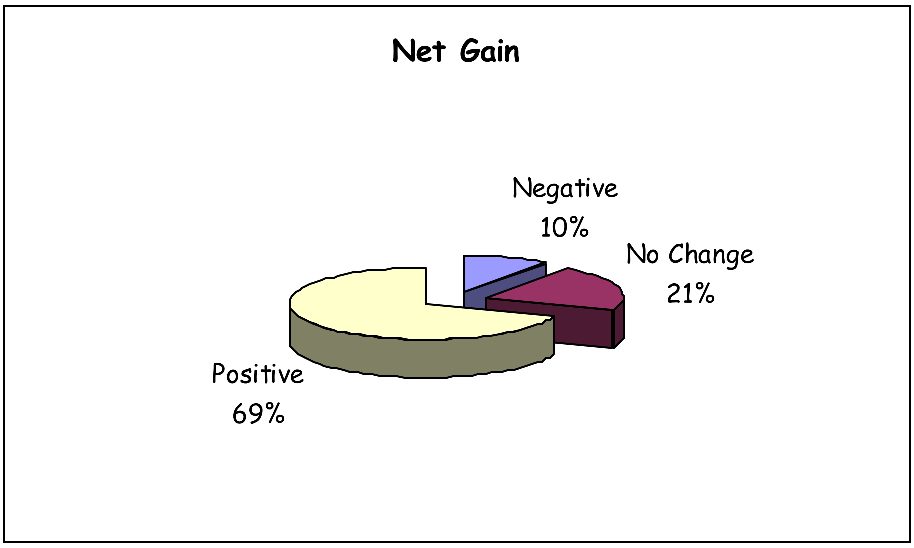


Figure 4.16: Net Gain Summary

At the commencement of the project, the study area's previous editions contained 644 names (refer appendix J). The data received during the study equated to 3000 road names, of which 1107 were printed. This represents a 71.9% increase in the total number of map names printed.

When the level of database maintenance is being assessed, appendix J3 data shows that 51 map sheets would have been affected during this time. This was calculated by totalling the number of sheets where less than 100% of the data obtained was used (due to generalisation) or there was a change in the number of names printed.

a. NSW Forests Point Features

Attributes were supplied for point features in three of the supplied map sheets in the 9232 mapping block (refer figure 4.17). From the characteristics of the point features collected it can be seen that within these three map sheets 18 individual features were found (refer table 4.13). These can be further categorised into seven different elements with attribution, as observed with the pits and the fire tower features, enabling further differentiation.

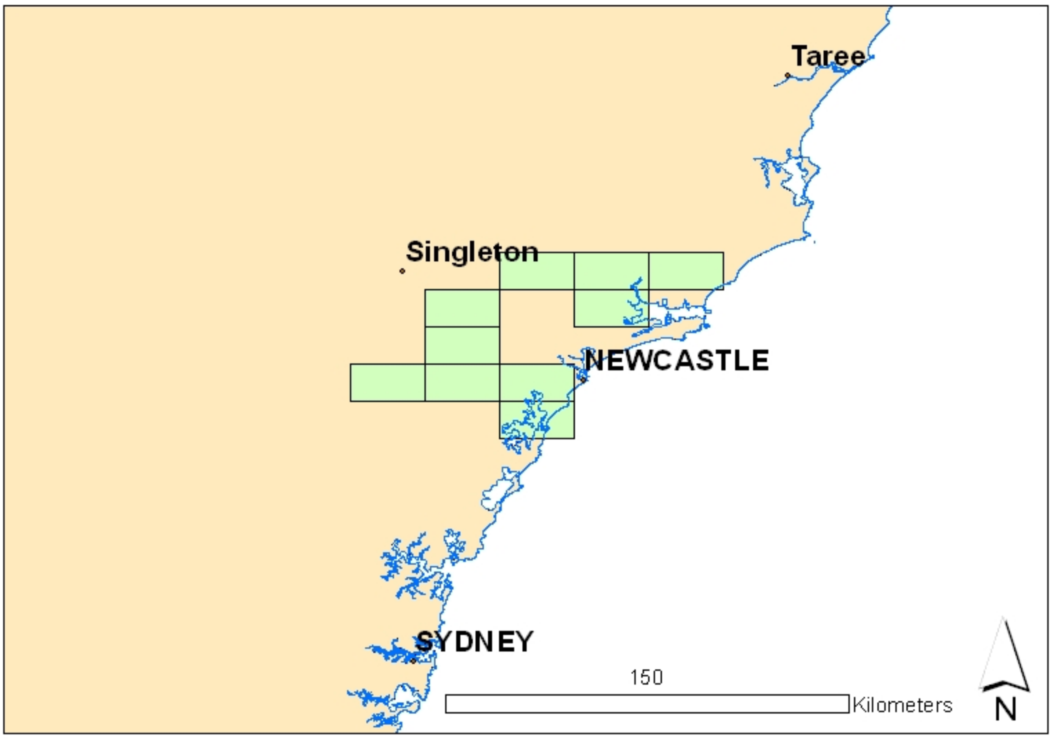


Figure 4.17: NSW Forests Point Data Locations

Table 4.13: Point Feature Summary

Element Collected	**Karuah**	**Paterson**	**Clarence Town**	**Total**
Bridge	4		2	6
Gate (Locked)	2			2
Fire Tower	1			1
Fire Tower (Abandoned)		1	1	2
Causeway	1	1		2
Pit (Gravel)	1	1		2
Pit (Clay)	1			1
Dam	1			1
Forestry Depot			1	1
Totals	**11**	**3**	**4**	**18**

The features that have been collected (refer appendix K-69, K-70 and K-72) are of interest to Forests NSW and are to be included in their overall asset management system. It is also understood that topographically significant (mapping) features may not have been included in the collection process because of their concentration on asset mapping only.

4.3 - Data Accuracy

the value of the map is a function of its accuracy

(Foody 2001, p. 41)

Data has been obtained from the three different sources of the NSW government gazette, NSW Fisheries, Gunnedah Shire Council, and Forests NSW. The accuracy of this data can vary between agencies and impacts not only on the study's results, but also on their usefulness and overall reliability.

4.3.1 - NSW Government Gazette

There were no discrepancies discovered in either timing or content during the pilot study or the 28-week data collection component from the government gazette. As such there is no reason to doubt the accuracy of data obtained during this time. A number of errata (refer table 4.6 and figure 4.5) were reported in the gazette for the GNB during the study period in relation to previously published gazette notifications. All errors, once identified, are corrected with an erratum, thus maintaining integrity between the gazette and the GNR.

4.3.2 - NSW Fisheries

In the areas marked A, B, and C (refer figure 4.18) there are several instances where the lease boundary can be seen to overlap the land as well as the water body. These may not necessarily be in error and further investigation would be required to establish this apparent anomaly. Ascertaining the individual circumstances under which the lease was granted and whether permission had been given for the occupier to occupy other than the water is as such outside the scope and significance of this study. NSW Lands have been working with NSW Fisheries to survey all current aquaculture leases presently below the high water mark (Ellis, R 2004, pers. comm., 30 March). At present there is no evidence to doubt the reliability of the lease attributes or of the positional accuracy of the boundary information obtained.

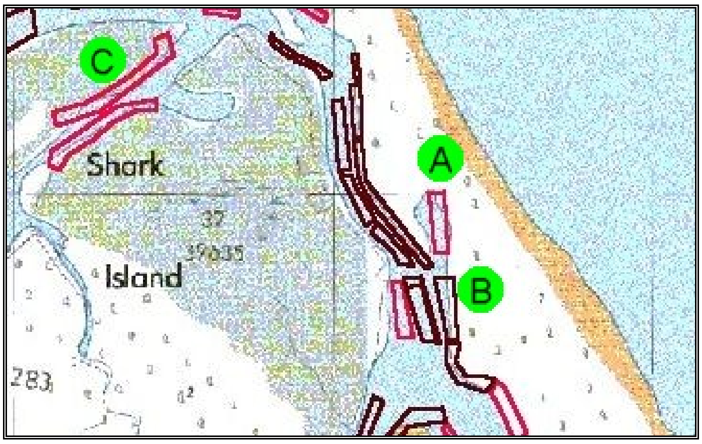


Figure 4.18: Lease Overlaps

4.3.3 - Gunnedah Shire

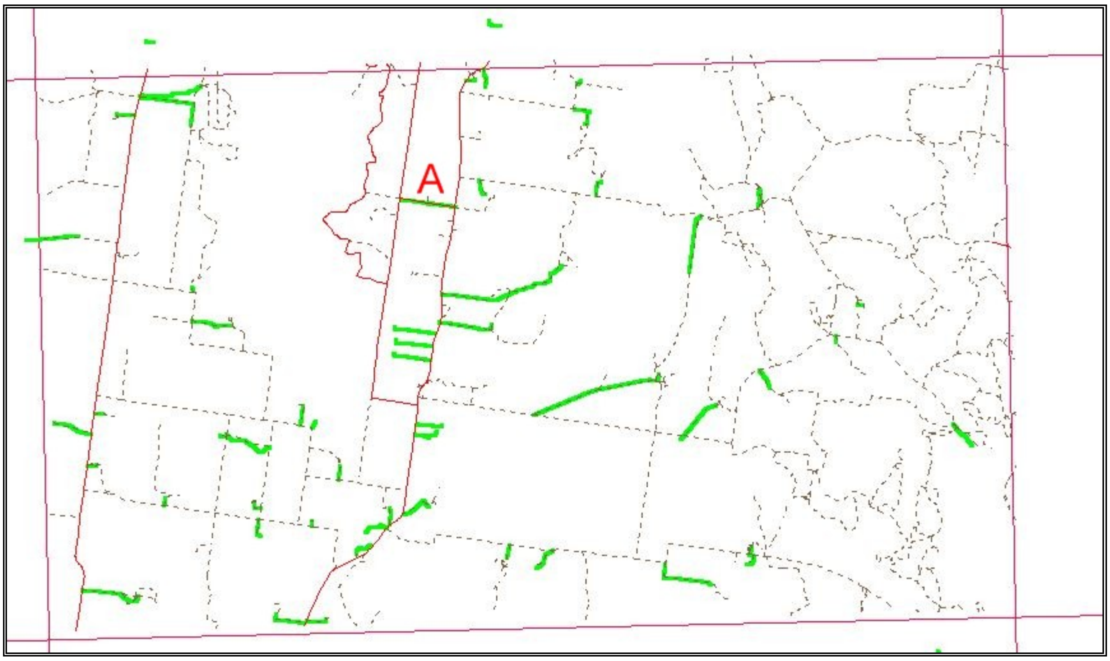
Within the data received from the SES collection in Gunnedah Shire, there was minor variation in the homestead names (refer table 4.14) and several occasions of missing road names (refer figures 4.19 and 4.20). From the table it can be seen that there were eight spelling variations for the 247 matching homestead features (signified by 8 (247)) with a further 29 features unnamed. These variations included:

- o spaces being included, for example, in “Homelea” versus “Home Lea”,
- o hyphens being added or substituted for spaces for example, “Home Lea” to “Home-Lea”, and
- o the removal or addition of a single character for example, “Acre” to “Acres” and “Milliss Station” to “Miliss Station”.

Table 4.14: Homestead Name Variations

Map Sheet	**Variations**	**Unnamed**
Willuri	2 (20)	3
Kelvin	4 (65)	5
Gulligal	1 (32)	3
Emerald Hill	1 (71)	8
Gunnedah	0 (59)	10
Total	**8 (247)**	**29**

In both the Kelvin and Gulligal map sheets (refer figures 4.19 and 4.20), the data received in the Gunnedah region contained occurrences where a named road was present in the DTDB but not contained in the data. In both figures 4.19 and 4.20, the named roads in the DTDB (previous editions) are shown in red with the green representing the data received. It can be seen in the regions marked A, where the two overlap, that a road name is required but, as no road names were received, only the position can be used for database inclusion. With each of these occurrences, the degree of uncertainty in the accuracy of the data increases. This ultimately increases the time required for assessing the data’s suitability for database inclusion.



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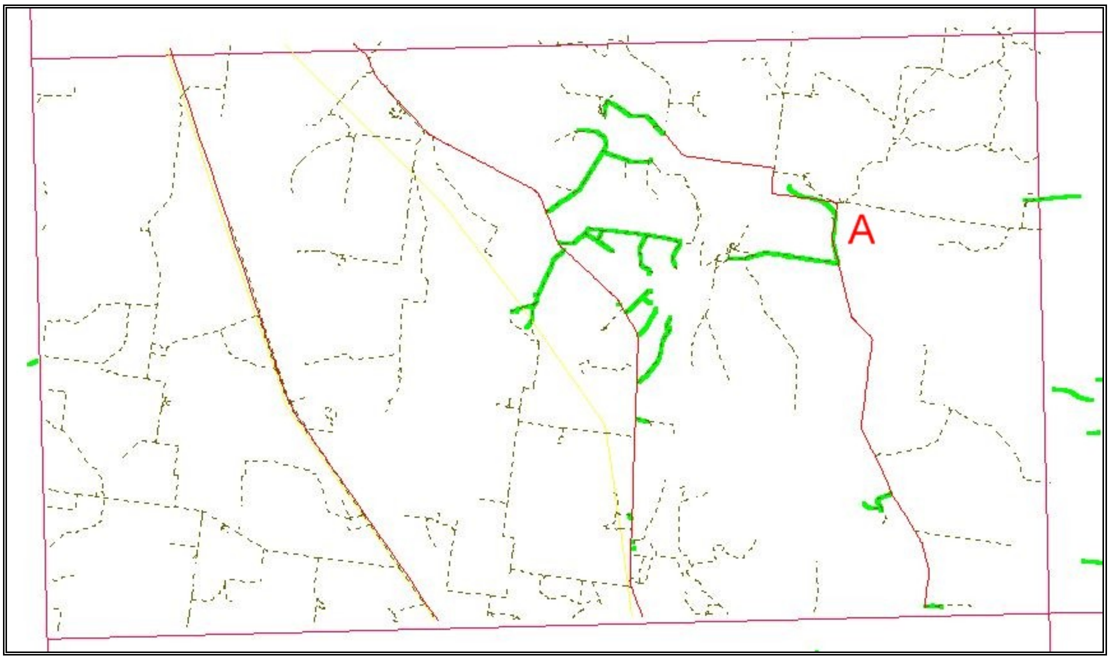
http://www.lands.nsw.gov.au/

Figure 4.19: Gunnedah Road Names - Kelvin



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http://www.lands.nsw.gov.au/

Figure 4.20: Gunnedah Road Names - Gulligal

4.3.4 - Forests NSW

Within the data received from NSW Forests (refer appendix K) there was some variation in data accuracy and consistency. The most noticeable of which was in road name continuity. The symbolized linework in figures 4.21 and 4.22 represents the road corridors within the respective maps. It can be seen from figure 4.21 that the dark symbology, representing the named road corridors, is not continuous. It can also be seen, in the areas marked A, B and C, that the necessary name attribute has not been supplied. This explains the lack of continuity.

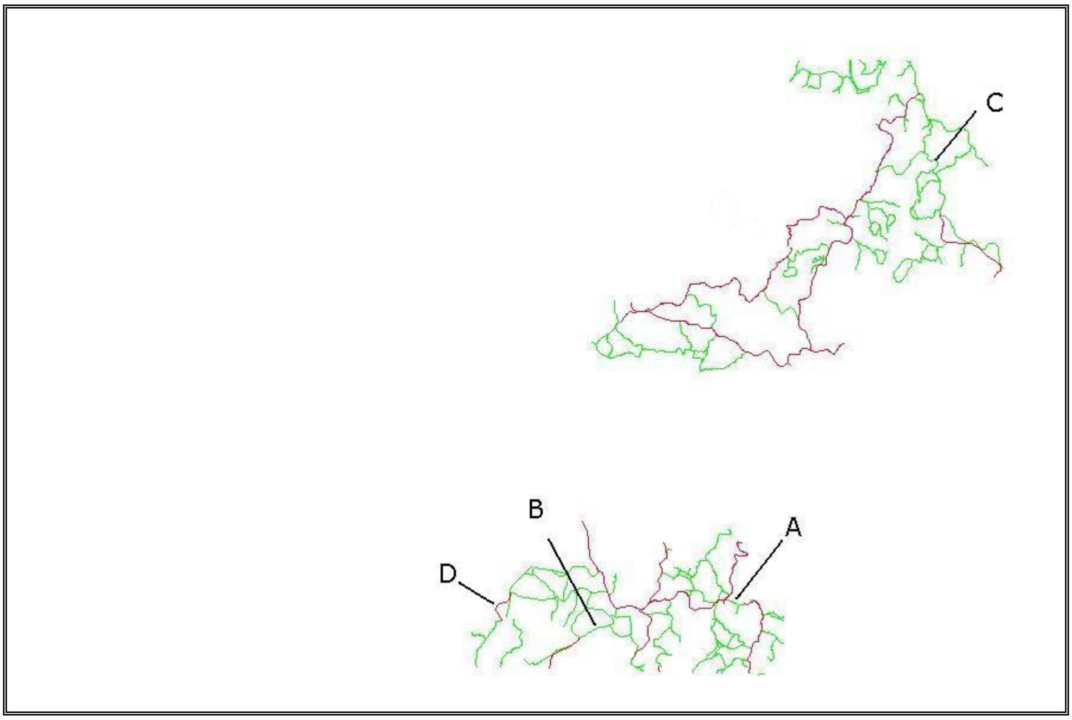

Figure 4.21: Road Name Continuity - 87241n

Whilst it is possible that the named road enters the state forest area and exits a short distance later, it is equally possible that it does not. It may be assumed, and later confirmed with field verification, that the road name is actually continuous in this region. Whilst the topographic map user may be able to reasonably deduce its path within the state forest road network, the digital data continues to contain unnamed line strings with the transportation network unfortunately remaining incomplete.

In the area marked D, initial inspection suggested that the area was in error. What is missing, is the highway that runs in an east west direction through the southern area and adjoins the road in question. The linework shown at D is, after further investigation, correct. Figure 4.22 also displays in parts, an incomplete road pattern (refer areas marked E and F). Named roads and tracks are also of major importance where they have been placed in forestry areas for fire mitigation purposes.

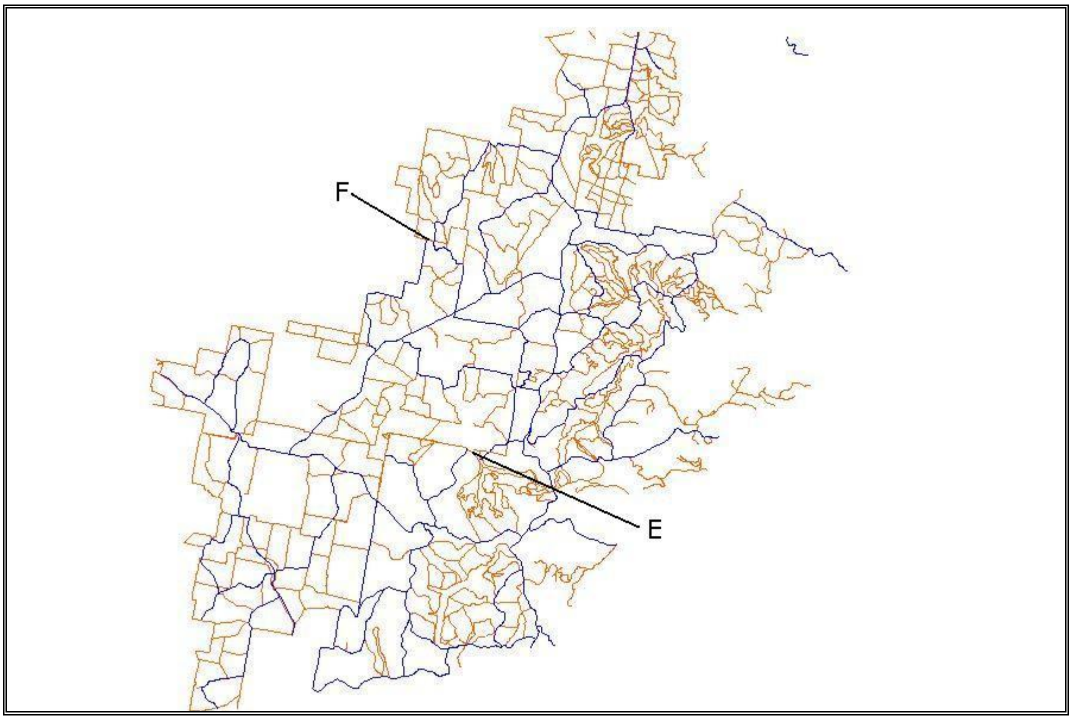

Figure 4.22: Road Name Continuity - 87242s

Advice would also be required for field staff to supply not only areas of named road network but specifically unnamed as well. To prevent confusion the roads in these areas may be required to be named, especially when the names, like the roads themselves, may be temporal in their nature. These situations are likely to occur when the road pattern is related to the harvesting cycle within the forest.

Despite these situations occurring throughout the study, the number of named road strings that have been verified have increased, thus demonstrating the successful nature of the data sharing arrangement.

4.4 - Data Summary

It has been shown that 210 individual map sheets (refer table 4.15), ignoring duplication due to the addition of the various components, would have required database maintenance or updating as a direct result of the data collection programs.

Table 4.15: Map Maintenance Summary

Activity / Phase	Individual Maps Identified
NSW Government Gazette	
Aquaculture Leases	11
Geographic Names	58
Road Names	71
Data Sharing	
Fisheries	3
Gunnedah	9
Forests	58
Total	210

When the duplicates are removed it can be seen that 183 map sheets have been identified as requiring database maintenance during this time (refer table 4.16).

It can also be seen, when the entire study area is analysed, that the maps requiring maintenance represented 16.4 % (183 out of 1114) of the state's topographic map holding (refer figure 4.23).

Table 4.16: Map Sheet Listing – Gazette and Data Sharing

Map Sheet
Abington, Albion Park, Armidale, Balala, Balranald, Bedulluck, Bega, Bellingen, Belowra, Bendethera, Bendoura, Bermagui, Berridale, Berrigan, Berry, Bimlow, Bobadah, Bodalla, Bogan Gate, Bombala, Bombay, Bondi, Botany Bay, Braidwood, Breeza, Broken Back, Broken Bay, Brunswick Heads, Bundarra, Bundemar, Cadgee, Canberra, Candelo, Capertee, Captains Flat, Cathcart, Cessnock, Clarence Town, Clybucca, Cobargo, Coolumbooka, Coombadjha, Cootamundra, Cowra Creek, Crookhaven, Curlewis, Dalton, Dandaloo, Denman, Dooralong, Dundee, Dunoon, Eden, Ellangowan, Emerald Hill, Emmaville, Eucumbene, Eungai, Glen Allen, Glen Elgin, Glen Innes, Gosford, Gostwyck, Grafton, Greta, Gulligal, Gundagai, Gunnedah, Hall, Hartley, Hornsby, Howlong, Huonbrook, Huskisson, Jerangle, Jerilderie, Jingellic, Junee, Kain, Karuah, Katoomba, Keewong, Kelvin, Kentucky, Kiah, Kilparney, Kingstown, Kulnura, Kydra, Laurieton, Leeton, Lismore, Lithgow, Maitland, Malara Creek, Manar, Mangrove, Milton, Missabotti, Mittagong, Mogo, Moree, Morisset, Moruya, Mount Adrah, Mount Imlay, Mount Kosciuszko, Munderoo, Murrah, Murrays Run, Narooma, Narromine, Nelligen, Nerrigundah, Nevertire, Nimmitabel, Numerella, Nymagee, Ournie, Pambula, Parramatta River, Paterson, Penrith, Pleasant Hills, Port Hacking, Port Stephens, Prospect, Quorrobolong, Raleigh, Red Range, Riverstone, Salisbury Plains, Sandon, Sappa Bulga, Sebastopol, Shannon Vale, South West Rocks, Springwood, Stonehenge, Stroud Road, Suggan Buggan, Swansea, Sydney Heads, Tarana, Temora, Thackaringa, The Branch, The Lagoon, The Meadows, Thredbo, Tinderry, Tongo, Tooma, Torryburn, Trundle, Tullamore, Tumbarumba, Turlee, Tweed Heads, Uralla, Walbundrie, Wallsend, Wandella, Watermark, Watsons Creek, Wauchope, Wee Waa, Weetaliba, Werris Creek, Whinstone, Whiporie, Willuri, Winton, Wirraba, Wollombi, Wollongong, Wolumla, Wyndham, Wyong, Yambulla, Yarrowyck, Yass, and Yowrie.

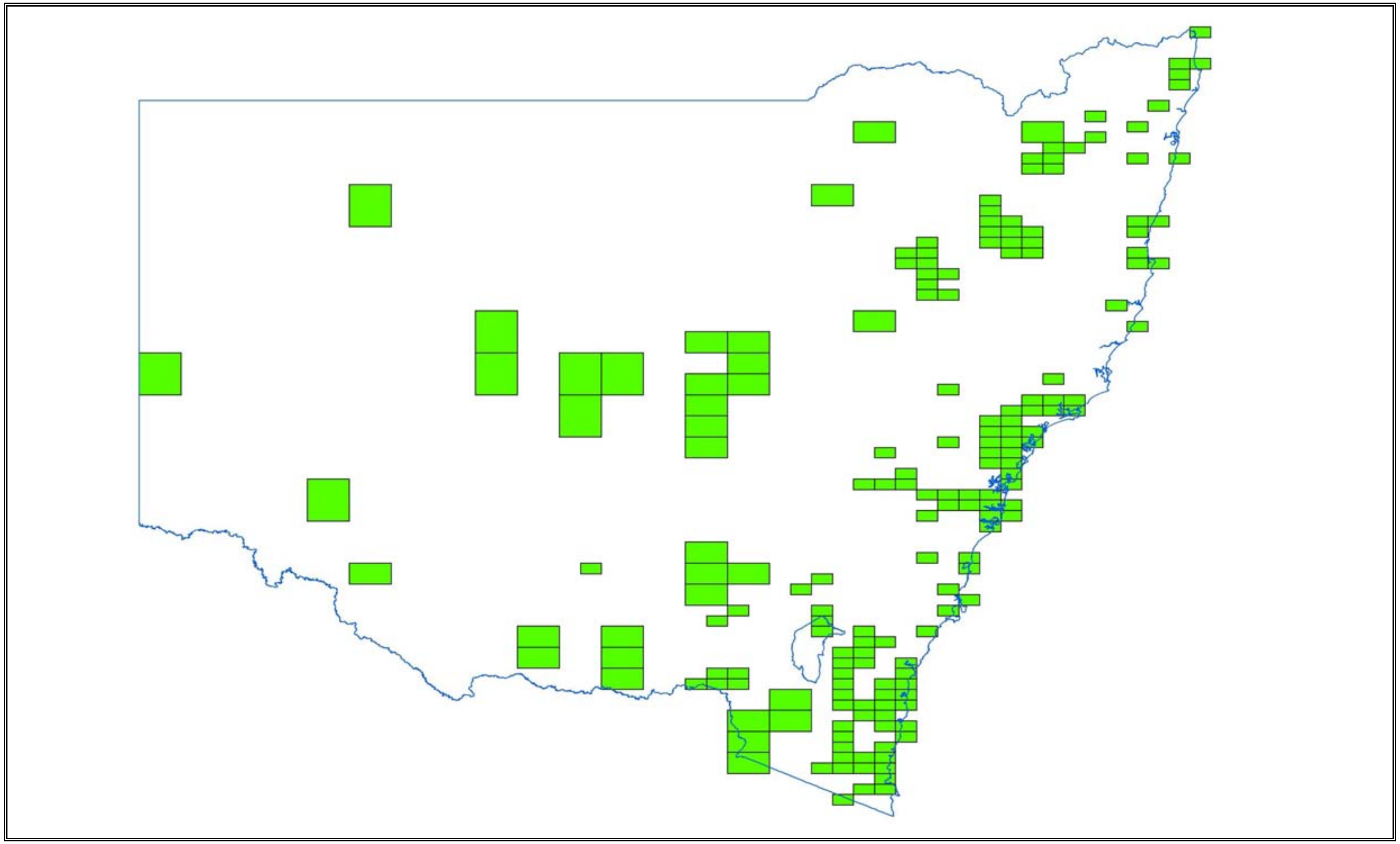

Figure 4.23: Total Study – Map Maintenance

4.5 - Summary: Chapter 4

Data was collected and analysed throughout the 28 week final data collection component of the study. This data comprised information from the weekly copies of the NSW Government Gazette, and additional information obtained through successful data sharing activities. NSW Fisheries, Gunnedah Shire Council, and Forests NSW represented both local and state tiers of government and provided data and expertise throughout this stage.

The study was able to show conclusively that government agencies are aware of changes in the natural and built environments and that this information, when made available, would streamline topographic database maintenance. It was also found that topographic maps and products could be maintained more efficiently, utilising data provided incrementally as part of a data sharing arrangement. These efficiencies would develop from the utilisation of temporally accurate data obtained from the various data custodians, who would each be regarded as experts in their individual fields and areas of interest. This data would have increased reliability and would require less verification prior to database insertion. Savings would also be achieved with additional time and resources being available for data collection rather than for the verification of other government datasets.

It has also been shown that, with an ageing stock of topographic maps (refer section 2.5), 46 of the 183 map sheets found to require data base maintenance were field revised over 25 years ago (refer NSW Department of Lands 2004 Map Catalogue). A system of continual database maintenance undertaken over the entire state would provide the mechanism to ensure a reduction in this timeframe. It can also be seen (refer figure 4.23) that the distribution of updates over the study period has not been isolated to any particular region, data sharing area or scale group. This further highlights the dynamic nature of change within both the natural and built environments whilst also demonstrating the continued usefulness of the system.

From the analysis of 28 weeks of published data from the NSW Government Gazette and through the successful data sharing activities with three government bodies, results and conclusions were obtained that further substantiate the hypothesis and provide additional support for the "Now Map" concept.

CHAPTER 5 – DISCUSSIONS, CONCLUSIONS, AND IMPLICATIONS

An expert seldom gives an objective view; he gives his own view.

(Harold 1986, p. 197)

5.1 - Introduction

The study was undertaken in two stages and focused on the relationships that exist in determining change within the natural and built environments as applicable to modern topographic mapping. These stages consisted of a 28-week information gathering process using the NSW Government Gazette, and a successful data sharing program using Gunnedah Shire Council, NSW Fisheries and Forests NSW.

During the map production process (refer chapter 2) there exists a number of significant relationships (refer figure 5.1). For any given area of interest it can be seen that there is a relationship between this, the number of maps in the map series and the scale that they are to be produced at. The production scale also influences the accuracy of the features collected, the quantity of features to be collected and displayed, and the number of different features to be maintained. Collectively these determine the capture methodology whilst also influencing the time required for data collection and the repeatability of continual data maintenance. It has also been established that a relationship exists between the capture time and the series revision cycle as well.

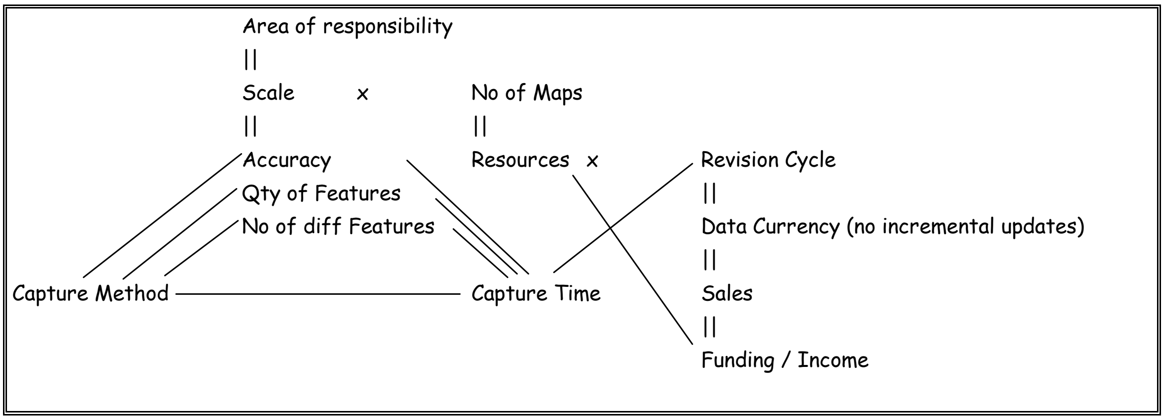

Figure 5.1: Map Production Relationships

The series revision cycle is also influenced by the amount of resources available in relation to the number of maps to be produced and maintained in the series. These resources are ultimately dictated by funding and income, which is in turn influenced by the sale of map related products. These sales are also influenced by the currency of the data providing the product's content, which is directly related to the revision cycle. These associations are independently influenced by the capture methodology, the overall area of government mapping responsibility and the resources available for its maintenance.

A revision cycle / schedule that does not include incremental update or another form of regular maintenance capability seriously undermines an organisation's ability to produce quality map related products in line with the needs of its customers. It is for this reason that the study was undertaken and has successfully substantiated the proposed hypothesis (refer section 1.1).

5.2 - Discussion

Topographic maps and products, when produced through a photographic revision program, are dependent on a timetable of aerial photography acquisition and operator assisted data revision. The spatial accuracy of the products produced are dependent on the overall process methodology and, whilst the temporal accuracy is equally dependent on that process, the underlying factor is the timetables that dictate both data revision and map production. Until recently (c 1997), it is most likely that these timetables would have been the same or very similar. Due to the introduction of the electronic age, technologically advanced organisations now have the mechanisms available to produce topographic maps and products at regular predefined intervals whilst independently maintaining their map production data more frequently.

This study has shown that government bodies from both local and state tiers maintain vast quantities of information through their own core business activities. It was also shown, in a small number of occasions, that the substance of this information could be found in the NSW government gazette as its record of government business. This facilitates regular and timely updating. In addition to obtaining information from the gazette, the study also demonstrated that the remaining required information could be successfully obtained through data sharing arrangements. The arrangements undertaken during the study further demonstrated the usefulness of obtaining spatially accurate data that is maintained by organisations throughout their own core business activities rather than from a central repository.

5.2.1 - Study Recommendations

The following recommendations are made, as a result of the study undertaken over the period March 2001 – November 2004.

1. Eliminate the duplication of effort required for spatial data collection and maintenance by streamlining information management within all NSW Government agencies. This will provide a more efficient use of government resources.

2. Change the format of notifications within the NSW Government Gazette to include, when deemed topographically significant, geographic coordinates in GDA94 for all spatially defined features which, at a minimum, defines the centroid and minimum bounding rectangle (MBR). This should be further developed to also include the spatial definition and outline of the feature.

3. Provide registered stakeholders with Government gazette notification summaries electronically, through the adoption of a system similar to the “notice to mariners” from the Hydrographic Office and “notice to airmen” from Airservices Australia.

4. Establish data sharing arrangements with each government authority, regardless of tier, for the exchange of topographically significant data on an incremental basis. This will enable the provision and maintenance of up to date topographic maps and products.

5.2.2 - Conclusions and Implications

When maintained through a series of data sharing arrangements, the data used for topographic maps and products would not become “out of date”, as the information would be both temporally and spatially accurate and provided incrementally within a regular timeframe. The certainty of this increases through the implementation of a “whole of government” data sharing arrangement within the local, state and federal tiers when applied to changes in both the natural and built environments. The term “out of date” means “no longer useful” or, since it was last updated, there have been more noticeable changes in the vicinity than the map user desires. Through a process of continual maintenance the map production data would never suffer this fate. The map production data would be, subject to the terms of the arrangements, updated incrementally in response to the changing environment and the needs of the mapping public. These changes, through regular integration with external sources, would further enhance the quality and usefulness of the map production data.

The following paragraphs discuss the conclusions formed for the two key areas of the study.

a. Government Gazette

The government gazette, whilst providing an accurate record of government business, is only providing a minor subset of the vast amount of information held by government organisations that could be made available for topographic mapping. Whilst the study concentrated on the areas of geographic names, aquaculture leases and road names, a wide variety of other topographically significant information is also published in the gazette. The government organisations responsible for this additional information, and that compared in the study, administer and operate under specific acts, regulations and guidelines. The gazette, since its inception, has provided an appropriate mechanism for notifying the public of this information. These notification processes need to be expanded to provide accurate readily accessible spatial information to accommodate the changing needs of government and the public.

The regular notification of relevant information demonstrates the strength of the present publishing system. Notifications provided without spatial referencing and appropriate attribution highlight its weaknesses. Whilst it may be true that the various government agencies actively maintain their individual holdings of spatial and associated attribute data, information is only as valuable as it is accessible. Without appropriate mechanisms for reporting all relevant information, the usability of the entire system is in doubt due to its perceived degree of uselessness and lack of problem solving ability. Additional attribute information, location diagrams, and the inclusion of geographic coordinates would also assist the gazette user in interpreting the current system of notifications, whilst also providing a more usable information product and removing any perceived shortfall.

The information contained in the government gazette observed during the study, in both the pilot and the final data collection phases, highlighted the range of topographically significant datasets currently maintained by government organisations. The value of this information would be further enhanced through the expansion of the present system by allowing additional previously unreported information (for example local government development applications) to also be included. These associated datasets would compliment those data currently being reported, thus adding to the total value of the system.

Accurate road naming is of immense benefit to the emergency services, especially within rural communities. The role of road naming is undertaken by local government authorities (refer section 2.2.2.1.b) using guidelines designed to assist with addressing and house numbering. The passage of information from the local government authority to the mapping community via the gazette assists with this important task and must continue. As the local government authorities complete their individual addressing programs, the spatially aware organisations will be in a position to supply their complete road fabric and attribution as part of an ongoing data sharing arrangement as identified by this study. With an active data maintenance process in place, this useful and necessary data is ready to be shared.

The notifications observed during the study provided accurate attribution for existing topographically significant roads and over time will result in a complete named road coverage. Consultation between adjoining organisations will ensure consistency at the shire boundary and reduce any potential user confusion. To economically maintain currency and relevance, database upgrades must be maintained, for every change, automatically through a data exchange system.

Despite aquaculture leases providing only minor map content, they are regularly reported in the gazette. The ongoing use of the gazette for the provision of aquaculture lease information would require additional attribution to be included in the existing topographic data model, that is, the lease identifiers. Once included, the lease identifiers would enable the confirmation of existing use for renewals and when provided, the deletion of symbology for withdrawals. The addition of leases recently granted would require support in the form of digital data, which may form part of a data sharing arrangement, or a plan of the area provided by Fisheries NSW. Regardless of the medium, accurate corner positions would be required to enable the accurate placement of the lease boundary. This data exchange system will provide current and relevant mapping data.

The Geographic Names Board maintains the Geographical Names Register and assigns geographic names (refer section 2.2.2.1.b). The process of assigning the names provides the location, description, topographic map name, and feature type. Once assigned, the names are published in the gazette with these attributes assisting in the accurate definition of the feature. From this point forward notifications concerning the feature do not include the map name or location details and rely on the feature name for identification. When dealing with errata, additional cross-referencing would be required to maintain the feature annotation for previously printed hardcopy maps.

b. Data Sharing Programs

The data sharing program utilised data obtained from NSW Fisheries, Gunnedah Shire Council, and Forests NSW. The aquaculture lease information provided by NSW Fisheries demonstrated the temporal attribute within the data set and highlighted the availability of accurate information of this type within the region. The data would be maintained with additional lease information supplied incrementally with each edition of the government gazette.

Gunnedah Shire Council provided data relevant to the emergency service operations of the SES in time of flood. This consisted of farm access tracks, homesteads and gates. As the dataset fulfilled a niche market, it was difficult to access the level of usability with respect to topographic map maintenance. This is also due to the dataset not being representative of each map sheet or consistent within the shire. As such, the data is unable to be used as a replacement for the existing dataset and would only be used as a supplementary source. Additional information would be required, as the lack of a previously present feature in the supplied data does not confirm a feature's deletion or removal.

The data supplied by Forests NSW reinforced the premise that government agencies access and assist in the maintenance of vast amounts of data. This information further demonstrated that data sharing arrangements could be successful, provided all concerned parties work towards a common goal. As also found in the arrangements with Gunnedah Shire, the absence of a road name does not mean that the road is not named, just that no name was collected. This unfortunately decreases the level of suitability for database inclusion with additional resources required for investigation and ground truthing. Hence a fully operational system would be best served by each party undertaking data sharing activities using agreed standards, methodologies and quality assurance procedures.

This is further highlighted (refer figure 4.22 and section 4.3.4) with the highway being disregarded and not collected by Forests NSW, as it is on land that is excluded from the state forest. This additional information would be obtained from external data sharing partners such as the RTA during a "whole of government" arrangement.

The study demonstrated that topographic maps could be maintained more efficiently through the use of data sharing and incremental updates. Existing identifiers can be accurately maintained through the use of appropriate data collection storage and transfer standards and a suite of database translation tools. To implement this within an active production environment would require a coordinated approach to map production, data maintenance, and data sharing within both of the tiers of government tested (refer chapter 4). Implementing the model proposed in the following paragraphs (refer section 5.2.3) would produce significant production savings through an efficient use of government resources and further enable the "Now Map" concept.

The implications of this approach include a change in the data collection, data maintenance and map revision processes, and a modification to the overall data revision and map production timetables. These enhancements would allow the associated processes to operate independently whilst also providing structure and purpose within the individual production groups. This means that, in areas where data sharing arrangements exist, the data would be continuously revised, with the production of image maps remaining dependent on the aerial photography program. The 1114 topographic map sheets for NSW would then be enhanced using imagery based on aerial photography. These processes would utilise individual production timetables designed to meet the needs of the mapping public in the provision of up to date topographic maps and products.

The current map production approach would continue until an improved process was introduced, with possible substitutes including image mosaicing and feathering from multiple image sources (refer section 5.4). The update would be, allowing for any resolution and geometric corrections, cut into the previous image area, thus allowing the composite image to be further utilised in product generation and production.

5.2.3 - Bringing it all together: A model for the future

The proposed model uses data sharing programs as a source for incremental updates. The supply of temporally accurate data, provided earlier than available under current arrangements, will improve future topographic map production and provide for the "maps on demand" style products. To accommodate the implementation plan, the participants need to be identified, along with the potential sources and methodology for incremental updates. The participants consist of two very distinct groups of people, those who are feature users and those who are the data custodians.

The feature users are individuals or organisations that:

- Use geographic information, as part of their core business, or as part of an interest or hobby, and/or
- Change topographically significant features, and/or
- Determine that features or data have changed, and are not data custodians.

The data custodians are individuals or organisations that maintain data as part of their own core business. This maintenance program usually includes a dedicated update and data resupply strategy. It is the identification of these custodians that is the key to the models success. Without knowing whom to source data from, it would be very difficult to have the most up to date information available for inclusion in the map production process. Demonstrating the model's benefits and suitability will increase the number of interested partners, and in turn increase the known data custodians and partnerships available as well.

Several potential sources for incremental updates are outlined by theme within the topographic data model (refer table 2.6). The key to these sources is that they deal with information and data that may be informative and topographically significant. To also assist with product and database maintenance, additional field revision services would also be negotiated with organisations that employ people who travel as part of their normal work duties. This would be especially significant where they have the capacity to note topographic changes within their work environment. Additional training coupled with the development and implementation of appropriate data collection procedures would also be required for these staff to maintain current collection standards. Current examples include:

- Local Government Health and Building Surveyors,
- Postal Contractors,
- Workcover, RTA, and Fisheries Inspectors,
- Department of Mineral Resources Geologists,
- Government surveyors,
- Soil conservation field staff,
- Emergency Services Staff, and
- Electricity meter readers and maintenance workers.

The planned structure and usage protocols of the implemented data supply and delivery system must also be considered. A single logically consistent database for all government information, providing as a minimum the functionality of the WALIS model (refer section 2.4.3.c), would potentially solve several of the concerns regarding data storage, the transfer of updates, licensing and copyright.

5.2.3.1 - Implementation Plan

The model's implementation undertakes a five-stage plan.

ONE: Data Authority Identification. The first stage is to identify which organisation is best suited to be the authority for a particular type of data. This decision would be based on an organisation's expertise and legislative responsibilities. It should be noted that an organisation's previous ability to produce hardcopy products does not automatically qualify it to be the particular data authority for the data used to make those products today.

TWO: Data Consolidation / Redistribution. After a consultative process between the present data custodians, agreement will be reached on which organisations are to become the new data authorities. The data and resources are then redistributed and where necessary consolidated by the new authority.

THREE: Persistent Identifier Allocation. For each feature held within each theme, the data authority allocates a "persistent identifier". These are used to identify the feature uniquely within the state with blocks of alphanumeric identifiers being used by each authority. This allocation would be carried out similar to that already in use in Britain for buildings (TOIDs). The identifier, once allocated, remains with the feature and is not reallocated on retirement.

FOUR: Data Redistribution. Once the allocation of persistent identifiers is completed, the data authority redistributes all relevant data with identifiers and attribute tables attached to all interested (previously identified) parties.

FIVE: Incremental Update. After the redistribution of data by the data authorities, the individual incremental update programs are able to commence using the relevant feature users and data authorities.

5.2.3.2 - Assessing Custodianship

For each feature held within the various government agencies, there are important questions that need to be answered when assessing custodianship.

- Is it topographically significant?
- If so, at what scale or range of scales?
- How would the feature be shown at these scales?
- Who knows about the changes in these features?
- Of these, who is the primary custodian?
- Who initiated the change if it wasn't the primary custodian?
- Is the primary custodian the person or organisation best able to maintain the data, or is an alternative required? For example, mangrove data is collected by LPI as part of the topographic map program despite having few staff trained in its identification. NSW Fisheries have trained staff, but almost no capability to provide map related data at topographic production scales.
- Can the custodian maintain the standard required for the state's geospatial database?

Prior to the model's implementation, three major points need to introduced and discussed. Firstly, the creation of a coordinating body within the mapping and surveying industries. Secondly, the role reversal that some organisations would have to undertake or experience as part of the implementation, and thirdly, the most significant of all, the modification to the individual database structures that presently exist within each government organisation.

In NSW, the surveying industry is coordinated by the Surveyor General and the Board of Surveyors and Spatial Information (BOSSI). To assist in the implementation and coordination of the model, two alternatives are considered. Firstly, the further expansion of the coordinating role presently undertaken by BOSSI would be required. Alternatively, the introduction of a dedicated spatial information coordination body, with the sole responsibility of coordinating and managing government spatial data collection, maintenance, and supply. The organisation could be named, for example, NSW Spatial Coordination Authority. With the introduction of a separate organisation, BOSSI would be able to concentrate on the registration, professional development, and management of surveyors.

Some organisations have always been data suppliers, whereas in the model they may be suppliers, customers or both. Due to this potential role reversal there would need to be a review of government spatial collection processes, data management procedures and the provision of client services. This review would be undertaken during the assessment of the current data custodians.

In addition, most organisations will have to introduce point level date stamping using a start and finish date for each feature, for example: *feature id, start_date, finish_date*.

The incremental update strategy relies on organisations retaining data that has been deleted through the use of retirement dates. As a result of the date stamping, the long-term benefit is that in the future this will also allow for the creation of temporal scene (historic) maps using time slicing.

All data custodians would be required to allocate persistent identifiers (refer stage three of implementation plan) to the data in their care, ensuring that duplication of identifiers within the "whole of government" arena does not occur. By allocating blocks of alphanumeric identifiers to each government agency involved, regardless of tier, this should not occur. Data custodians would also be required to establish appropriate data transfer and storage standards and formats. These will also be used in establishing appropriate verification methodology and spatial data matching techniques, required for maintaining a standard in the form of accurate spatial data. These techniques would be shared with all agencies within the data sharing arrangement for the purpose of maintaining at a minimum the present topographic data standard.

5.2.4 - Data Integration

The current topographic production process (refer figure 5.2) allows for the inclusion of data from external agencies. To streamline the process and prevent the duplication of effort, coordination at inter-agency level would be required. Once established at local government level, the inter-agency coordination would be used in a modified cadastral data integration process (refer figure 5.3), to allow for developments to be automatically available upon completion.

This would also allow for road corridors that are named on a new deposited plan, to be placed in the cadastral fabric with the creation of the subdivision. These would then be added to the topographic road network at the start of the development.

5.2.5 - Model Partners

The proposed topographic production process (refer chapter 2 and figure 5.2) utilises data from the various topographic themes and is able to also, as previously explained (refer section 5.2.5), accommodate data integration with the model's partners. Priority would be given in establishing partnerships where the sponsoring agency has the ability to maintain appropriate topographic data within one or more of the themes.

It is also envisaged that once the model is implemented, the number of parties interested in receiving topographic data incrementally will increase. These organisations will not be isolated to any one government tier and would contain both public and private sector participants. Data supply arrangements would be negotiated (refer section 2.4) to accommodate the needs of both parties involved in the partnership. Examples of these potential partnerships are described below.

a. Commonwealth Government Organisations

- **Defence Estate:** - road and building footprints over defence land.

- **Department of Administrative Services:** - commonwealth government property register.

b. State Government Organisations

- **SES:** - The organisation is seen as a receiver of information rather than a supplier, despite being regarded as an adviser. Arrangements are in place with several state government agencies in relation to information dealing with flood related matters, for example bridges, culverts, and causeways.
- **Department of Environment:** - Approval is required from the department prior to land clearing. As the department's mandate includes monitoring the natural vegetation, any changes in the landscape would be available for supply after each application for clearing is assessed. Appropriate methodology would be required to ensure all assessments and any future monitoring is conducted to provide sufficient accuracy and detail for multi scale topographic mapping.

c. Local Government

Anecdotal evidence suggests that each organisation involved with the emergency services would like topographic maps and products maintained more regularly. The individual local government authorities are included in this group. The need is highlighted with councils such as Gunnedah (refer chapters 3 and 4) and Kempsey being affected at times due to local flooding. The local government organisations observed during this study have been interested in data sharing and incremental updates due to reasons associated with the high incidence of emergency service response, land zoning and development, and other local community activities.

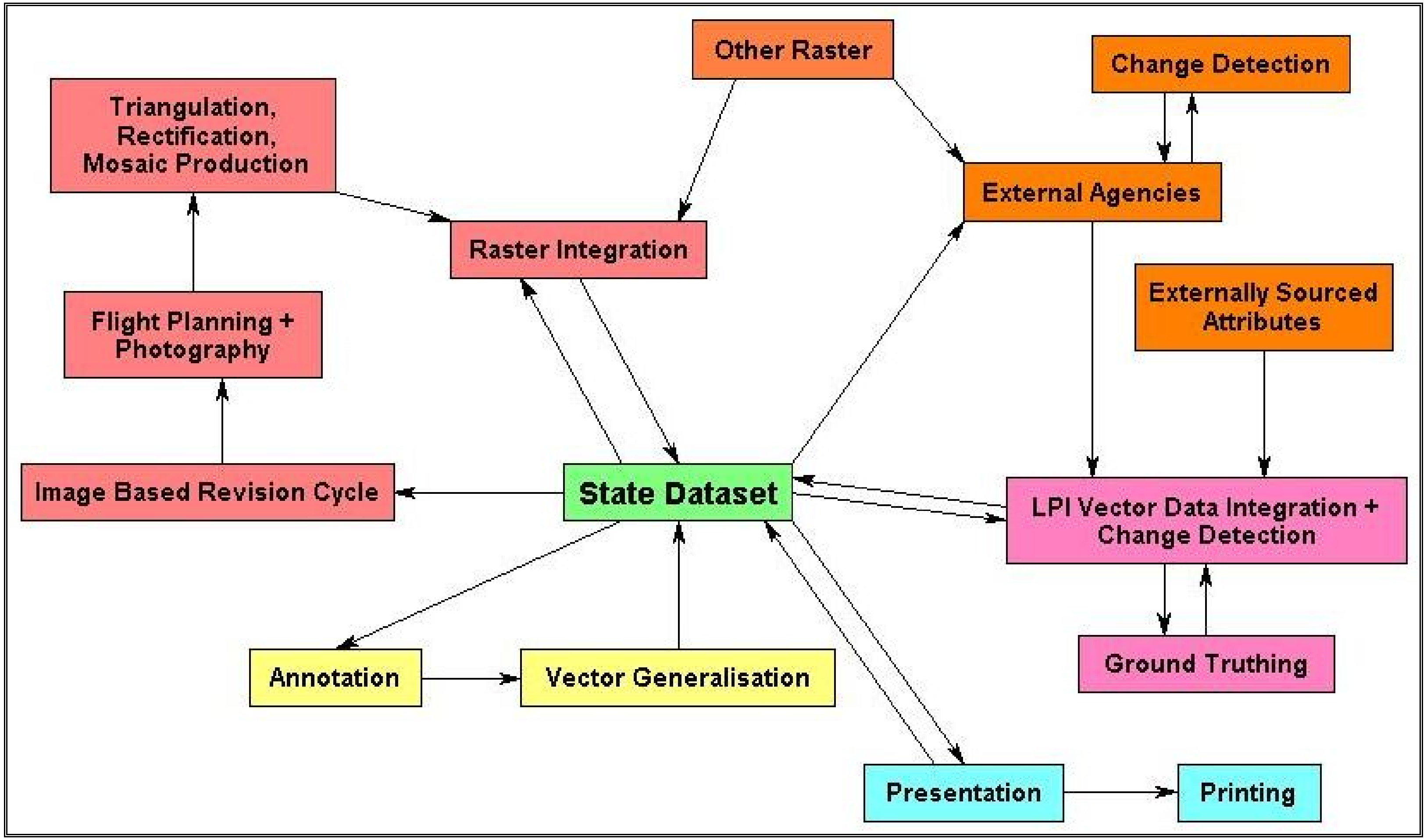

Figure 5.2: Topographic Data Integration Framework

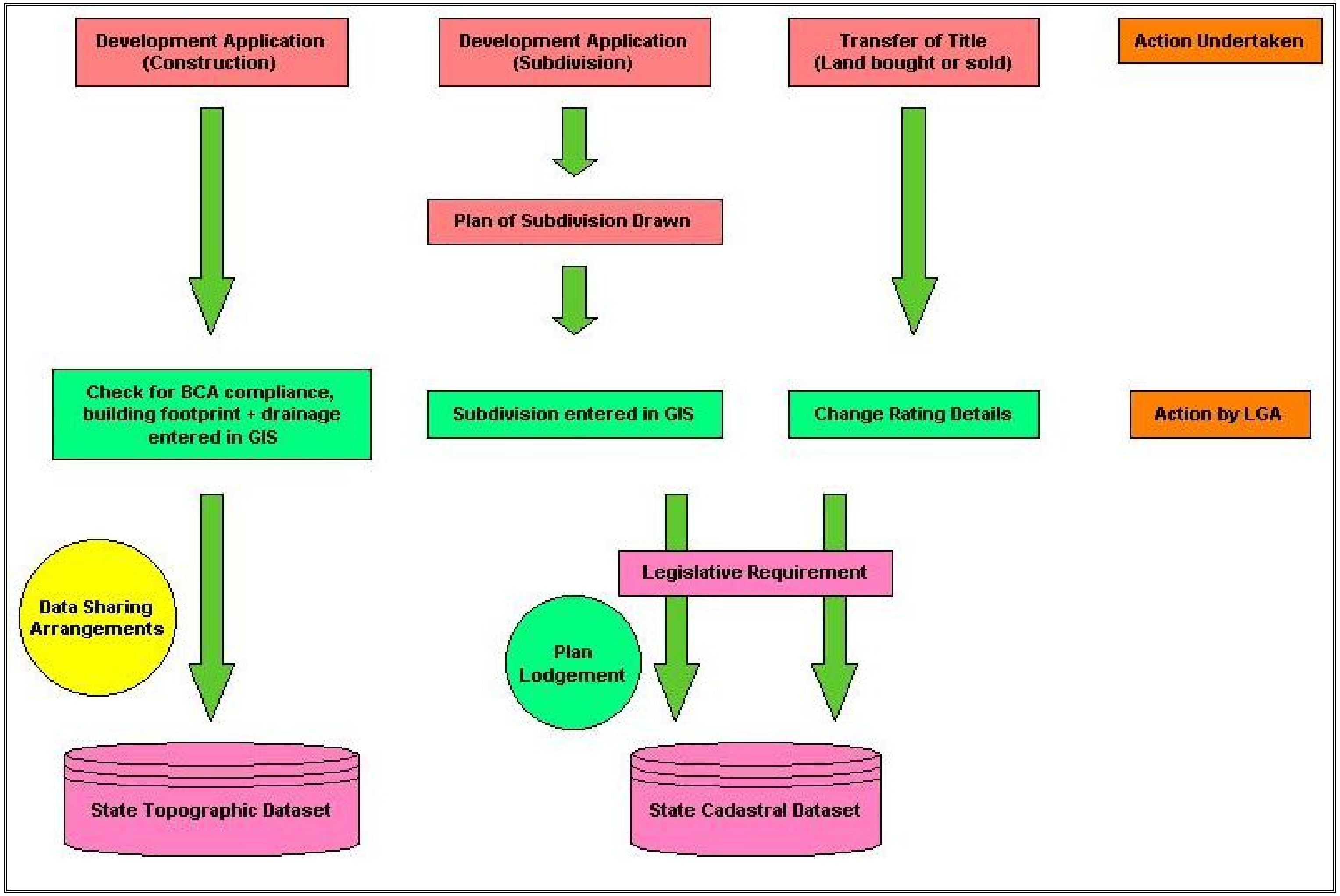

Figure 5.3: Topographic Data Integration Framework – Cadastral Component

5.3 - Summary: Chapter 5

> *As a rule, the map user assumes that a topographic map reflects the current landscape situation objectively and true to scale*
>
> (Meine 1984, p. 22)

This study focused on the aspects of data sharing and how those who participate in a data sharing program may be involved in the production of topographic maps through the provision of incremental updates. As this updated information becomes available, customers would have access to on demand mapping services that would ultimately enable relevant, up to date maps and map related data to enter society. Additional savings to government is apparent through the elimination of effort required to maintain duplicate data sets.

Up to date topographic maps and data can be produced and maintained through the adoption of data sharing programs and arrangements, incremental updates, and through a modification of the present production and maintenance schedules. These modifications to the existing schedules would maximise the availability of contemporary products with the incrementally maintained data used in their production. Through the adoption of these individual production systems, the data used for map production would be constantly maintained. This allows for the printed topographic maps to contain information that is both temporally and spatially accurate at the time of production.

The system itself is not complicated. There needs to be a commitment from organisations, both public and private to recognise the benefits of contemporary spatial information, to be involved, and benefit from accessing accurate topographic maps. The system ultimately will provide data with the content and consistency that the mapping public desire within a desirable production timeframe using economic best practice. The change detection system was also shown to be suitable for spatial data output in the form of on demand topographic mapping as well as providing current information in a timely manner, which when implemented will improve temporal accuracy, aspatial attribution and spatial position.

The research has outlined a product and established a methodology that addresses the needs of geographic information customers. These requirements can be clearly categorised as consistent, complete, current, and correct. The “Now Map” will provide not only these but also specialised topographic data and map related products as well.

5.4 - Future Research Opportunities

Our understanding of the world is built up of innumerable layers. Each layer is worth exploring, as long as we do not forget that it is one of many. Knowing all there is to know about one layer – a most unlikely event – would not teach us much about the rest.

(Harold 1986, p. 91)

Despite the ability to record the spatial position of a feature using a variety of tools including rectified imagery and GPS, there is still, as demonstrated during the data sharing trial, a degree of variation in the allocation of attribution to a particular feature. Future research opportunities focusing on the accurate attribution of spatial features include the automated identification of features from hyperspectral imagery through the use of unique spectral signatures, and the automated extraction of features from multispectral imagery using band slicing techniques.

Additional research should also be considered in the investigation of image fusion techniques for feathering in the generation of mosaics. This would enable the creation of additional map products through the merging of image data with different temporal accuracies. Additional opportunities also exist in the areas of SAR exploitation and manmade object detection, multisensor image fusion and object level change detection (Pacific Sierra Research 2001).

As the mapping public becomes further technologically advanced, research should also be considered in the automated generalisation of features in relation to their anticipated production scale. Available tools may include the following for use in field collection and ground truthing.

> *... in the wireless world, cell phones, personal digital assistants (PDA's), laptops and car computers soon will be 'wireless, position-aware internet devices'. They will be position-aware via calculations of signal power from multiple nearby cellular communications transmitting antennas or built-in Global Positioning System (GPS) or other location determining technologies*
>
> (Lake 2001, p. 39).

An additional load on the available resource may result, without the development of appropriate methodology and a suite of automated generalisation tools.

Specific research opportunities identified during the study, in addition to those above, may be undertaken in respect to resource planning, data sharing agreements and automated online supply, and the process of allocating geographic names. These include:

- Investigate the benefits available from, the use of online data entry and reporting mechanisms similar to that used by Hydrographic Office for their Notice to Mariners and due to the increasing number of available online names databases, the scope for cooperative incremental data sharing agreements;

- Develop protocols to allow for an estimation of resource requirements and enable continuing forward planning for mapping programs, investigating the total change in the built environment;

- Ascertain the usefulness of each gazette amendment entry and the map face modifications required for their action within an active production environment thus providing a more accurate assessment of the maintenance process;

- Investigate whether any benefit would exist, from modifying the Geographical Names Register to accommodate the minimum bounding rectangle (mbr) for each feature, and all topographic sheets applicable to their extent (for example Great Dividing Range), for the purpose of automated text manipulation and maintenance; and

- Matching the allocation of geographic names to the current topographic map program or vice versa, to ascertain whether a pattern existed with respect to maps, decision making bodies, and individual locations.

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LIST OF APPENDICES

Appendix A

Glossary

Sources

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[B] Glossary of Terms 2000, URISA

[C] Canri Glossary, viewed 14 May 2004, <http://www.canri.nsw.gov.au/glossary.html>

[D] Glossary of Terms, 2002, Geoscience Australia, viewed 28 April 2004, <http://www.ga.gov.au/about/glossary.jsp>

Australian Spatial Data Infrastructure (ASDI)
The Australian Spatial Data Infrastructure is a national initiative to provide better access to all Australians to essential geographic information (spatial data). The primary objective of ASDI is to ensure that users of spatial data will be able to acquire consistent data sets to meet their requirements, even though the data is collected and maintained by different authorities. The national infrastructure helps ensure all such authorities concern themselves with the national interest, thereby maximising governments' return on investment in data collection and maintenance.

[C]

Cadastre
A public record, survey, or map of the value, extent, and ownership of land as a basis of taxation. See also **multipurpose cadastre**.

[B]

Cartography
The science and art of making maps and charts.

[B]

Gazetteer
A comprehensive authoritive list of geographic features and their spatial coordinates.

[C]

Geocode
To use a spatial feature name or address to produce a mappable location expressed in spatial coordinates.

[C]

Geodesy
The geologic science of measuring the size and shape of the earth.

[B]

Interoperabillity
The ability of independent, distributed software components to operate together as part of a larger system.

[C]

Metadata
"Data about data"; describes the content, quality, currency and availability of data. Essential for discovering data and determining its suitability for a particular use.

[C]

Multipurpose cadastre
A comprehensive land information system at the parcel level. Land base includes all parcel boundaries, right-of-ways, and easements with each parcel linked to supporting attribute records such as a survey control network land use, land cover, or political boundaries.

[B]

National spatial data infrastructure (NSDI) (USA)
Coordinated by the Federal Geographic Data Committee (FGDC), the NSDI encompasses policies, standards, and procedures for organizations to cooperatively produce and share geographic data. The 17 federal agencies that make up the FGDC are developing the NSDI in cooperation with organizations from state, local and tribal governments, the academic community, and the private sector.

[B]

Parcel
A portion of the earth defined by a boundary. In GIS, usually a plot of land inside of which certain assigned rights apply regarding occupancy and/or use of land, air, or water. The most significant is the ownership parcel that serves as the basic land entity for defining responsibilities of the individual and governments regarding land use and occupancy.

[B]

Photogrammetry
1) The process of making maps or scale drawings from photographs, especially aerial photographs.
2) The process of making precise measurements by means of photography.

[B]

Projection
A mathematical method for representing the shape of the earth on a flat plane; a formula that converts latitude-longitude locations on the earth's spherical surface to X, Y locations on a map's flat surface.

[B]

Raster
An image containing individual dots with color values, called cells (or pixels), arranged in a rectangular, evenly spaced array. Aerial photographs and satellite images are examples of raster images used in mapping.

[B]

Rectification
A set of techniques for removing data errors through calculation or adjustment. In image processing, computer programs that remove distortion within a digital image, aerial photography, or remotely sensed data by removing parallax errors due to relief (high ground being closer to the camera than low lying areas), camera tilt, awkward corners, and other distortions.

[B]

Remote sensing
The process of obtaining information about land, water, or an object without any physical contact between the instrument doing the sensing and the subject. Remote sensing most often refers to collecting data using instruments aboard aircraft or satellites.

[B]

Topographic Surveying
Involves establishing the contour level and interval of the earths surface above and below sea level based on a particular control survey system. These surveys may be done by aerial, photogrammetric and ground survey and involves recording of natural features such as hills, streams, valleys and cultural features such as roads, bridges, railways, etc. These surveys are used to make topographic maps.

[D]

Topography
A description of all the physical features of an area of land and their relative positions, either in words or by way of a map.

[A]

Vector
Any quantity having both amount and direction. Vectors are usually represented by directed line segments; the length of the line segment shows the vector quantity, and its direction is the same as that of the vector. A vector map contains the data about lines that allows the computer to calculate length and direction. This is contrasted with a raster map that displays images but not the data for line calculation.

[B]

Virtual reality modeling language (VRML)
Used to serve three-dimensional information over the Internet using a VRML browser. In recent years the potential for visualizing urban spaces, elevation information, surface conditions, and other similar applications have found widespread use in planning and community participation process over the Internet.

[B]

NSW Government

Ministerial Portfolios

NSW Government Ministerial Portfolios (as at 06 Jan 2004)

- Aboriginal Affairs
- Agriculture and Fisheries
- Arts
- Attorney General
- Central Coast
- Citizenship
- Commerce
- Community Services
- Disability Services and Ageing
- Education and Training
- Emergency Services
- Energy and Utilities
- Environment
- Fair Trading
- Gaming and Racing
- Health
- Housing
- Hunter
- Illawarra
- Industrial Relations
- Infrastructure and Planning
- Justice
- Juvenile Justice
- Local Government
- Mineral Resources
- Natural Resources
- Police
- Premier
- Regional Development
- Roads
- Rural Affairs
- Science and Medical Research
- Small Business
- State
- State Development
- Tourism and Sport and Recreation
- Transport Services
- Treasurer
- Western Sydney
- Women
- Youth

Source: http://www.directory.nsw.gov.au

NSW Topographic Map Production Statistics: 1949 to October 2002

Appendix C: Map Production Statistics – 1949 to October 2002

Year Range	Photo to Field							Field to Print							Photo to Print						
	Edition			Scale (1:x)				Edition			Scale (1:x)				Edition			Scale (1:x)			
	1st	2nd	3rd	25000	31680	50000	100000	1st	2nd	3rd	25000	31680	50000	100000	1st	2nd	3rd	25000	31680	50000	100000
Less than 1	22	2	4	22	2	3	1	32	65	56	117	3	6	27	-	-	-	-	-	-	-
1 - 2	145	58	61	212	-	26	26	403	249	57	481	94	58	76	7	13	17	34	1	-	2
2 - 3	218	103	41	304	3	38	17	518	144	19	440	75	106	60	49	37	59	128	1	11	5
3 - 4	252	121	26	320	17	41	21	148	66	-	135	10	52	17	149	49	45	195	1	31	16
4 - 5	146	102	-	141	11	61	35	28	11	-	17	2	17	3	226	83	10	276	3	18	22
5 - 6	137	100	-	127	32	31	47	15	-	-	5	3	3	4	212	174	1	258	23	42	64
6 - 7	79	37	-	53	34	15	14	10	-	-	-	4	2	4	177	97	-	178	18	53	25
7 - 8	53	9	-	14	36	5	7	-	-	-	-	-	-	-	95	56	-	87	24	31	9
8 - 9	28	-	-	-	25	-	3	1	-	-	-	1	-	-	91	22	-	30	47	21	15
9 - 10	29	-	-	-	11	11	7	-	-	-	-	-	-	-	37	1	-	2	20	10	6
10 - 11	19	2	-	2	9	2	8	-	-	-	-	-	-	-	41	-	-	4	21	7	9
11 - 12	13	-	-	-	9	4	-	1	1	-	2	-	-	-	28	1	-	1	13	6	9
12 - 13	10	2	-	2	4	6	-	-	-	-	-	-	-	-	16	1	-	1	11	1	4
13 - 14	4	-	-	-	-	1	3	1	-	-	-	1	-	-	9	2	-	2	4	5	-
14 - 15	1	-	-	-	-	-	1	-	-	-	-	-	-	-	11	-	-	-	3	7	1
Over 15	1	-	-	-	-	-	1	-	-	-	-	-	-	-	9	-	-	1	3	1	4

Gazette Amendments by Organisation

Appendix D: Pilot Study - Gazette Amendments by Organisation

Organisations	**Entries**	**Potential Amendments**
Bathurst City Council	1	1
Cooma Monaro Shire Council	1	1
Corrective Services	1	1
Evans Shire Council	1	1
Hornsby Shire Council	1	1
Lake Macquarie City Council	1	1
Land and Housing Corporation	1	1
Lithgow City Council	1	1
Liverpool City Council	1	1
Local Government	1	1
Midcoast County Council	1	1
Oberon Council	1	1
Queanbeyan City Council	1	1
Richmond Valley Council	1	1
Shellharbour City Council	1	1
Shoalhaven City Council	1	1
Sport and Recreation	1	1
Wyong Shire Council	1	1
Parramatta City Council	1	2
Wagga Wagga City Council	1	2
Waringah Council	2	2
Weddin Shire Council	2	2
Baulkham Hills Shire Council	3	3
Blacktown City Council	3	3
Forests NSW	3	3
Housing	3	3
Hastings Council	3	4
NPWS	4	4
DITM	2	5
Education and Training	3	5
Port Stephens Council	2	5
South Sydney City Council	1	5
Transgrid	5	6
Public Works	4	7
District Court	4	8
Rural Lands Protection Act	1	8
Bega Valley Shire Council	5	9
Greater Taree City Council	6	11
NSW Fire Brigades	4	11
Tweed Shire Council	7	11
Rail Infrastructure Corporation	2	13
Supreme Court	1	14

Mineral Resources	16	25
Inverell Shire Council	1	33
Aboriginal Affairs	3	34
NSW Fisheries	15	65
DUAP	52	80
RTA	30	88
Sydney Water	29	174
GNB	19	217
DLWC	132	244
Total	**387**	**1124**

Geographical Names Summary

Appendix E: Geographic Names Summary

Map Name	Balranald	Bedulluck	Berridale	Berrigan	Berry	Bimlow	Bobadah	Bombala	Botany Bay	Broken Bay	Canberra	Capertee	Cessnock	Coombadjha	Cootamundra	Dalton	Denman	Dunoon	Eden	Ellangowan
Scale / Date	50	25	50	50	25	25	100	25	25	25	25	25	25	25	50	50	25	25	25	25
7-Dec-01																				
14-Dec-01																				
21-Dec-01									1	1									1	
28-Dec-01																				
4-Jan-02																				
11-Jan-02																				
18-Jan-02																				
25-Jan-02																				
1-Feb-02																				
8-Feb-02																				
15-Feb-02																				
22-Feb-02																				
1-Mar-02																				
8-Mar-02												1	1					1		
15-Mar-02																				
22-Mar-02																				
29-Mar-02																				
5-Apr-02																				
12-Apr-02			1	2			1				2			1		2	1			
19-Apr-02						4									1					
26-Apr-02	6																			
3-May-02																				
10-May-02																				
17-May-02																				
24-May-02																				
31-May-02		1			2			1												1
7-Jun-02																				
14-Jun-02																				
	6	1	1	2	2	4	1	1	1	1	2	1	1	1	1	2	1	1	1	1
268																				

Map Name	Grafton	Hall	Hornsby	Huonbrook	Huskisson	Jerilderie	Keewong	Kilparney	Kulnura	Lismore	Maitland	Malara Creek	Mittagong	Moree	Morisset	Nymagee	Parramatta River	Port Hacking	Port Stephens
Scale / Date	25	25	25	25	25	50	100	100	25	25	25	25	25	50	25	100	25	25	25
7-Dec-01																			
14-Dec-01	1			1	1	1											1		1
21-Dec-01			1					1	1							12			
28-Dec-01																			
4-Jan-02																			
11-Jan-02																			
18-Jan-02																			
25-Jan-02																			
1-Feb-02																			
8-Feb-02																			
15-Feb-02																			
22-Feb-02																			
1-Mar-02																			
8-Mar-02										1							2	1	
15-Mar-02																			
22-Mar-02																			
29-Mar-02																			
5-Apr-02																			
12-Apr-02		2					1				3	2		2			2		
19-Apr-02		2																	
26-Apr-02																			
3-May-02																			
10-May-02																			
17-May-02																			
24-May-02																			
31-May-02			1												1		2		
7-Jun-02																			
14-Jun-02													1						
	1	4	2	1	1	1	1	1	1	1	3	2	1	2	1	12	7	1	1
268																			

Map Name	Prospect	Riverstone	Sebastapol	Stroud Road	Suggan Buggan	Swansea	Sydney Heads	Temora	Thackaringa	The Meadows	Tongo	Turlee	Tweed Heads	Wallsend	Wee Waa	Whiporie	Winton	Wollongong	Yass	Not Specified	Erratum	Modified Boundaries
Scale / Date	25	25	50	25	50	25	25	50	100	100	100	100	25	25	50	25	25	25	50			
7-Dec-01																						
14-Dec-01	3				1		1							2			1					
21-Dec-01		1																1		40		4
28-Dec-01																						
4-Jan-02																						
11-Jan-02		1																				3
18-Jan-02																						
25-Jan-02																						
1-Feb-02																						
8-Feb-02																					4	
15-Feb-02																					2	
22-Feb-02																					2	
1-Mar-02																						
8-Mar-02	1												1	1								
15-Mar-02																						
22-Mar-02																					1	
29-Mar-02																						
5-Apr-02																						
12-Apr-02				1					2	8		1			1	1			1			
19-Apr-02																						
26-Apr-02			1					2												69	4	14
3-May-02																						
10-May-02																						
17-May-02																					3	
24-May-02																						
31-May-02	1					2	1				1			1							1	
7-Jun-02																					1	6
14-Jun-02																						
	5	2	1	1	1	2	2	2	2	8	1	1	1	4	1	1	1	1	1	109	18	27
268																						

Road Name Summary

Appendix F: Road Names Summary

Date / Council	Baulkham Hills	Bega Valley	Bellingen	Blacktown	Bombala	Blue Mountains	Byron	Cessnock	Dungog	Gundagai	Hastings	Hume	Kempsey	Ku-ring-gai	Lake Macquarie	Lane Cove	Leeton	Lithgow	Lockhart	Narromine	Oberon	Parkes	Penrith	Quirindi	Severn	Shellharbour	Shoalhaven	Singleton	Snowy River	Tumbarumba	Uralla	Waverley	Wyong
7-Dec-01								1											3														
14-Dec-01																										10						1	
21-Dec-01										1												5											
28-Dec-01					2																												
4-Jan-02																																	1
11-Jan-02															4															8			
18-Jan-02											1																						
25-Jan-02													1					2			2		1										19
1-Feb-02						3																											
8-Feb-02																		1		8													
15-Feb-02																	2		4														
22-Feb-02																												1					
1-Mar-02																															50		
8-Mar-02																																	9
15-Mar-02																																	
22-Mar-02																									158								
29-Mar-02																								1									
5-Apr-02																																	
12-Apr-02		1										2		1															7				
19-Apr-02																														5			
26-Apr-02																																	
3-May-02				1						1					1															2			
10-May-02	1			1																													
17-May-02	1		3	1												1											2						
24-May-02	1																																
31-May-02				1																													
7-Jun-02									1														1										
14-Jun-02							4			1																							
Total	3	1	3	4	2	3	4	1	1	3	1	2	1	1	5	1	2	3	7	8	2	5	2	1	158	10	2	1	7	15	50	1	29
Ads	3	1	1	4	1	1	1	1	1	3	1	1	1	1	2	1	1	2	2	1	1	1	2	1	1	1	1	1	1	3	1	1	3

Aquaculture Lease Summary

Appendix G: Aquaculture Lease Summary

				Estuary																																
Gazette Date	Cancelled / Revoked / Withdrawn	Grants	Renewal	Bellinger River	Brisbane Water	Camden Haven	Camden River	Clarence River	Clyde River	Crookhaven River	Georges River - Lime Kiln Bay	Georges River - Quibray Bay	Georges River - Woolooware Bay	Hastings River	Hawkesbury River	Hunter River	Macleay River	Manning River	Merimbula Lake	Moruya River	Nambucca River	Narrawallee Creek	Pambula River	Patonga Creek	Port Stephens	Port Stephens - Karuah	Port Stephens - Nelson Bay	Port Stephens - Tea Gardens	Richmond River	Sandon River	Towamba River - Kiah Inlet	Tuross Lake	Wagonga Inlet	Wallis Lake	Wapengo Lake	Wonboyn River
7-Dec-01																																				
14-Dec-01	59/275																						W													
14-Dec-01	59/379																																			W
14-Dec-01	63/145																						W													
14-Dec-01	64/165																	W																		
14-Dec-01	73/300																																			W
14-Dec-01	73/401																																			W
14-Dec-01	73/426																																			W
14-Dec-01	74/187																																			W
14-Dec-01	81/087																						W													
14-Dec-01	83/064																																			W
14-Dec-01	84/112																																			W
14-Dec-01	90/031								W																											
14-Dec-01		00/038															G																			
14-Dec-01		01/002																					G													
14-Dec-01			57/280						R																											
14-Dec-01			71/271							R																										
14-Dec-01			83/088		R																															
14-Dec-01			88/041						R																											
14-Dec-01			97/033			R																														
21-Dec-01																																				
28-Dec-01																																				
4-Jan-02	59/007																																W			
4-Jan-02	61/021														W																					
4-Jan-02	64/165																	W																		
4-Jan-02	67/006						W																													
4-Jan-02	72/290																																W			
4-Jan-02	84/142																																W			
4-Jan-02	90/031								W																											
4-Jan-02	93/015									W																										

4-Jan-02	97/032					W																														
4-Jan-02		00/031																														G			
4-Jan-02		00/038														G																			
4-Jan-02		00/044																													G				
4-Jan-02		00/049								G																									
4-Jan-02		00/051				G																													
4-Jan-02		00/052				G																													
4-Jan-02		84/165																															G		
4-Jan-02		99/013				G																													
4-Jan-02		99/014				G																													
4-Jan-02		99/015				G																													
4-Jan-02		99/016				G																													
4-Jan-02		99/029																								G										
4-Jan-02		99/031				G																													
4-Jan-02		99/032				G																													
4-Jan-02		99/033				G																													
4-Jan-02			57/208						R																										
4-Jan-02			70/051																						R											
4-Jan-02			70/495																R																	
4-Jan-02			70/538												R																					
4-Jan-02			71/262						R																										
4-Jan-02			71/271							R																									
4-Jan-02			72/048												R																					
4-Jan-02			72/072																	R																
4-Jan-02			85/002																														R		
4-Jan-02			85/101						R																										
4-Jan-02			85/212															R																		
4-Jan-02			86/085																													R			
4-Jan-02			87/064		R																														
4-Jan-02			97/033			R																													
11-Jan-02																																				
18-Jan-02		90/029																								G										
18-Jan-02			70/538												R																					
18-Jan-02			71/132																													R				
25-Jan-02																																				
1-Feb-02																																				
8-Feb-02	86/145																W																			
8-Feb-02	91/028																W																			
8-Feb-02	93/014																W																			
8-Feb-02	58/055																W																			
8-Feb-02	77/190																W																			
8-Feb-02		99/021														G																				
8-Feb-02		99/022														G																				
8-Feb-02		01/019																											G							
8-Feb-02		96/076																										G								

8-Feb-02			71/216														R																			
8-Feb-02			86/208											R																						
8-Feb-02			71/225											R																						
8-Feb-02			86/205						R																											
8-Feb-02			70/537											R																						
8-Feb-02			86/076																																R	
8-Feb-02			85/086																														R			
8-Feb-02			86/111																		R															
8-Feb-02			71/156																							R										
8-Feb-02			84/186		R																															
8-Feb-02			71/253						R																											
8-Feb-02			57/014																															R		
8-Feb-02			57/190															R																		
8-Feb-02			71/173															R																		
8-Feb-02			84/068							R																										
8-Feb-02			84/128						R																											
8-Feb-02			84/169																													R				
15-Feb-02		01/014									G																									
15-Feb-02		01/015											G																							
15-Feb-02		01/016										G																								
15-Feb-02			70/295																				R													
15-Feb-02			71/150														R																			
15-Feb-02			71/181																																R	
15-Feb-02			71/302							R																										
15-Feb-02			71/400																R																	
15-Feb-02			85/147					R																												
15-Feb-02			86/066															R																		
15-Feb-02			86/150																											R						
15-Feb-02			87/032																								R									
15-Feb-02			88/044																				R													
22-Feb-02	69/177																W																			
1-Mar-02																																				
8-Mar-02			57/214																															R		
8-Mar-02			83/343		R																															
8-Mar-02			84/222	R																																
8-Mar-02			85/083													R																				
8-Mar-02			86/105																											R						
15-Mar-02																																				
22-Mar-02	69/476																																		W	
22-Mar-02	69/643																																		W	
22-Mar-02	81/129																																		W	
22-Mar-02	85/226																																		W	
22-Mar-02	86/150																											W								
22-Mar-02		00/045																																	G	
22-Mar-02		00/047																																	G	

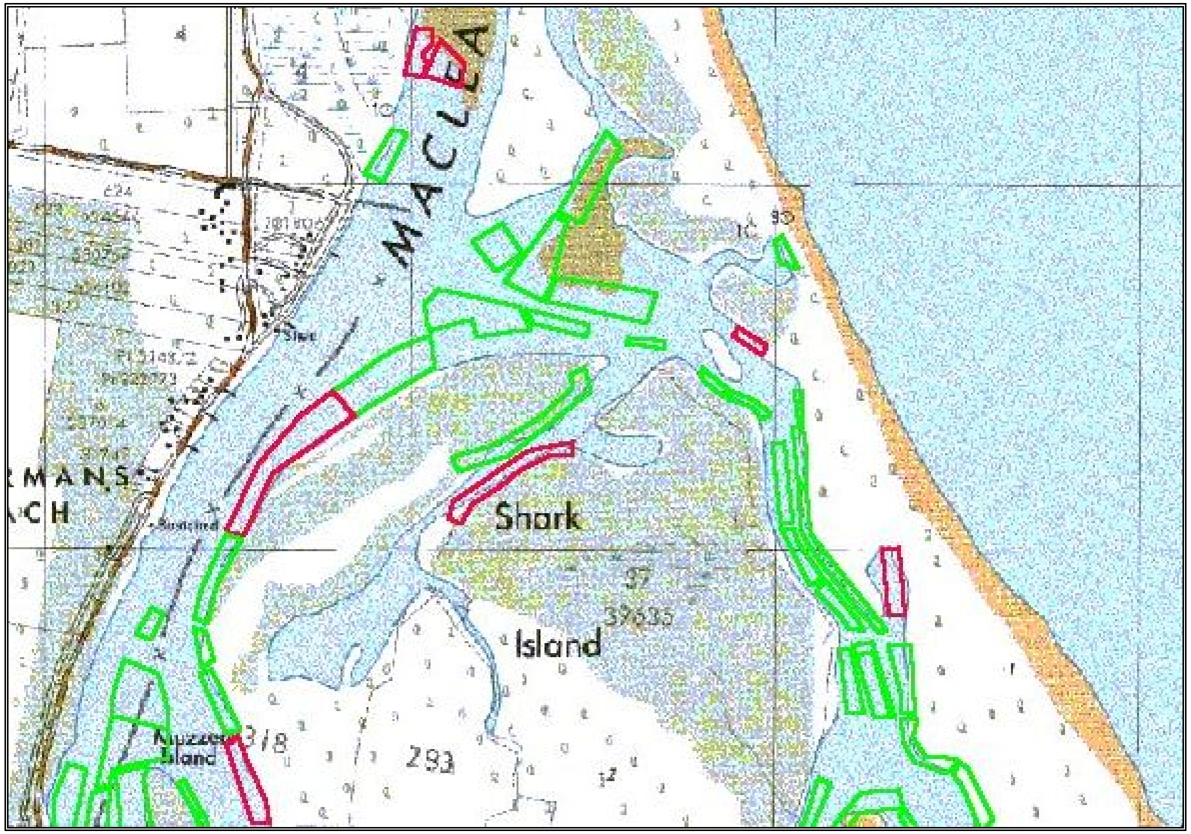
22-Mar-02		86/105																												G						
22-Mar-02			57/194											R																						
22-Mar-02			71/273												R																					
22-Mar-02			72/117						R																											
22-Mar-02			72/118						R																											
22-Mar-02			72/223																															R		
22-Mar-02			86/245															R																		
22-Mar-02			86/246															R																		
22-Mar-02			87/031																															R		
22-Mar-02			99/027																							R										
29-Mar-02																																				
5-Apr-02	61/198																											W								
5-Apr-02	72/266																											W								
5-Apr-02		01/028																										G								
5-Apr-02			56/233																															R		
5-Apr-02			58/061															R																		
5-Apr-02			71/226											R																						
5-Apr-02			72/257											R																						
5-Apr-02			85/007	R																																
5-Apr-02			85/008	R																																
5-Apr-02			86/190																		R															
5-Apr-02			86/191																		R															
5-Apr-02			86/194																												R					
5-Apr-02			86/215											R																						
5-Apr-02			87/156															R																		
5-Apr-02			87/157															R																		
5-Apr-02			88/086																							R										
5-Apr-02			89/007																									R								
12-Apr-02																																				
19-Apr-02	78/049																					W														
19-Apr-02	87/215				W																															
19-Apr-02			71/151							R																										
19-Apr-02			72/038															R																		
19-Apr-02			72/196																									R								
19-Apr-02			82/073																													R				
19-Apr-02			85/148											R																						
19-Apr-02			86/053		R																															
19-Apr-02			86/184																							R										
19-Apr-02			87/159																														R			
19-Apr-02			88/002																		R															
19-Apr-02			96/062																															R		
26-Apr-02																																				
3-May-02	60/010																																W			
3-May-02	65/174																																W			
3-May-02	66/171																																W			

3-May-02	80/144																																W			
3-May-02	83/100																																W			
3-May-02			85/163	R																																
10-May-02		00/032							G																											
10-May-02			71/314					R																												
10-May-02			71/407																									R								
10-May-02			86/171																																	R
10-May-02			87/188						R																											
17-May-02		00/053								G																										
17-May-02			56/186																							R										
17-May-02			56/214											R																						
17-May-02			57/052																					R												
17-May-02			72/239											R																						
17-May-02			72/324																							R										
17-May-02			85/155																	R																
17-May-02			86/151											R																						
17-May-02			86/176							R																										
17-May-02			87/012													R																				
17-May-02			87/017						R																											
17-May-02			87/027						R																											
24-May-02																																				
31-May-02			71/230															R																		
31-May-02			71/408																							R										
31-May-02			72/066															R																		
31-May-02			86/250																															R		
31-May-02			87/011						R																											
7-Jun-02																																				
14-Jun-02																																				
Totals				4	6	12	1	2	17	9	1	1	1	14	2	2	8	19	2	2	3	1	7	1	6	4	6	1	1	4	1	4	12	9	8	8
179	41	31	107																																	
			W	0	1	1	1	0	2	1	0	0	0	0	1	0	1	7	0	0	0	1	3	0	0	0	2	0	0	1	0	0	8	0	4	7
			G	0	0	9	0	0	1	2	1	1	1	0	0	0	4	0	0	0	0	0	1	0	2	0	2	1	0	1	0	1	1	1	2	0
			R	4	5	2	0	2	14	6	0	0	0	14	1	2	3	12	2	2	3	0	3	1	4	4	2	0	1	2	1	3	3	8	2	1

Data Sharing Example 1:

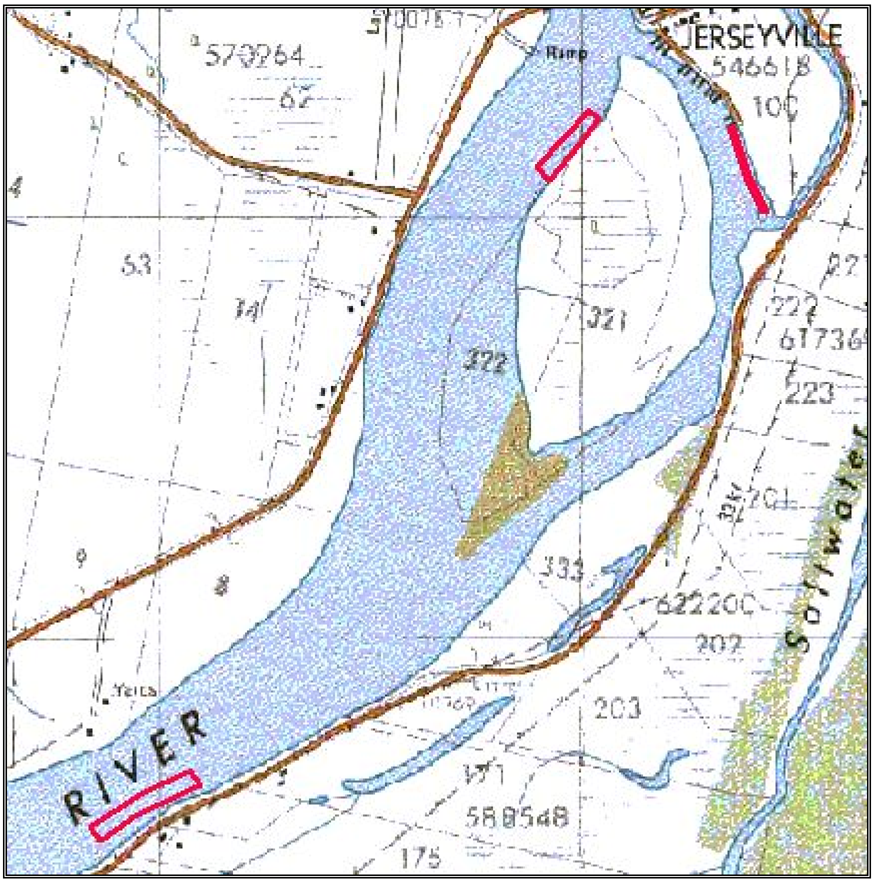
NSW Fisheries – Macleay Estuary Oyster Leases

Appendix H-1: Eungai (9436-2-N)



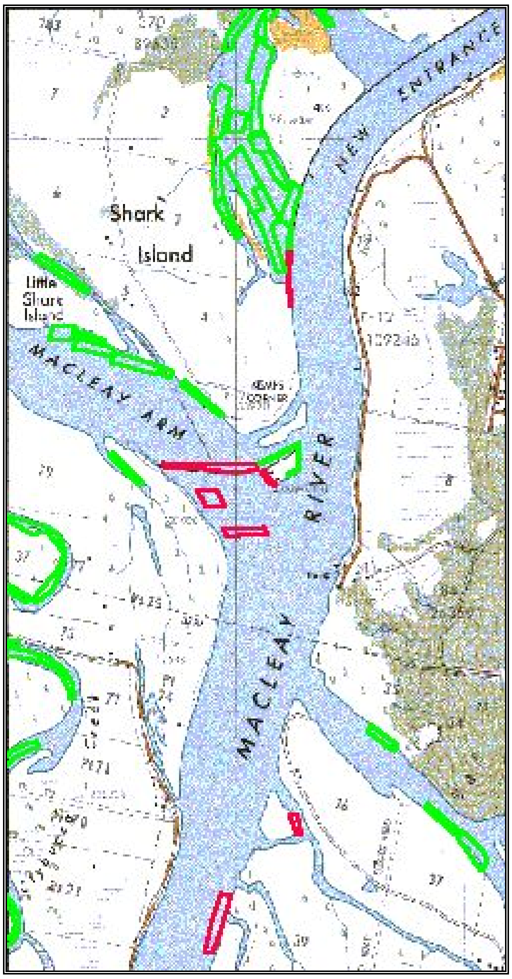
Oyster lease data integrated with Eungai 1:25000 topographic map

Appendix H-2: South West Rocks (9536-3-S)



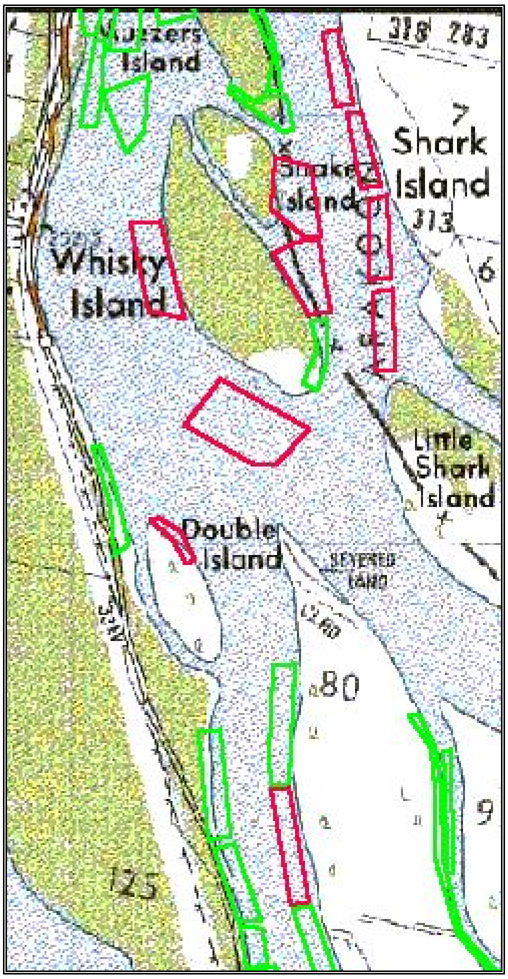
Oyster lease data integrated with South West Rocks 1:25000 topographic map

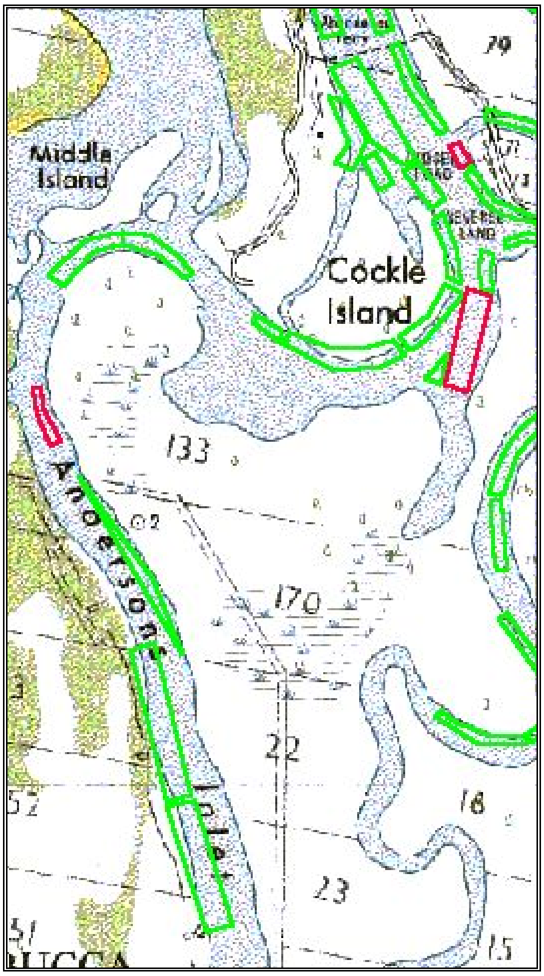
Appendix H-3



Oyster lease data integrated with South West Rocks 1:25000 topographic map

Appendices H-4 and H-5: Clybucca (9436-2-S)





Oyster lease data integrated with Clybucca 1:25000 topographic map

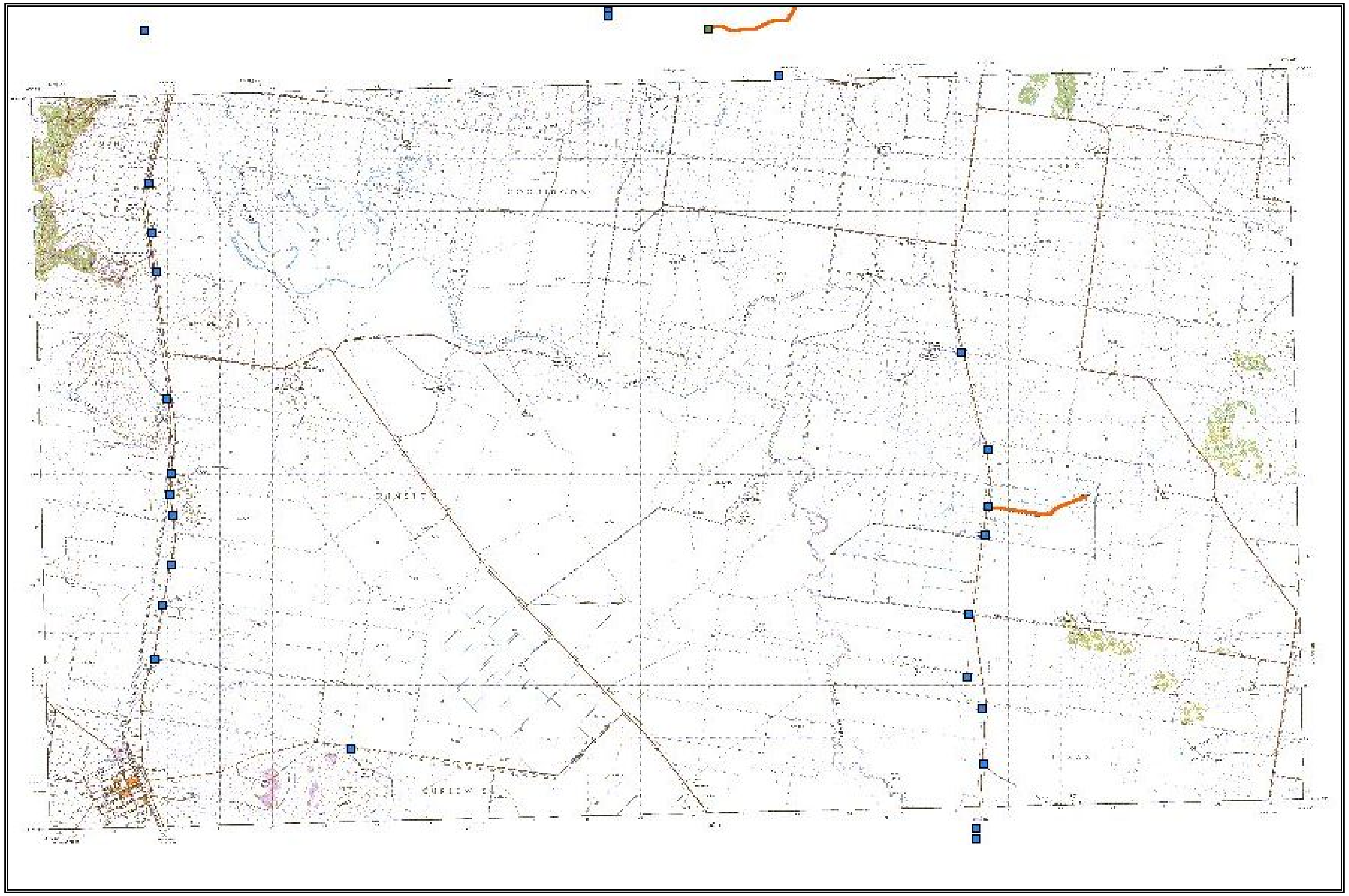
Data Sharing Example 2:

Gunnedah Shire Council –

Property Access

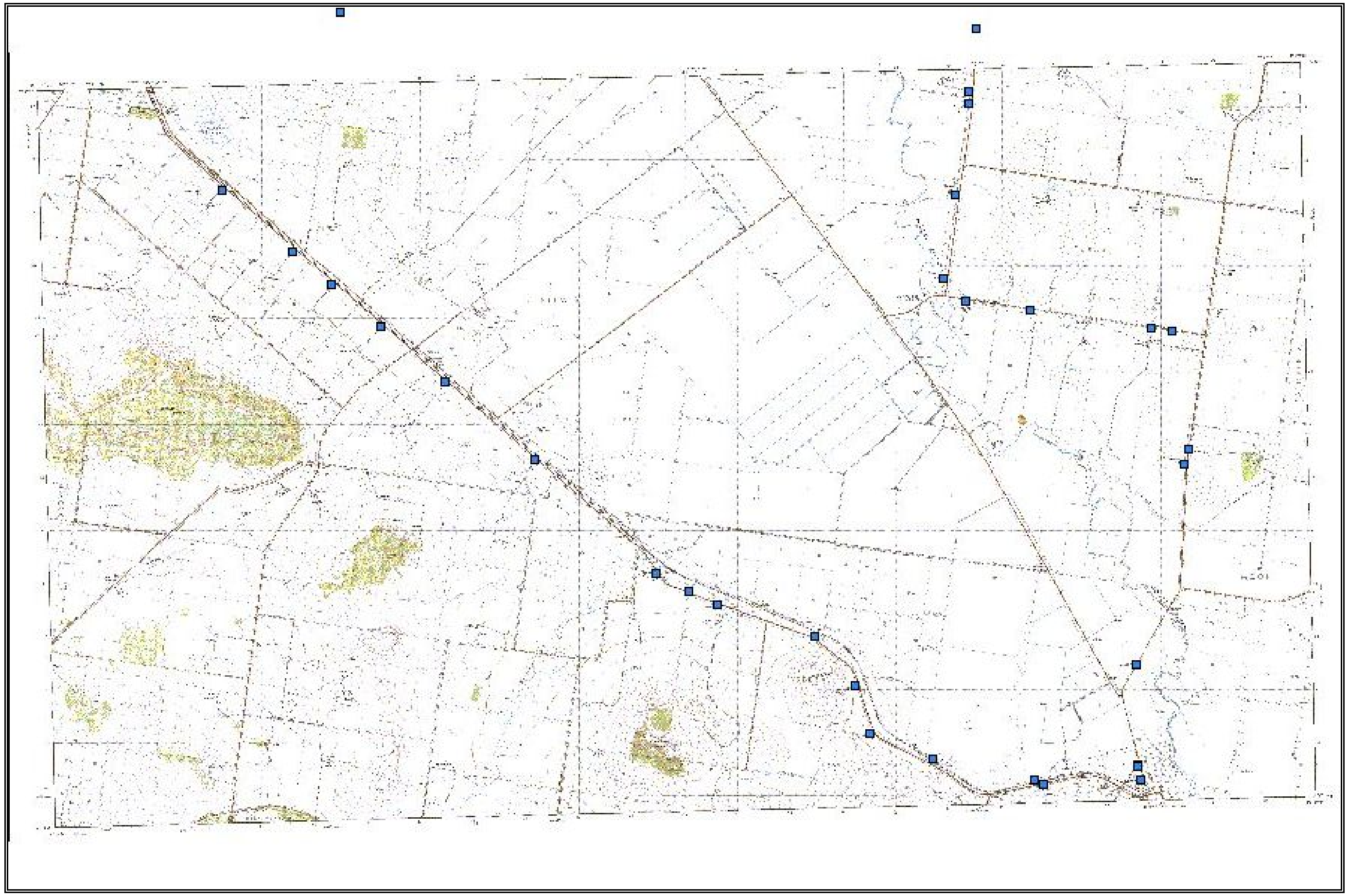
Information

Appendix I-1: Curlewis (8935-1n)



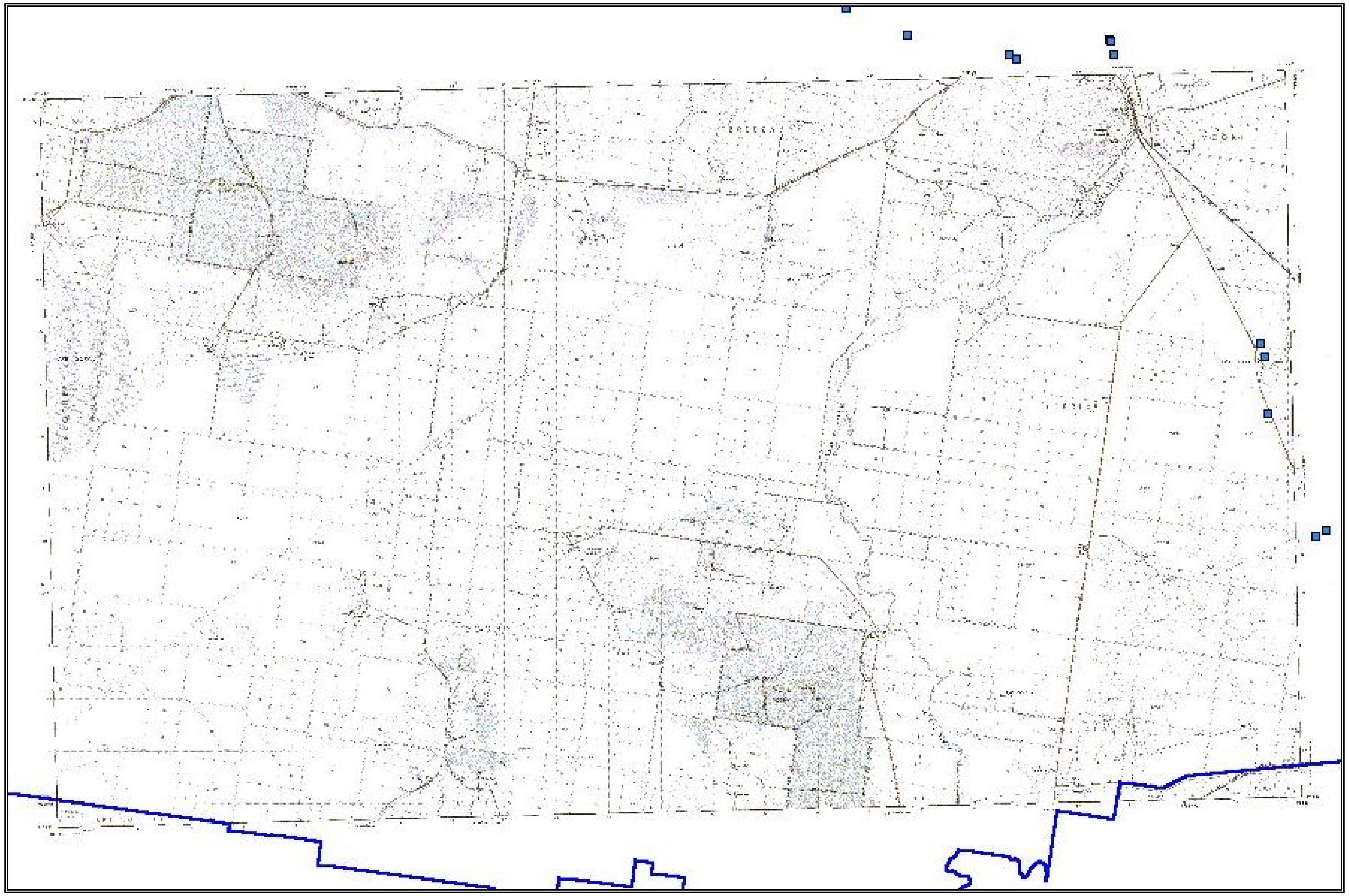
Gunnedah Shire data integrated with Curlewis 1:25000 topographic map

Appendix I-2: Watermark (8935-1s)



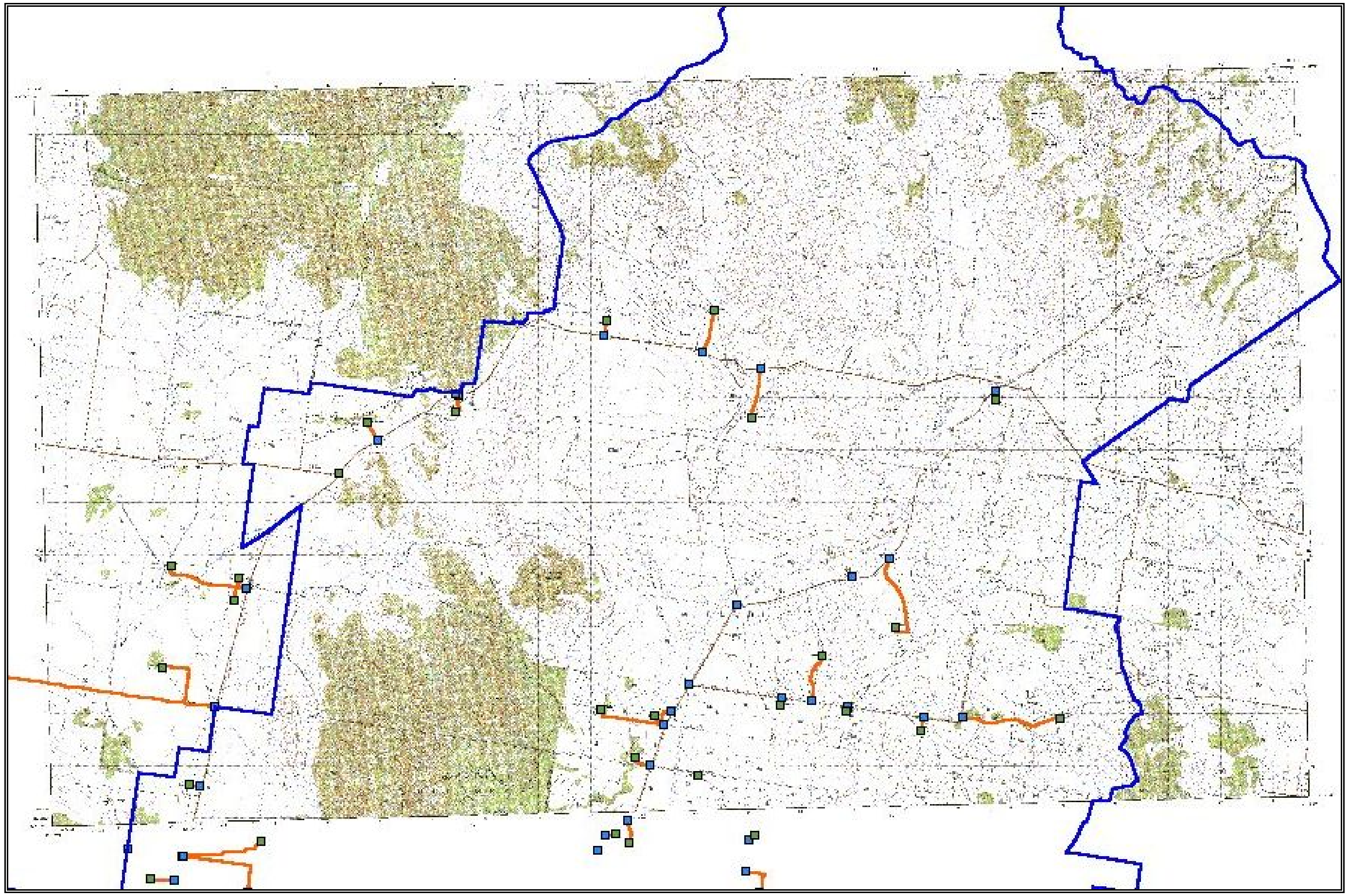
Gunnedah Shire data integrated with Watermark 1:25000 topographic map

Appendix I-3: Breeza (8935-2n)



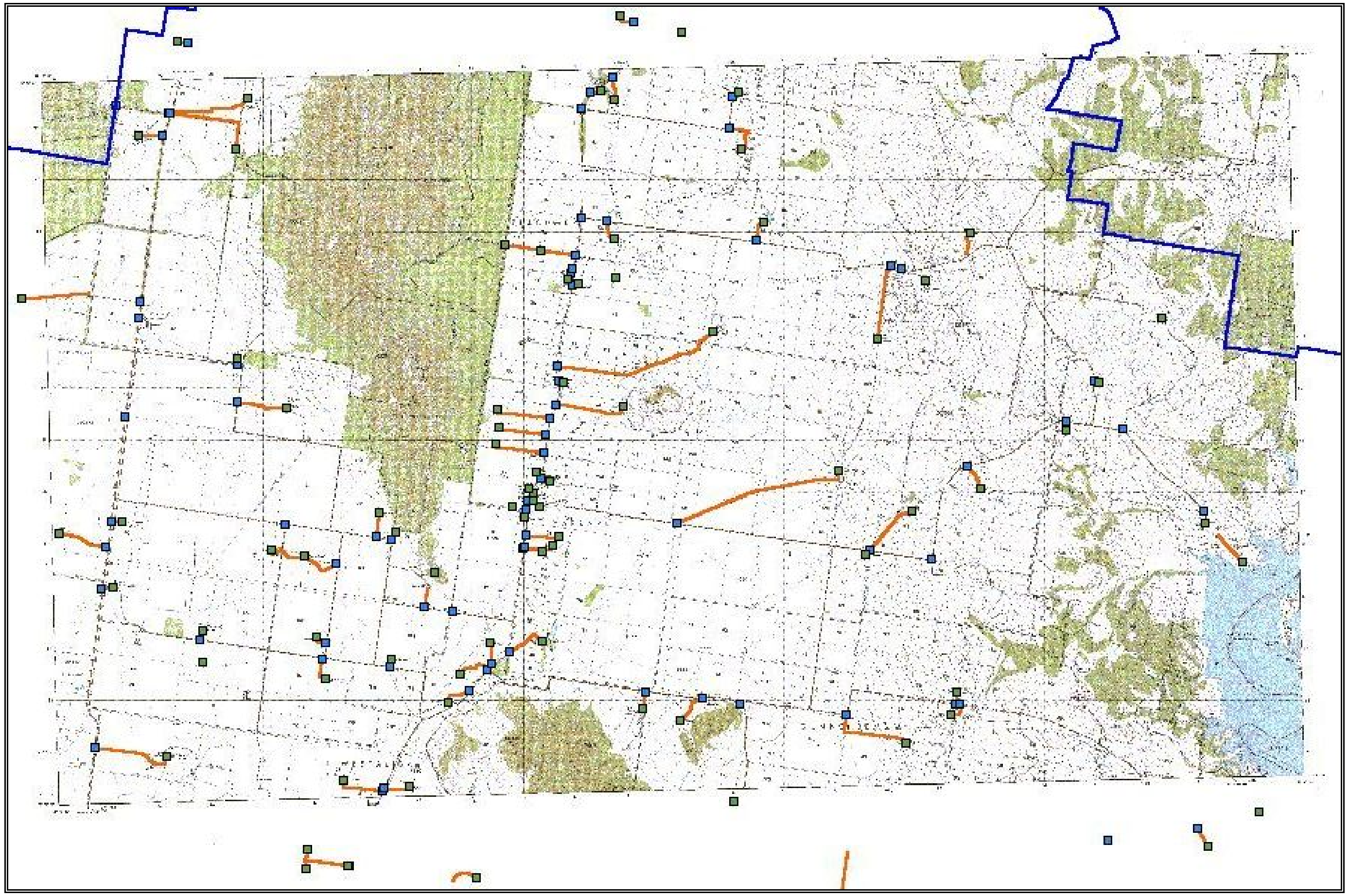
Gunnedah Shire data integrated with Breeza 1:25000 topographic map

Appendix I-4: Willuri (8936-1s)



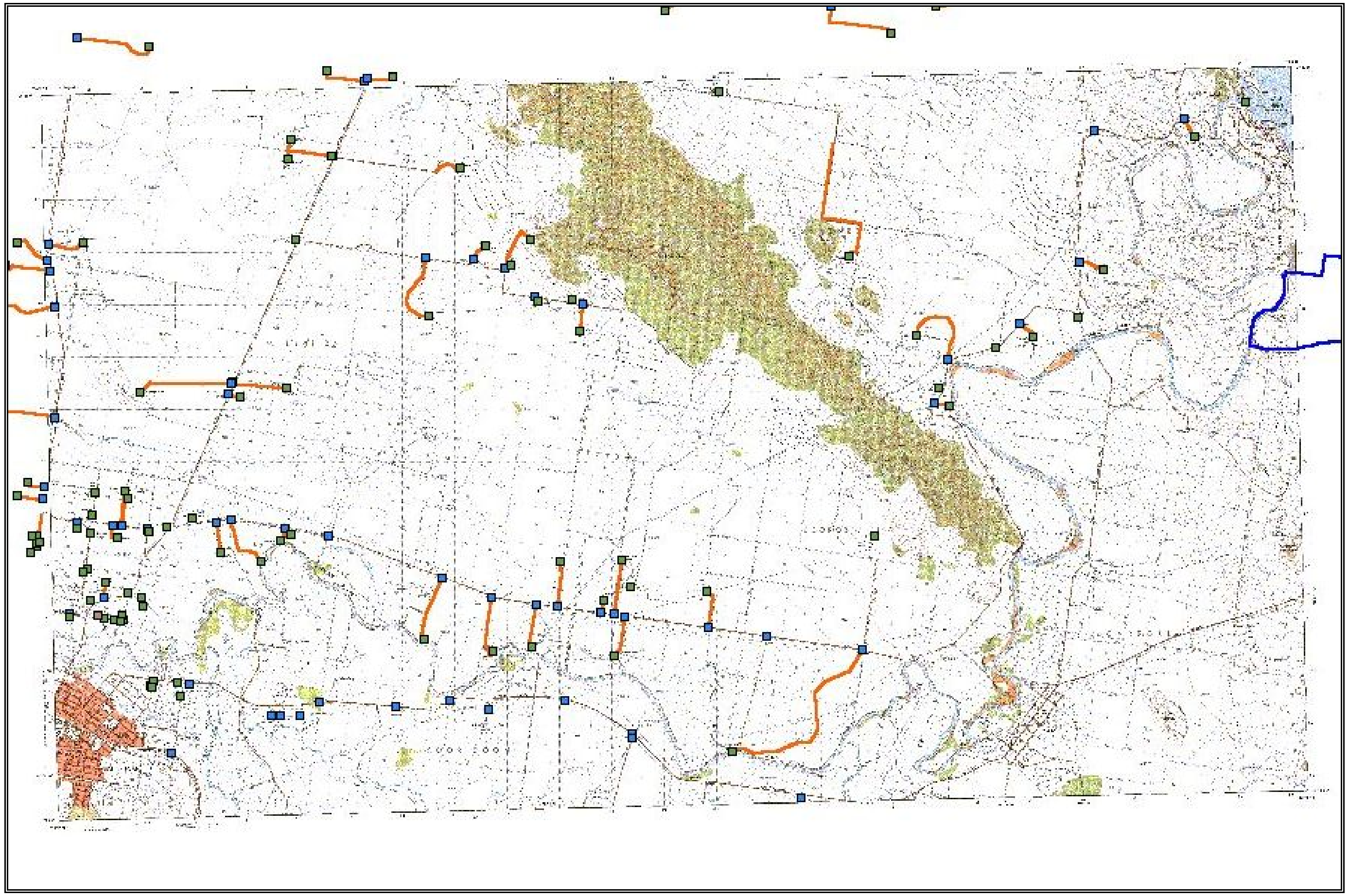
Gunnedah Shire data integrated with Willuri 1:25000 topographic map

Appendix I-5: Kelvin (8936-2n)



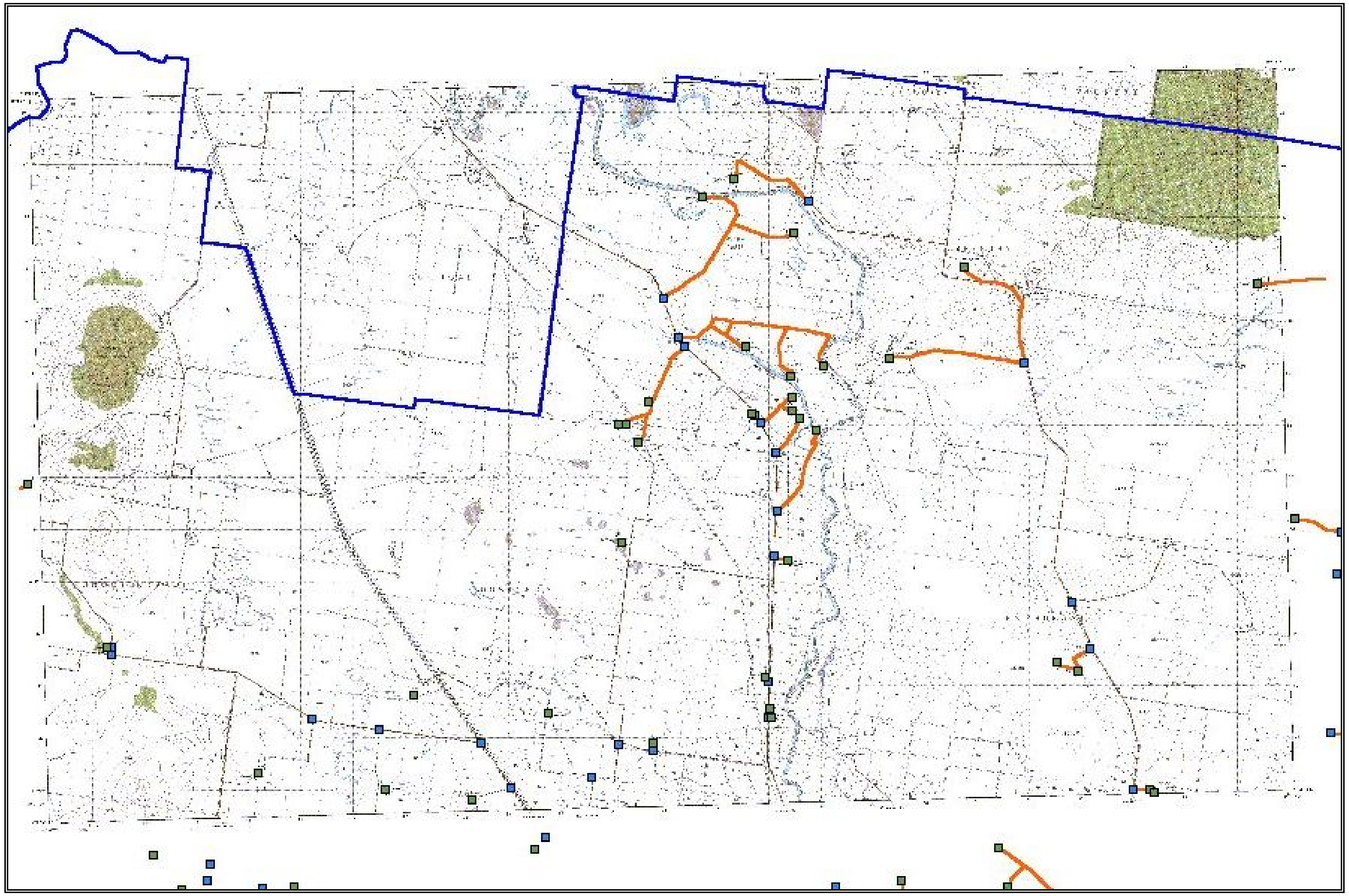
Gunnedah Shire data integrated with Kelvin 1:25000 topographic map

Appendix I-6: Gunnedah (8936-2s)



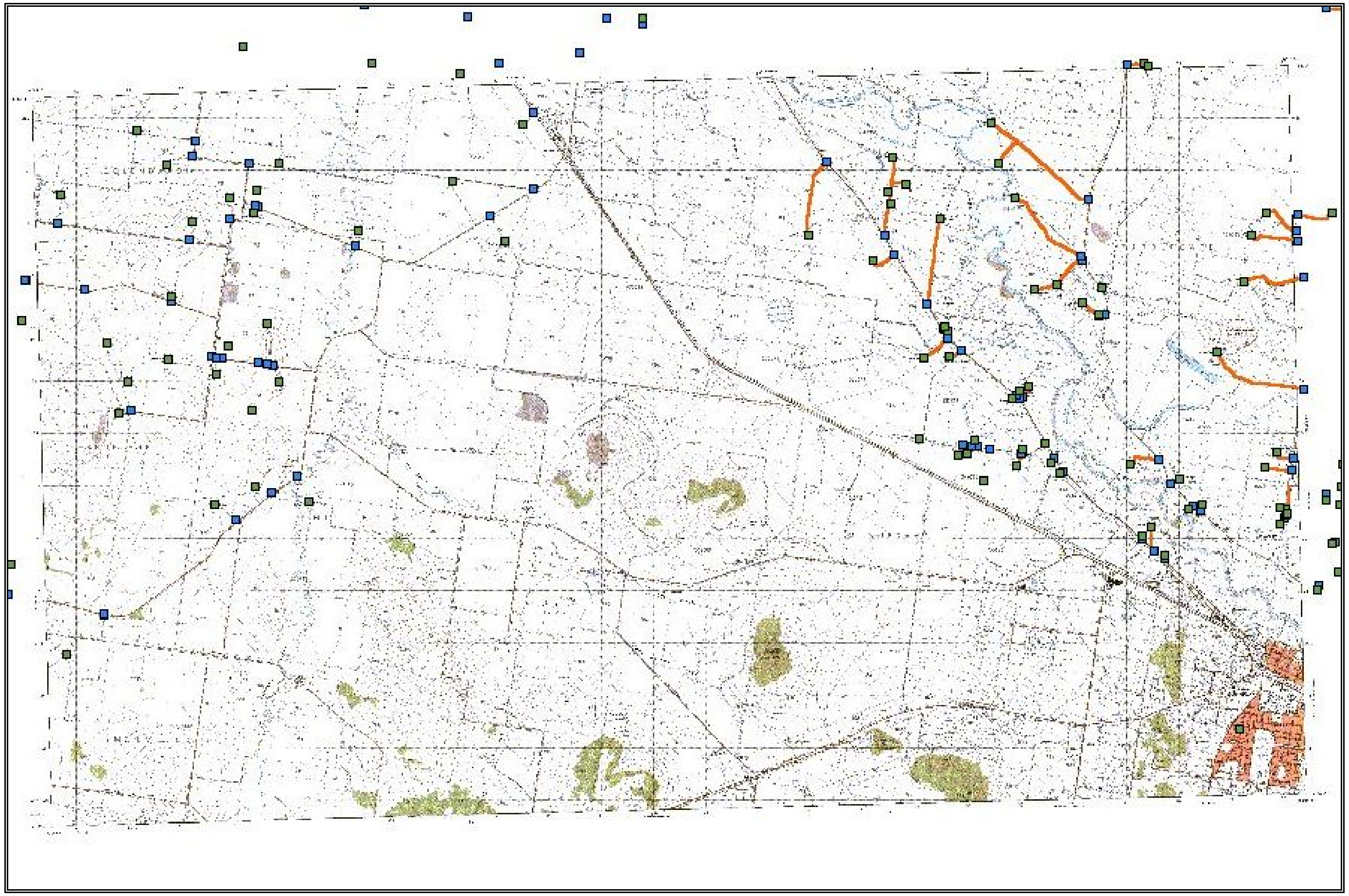
Gunnedah Shire data integrated with Gunnedah 1:25000 topographic map

Appendix I-7: Gulligal (8936-3n)



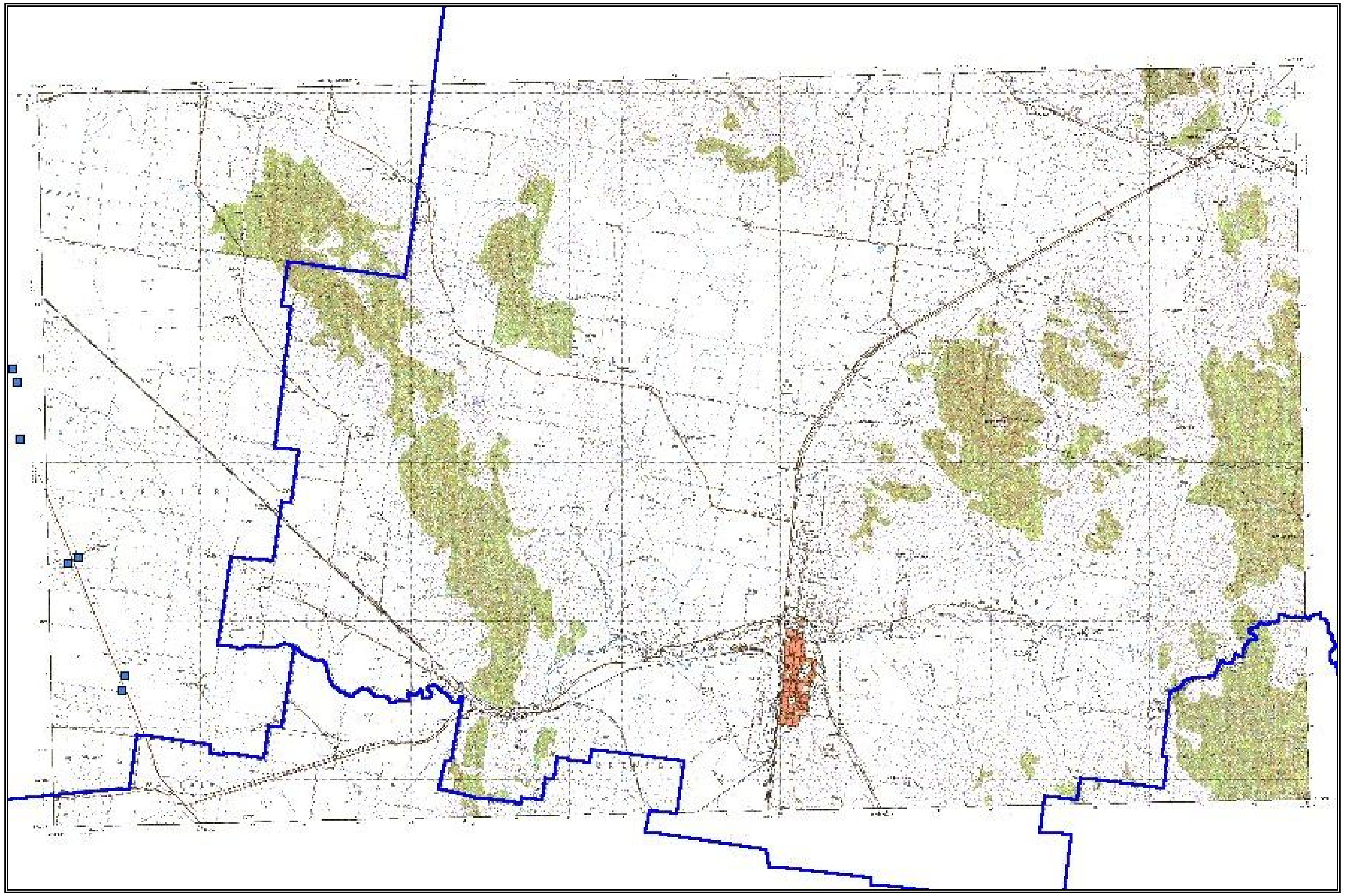
Gunnedah Shire data integrated with Gulligal 1:25000 topographic map

Appendix I-8: Emerald Hill (8936-3s)



Gunnedah Shire data integrated with Emerald Hill 1:25000 topographic map

Appendix I-9: Werris Creek (9035-3n)



Gunnedah Shire data integrated with Werris Creek 1:25000 topographic map

NSW Forests Data Result Summary

Appendix J-1: NSW Forest Lines Data Result Summary

Identifier	Map Sheet	Total lines collected	Named road segments	Unique Names	Other line features
F01	Thredbo	18	7	3	0
F02	Mount Kosciuszko	15	0	0	0
F03	Yambulla	29	17	5	0
F04	Nimmitabel	356	79	11	0
F05	Glen Allen	357	116	22	1
F06	Cathcart	131	46	15	0
F07	Coolumbooka	1489	446	38	0
F08	Cowra Creek	20	20	8	0
F09	Numerella	14	14	9	0
F10	Kydra	16	0	0	0
F11	Captains Flat	23	22	9	1
F12	Tinderry	30	26	13	0
F13	Jerangle	39	37	16	0
F14	Whinstone	14	13	5	1
F15	Eden	216	137	39	0
F16	Kiah	327	177	44	0
F17	Mount Imlay	546	415	72	1
F18	Bega	63	31	7	0
F19	Wolumla	4	4	2	0
F20	Pambula	157	133	42	1
F21	Candelo	163	115	34	0
F22	Wyndham	84	51	13	4
F23	Nerrigundah	851	847	379	1
F24	Cadgee	1093	1093	329	0
F25	Wandella	378	378	167	14
F26	Cobargo	40	25	4	0
F27	Yowrie	14	14	9	0
F28	Belowra	147	145	67	0
F29	Bendethera	91	91	37	0
F30	Bendoura	404	240	61	0
F31	Kain	149	139	41	0
F32	Braidwood	56	55	8	0
F33	Manar	5	3	1	0
F34	Bombay	81	78	13	0
F35	Murrah	84	33	3	0
F36	Bermagui	127	36	8	0
F37	Bodalla	624	587	181	0
F38	Narooma	1038	999	327	0
F39	Mogo	685	667	291	0
F40	Moruya	212	209	79	0
F41	Morriset	950	589	176	0
F42	Dooralong	394	255	84	0
F43	Wyong	359	214	65	0
F44	Gosford	2	0	0	0
F45	Mangrove	185	27	5	0
F46	Murrays Run	221	99	28	0
F47	Kulnura	154	61	15	0
F48	Greta	17	4	1	0

Identifier	Map Sheet	Total lines collected	Named road segments	Unique Names	Other line features
F49	Cessnock	200	98	19	0
F50	Quorrobolong	385	209	62	0
F51	Broken Back	328	113	9	0
F52	Wollombi	106	84	30	3
F53	Swansea	83	1	1	0
F54	Clarence Town	228	84	19	0
F55	Karuah	695	341	42	16
F56	Wallsend	267	42	9	0
F57	Paterson	190	60	8	1
F58	The Branch	200	92	15	0

Appendix J-2: NSW Forests Points Data Summary

Identifier	Map Sheet	Total points collected	Unique Point Classes	Total Names	Unique Names
F54	Clarence Town	4	3	0	0
F55	Karuah	11	7	0	0
F57	Paterson	39	3	0	0

Appendix J-3: NSW Forests Data Comparison Summary

Block	Map Name	No of Unique Road Names			% Data Used	+ / - Change
		Previous	Data	Printed		
8524	Thredbo	3	3	3	100	Nil
8525	Mount Kosciuszko	Nil	Nil	Nil	N/A	Nil
8723	Yambulla	Nil	5	5	100	5
8724	Nimmitabel	2	11	10	90.9	8
	Glen Allen	9	22	22	100	13
	Cathcart	8	15	13	86.7	5
	Coolumbooka	3	38	38	100	35
8725	Cowra Creek	2	8	1	12.5	-1
	Numerella	Nil	9	1	11.1	1
	Kydra	1	Nil	Nil	N/A	-1
8726	Captains Flat	2	9	2	22.2	Nil
	Tinderry	Nil	13	1	7.7	1
	Jerangle	3	16	6	37.5	3
	Whinstone	2	5	2	40	Nil
8823	Eden	17	39	38	97.4	21
	Kiah	21	44	38	86.4	17
	Mt Imlay	10	72	58	80.6	48
8824	Bega	4	7	7	100	3
	Wolumla	2	2	2	100	Nil
	Pambula	7	42	7	16.7	Nil
	Candelo	14	34	28	82.4	14
	Wyndham	3	13	12	92.3	9
8825	Nerrigundah	21	379	34	9.0	13
	Cadgee	31	329	31	9.4	Nil
	Wandella	19	167	27	16.2	8
	Cobargo	4	4	4	100	Nil
	Yowrie	Nil	9	3	33.3	3
	Belowra	7	67	9	13.4	2
8826	Bendethera	8	37	3	8.1	-5
	Bendoura	8	61	29	47.5	21
	Kain	8	41	11	26.8	3
8827	Braidwood	2	8	8	100	6
	Manar	1	1	1	100	Nil
	Bombay	6	13	8	61.5	2
8924	Murrah	2	3	3	100	1

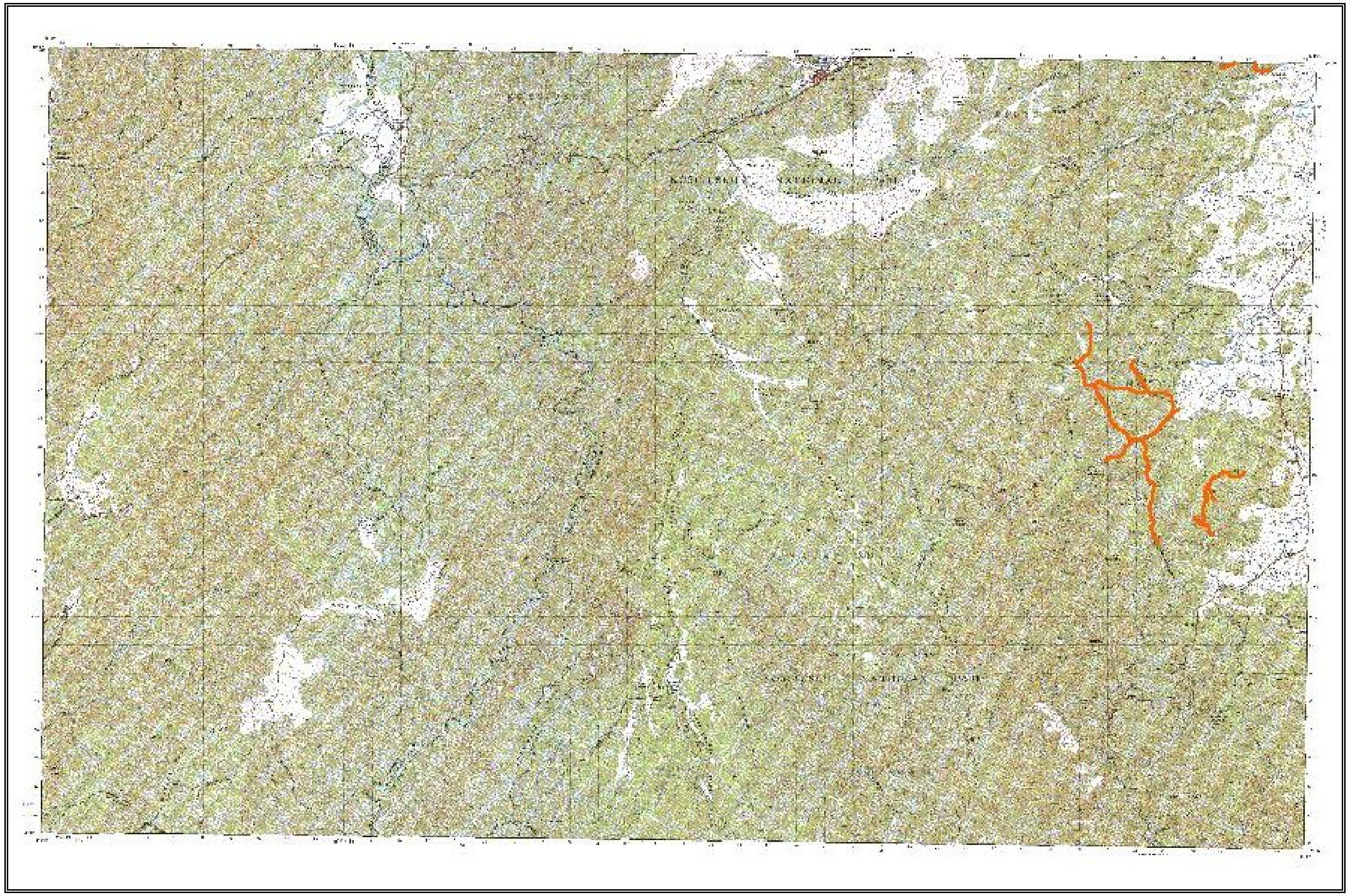
8925	Bermagui Bodalla Narooma	8 16 27	8 181 327	6 38 42	87.5 21.0 12.8	-2 22 15
8926	Mogo Moruya	36 13	291 79	65 21	22.3 26.6	29 8
9131	Morisset Dooralong Wyong Gosford Mangrove Murrays Run Kulnura	49 62 48 Nil 1 21 12	176 84 65 Nil 5 28 15	124 71 51 Nil 5 25 11	70.5 84.5 78.5 N/A 100 89.3 73.3	75 9 3 Nil 4 4 -1
9132	Greta Cessnock Quorrobolong Broken Back Wollombi	1 10 31 1 7	1 19 62 9 30	Nil 17 52 9 25	Nil 89.5 83.9 100 83.3	-1 7 21 8 18
9231	Swansea	1	1	1	100	Nil
9232	Clarence Town Karuah Wallsend Paterson	16 30 8 5	19 42 9 8	19 34 8 6	100 81.0 88.9 75	3 4 Nil 1
9332	The Branch	11	15	12	80	1

Data Sharing Example 3:

NSW Forests – Vehicular

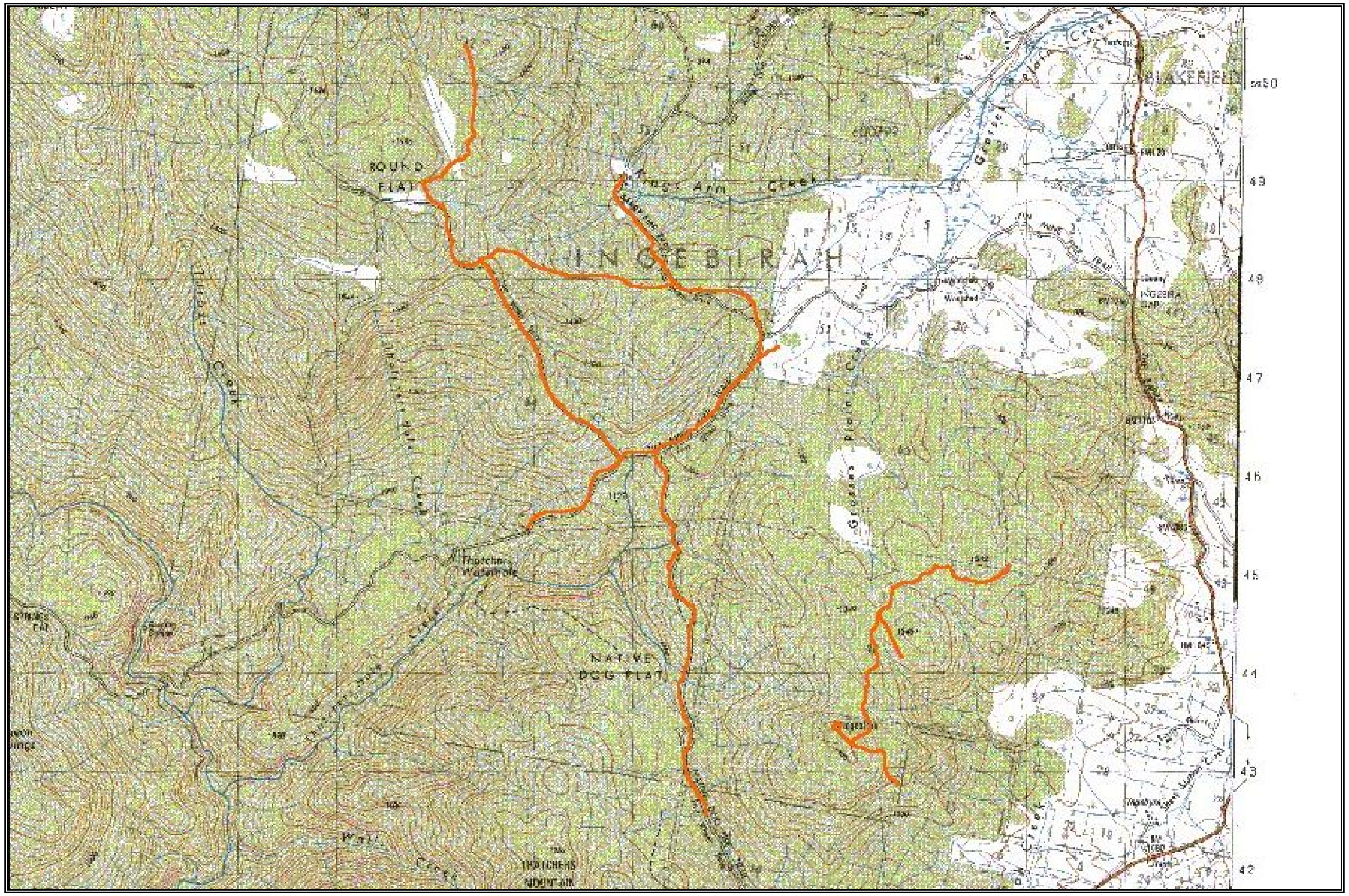
Roads and Tracks

Appendix K-1: Thredbo (8524-n)



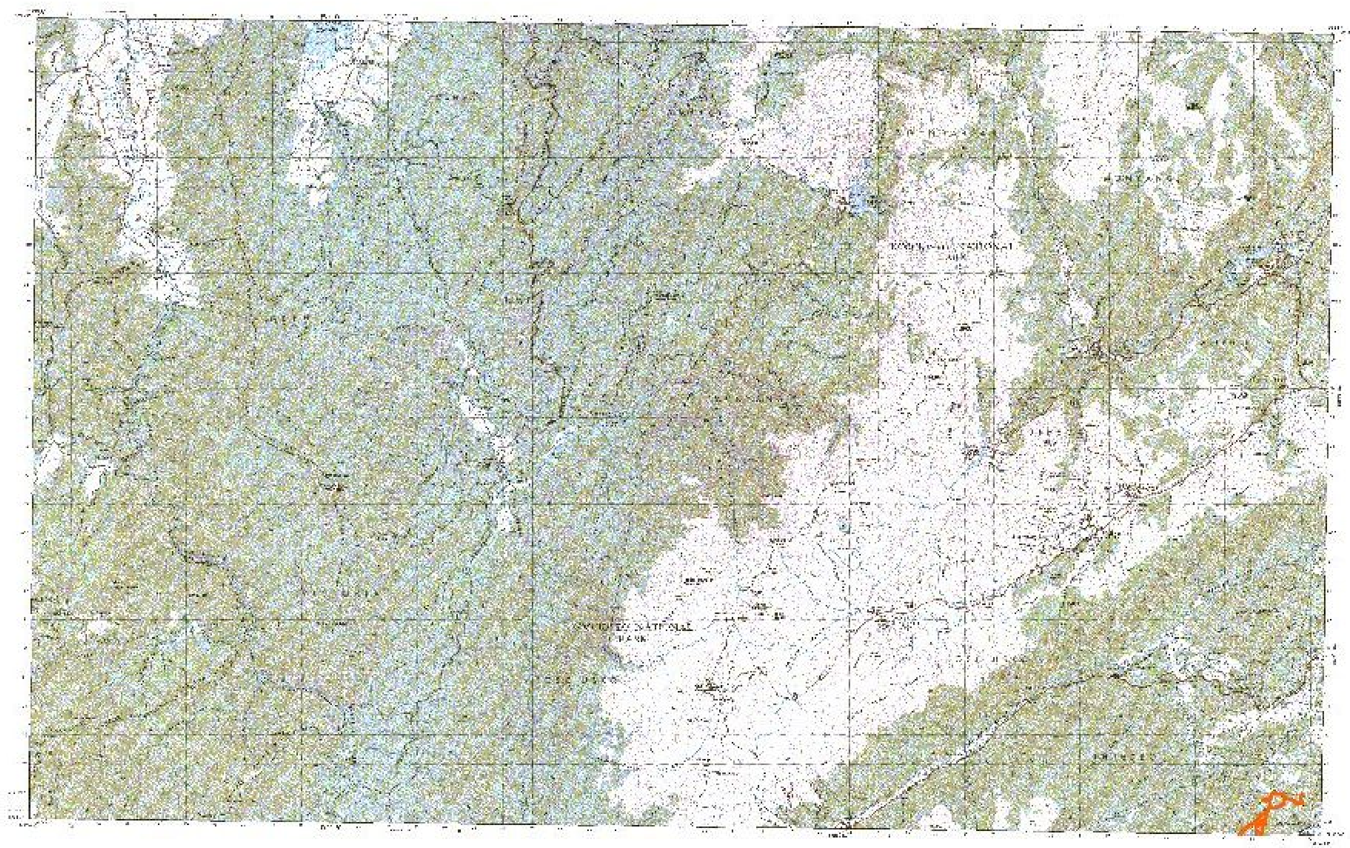
NSW Forests Data integrated with Thredbo 1:50000 Topographic Map

Appendix K-2



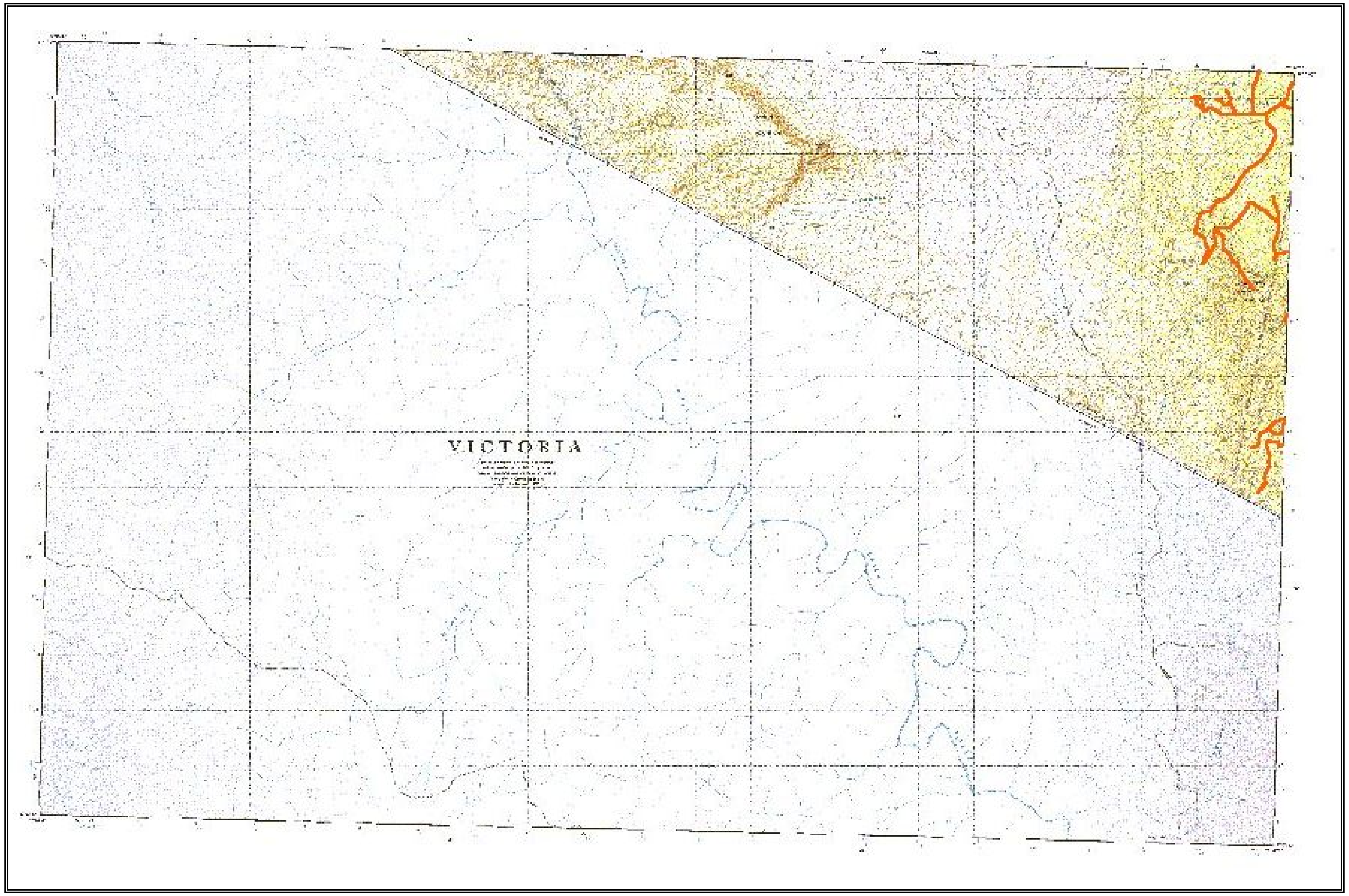
Inset of NSW Forests Data integrated with Thredbo 1:50000 Topographic Map

Appendix K-3: Mount Kosciuszko (8525-s)



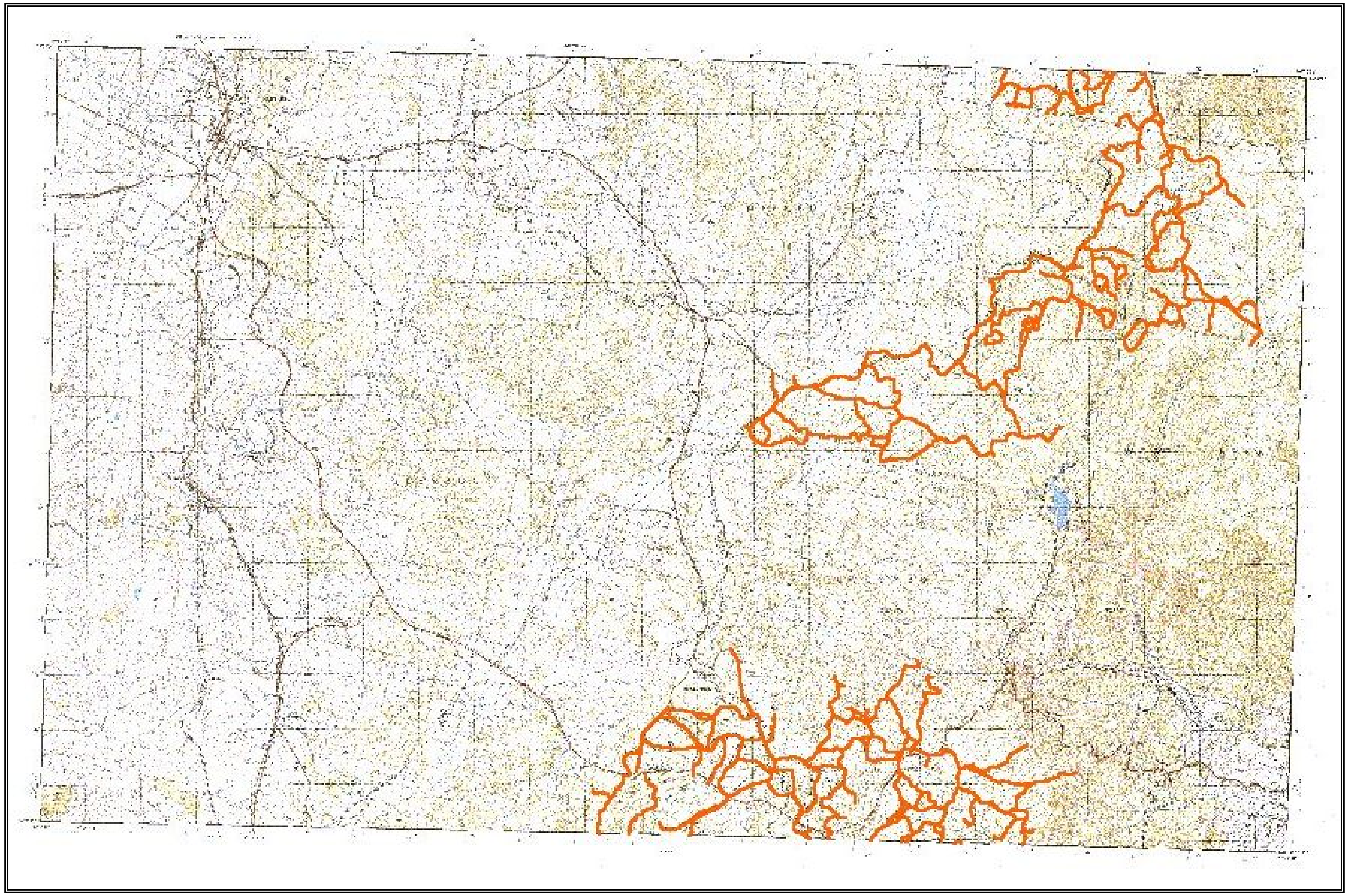
NSW Forests Data integrated with Mount Kosciuszko 1:50000 Topographic Map

Appendix K-4: Yambulla (8732-2n)



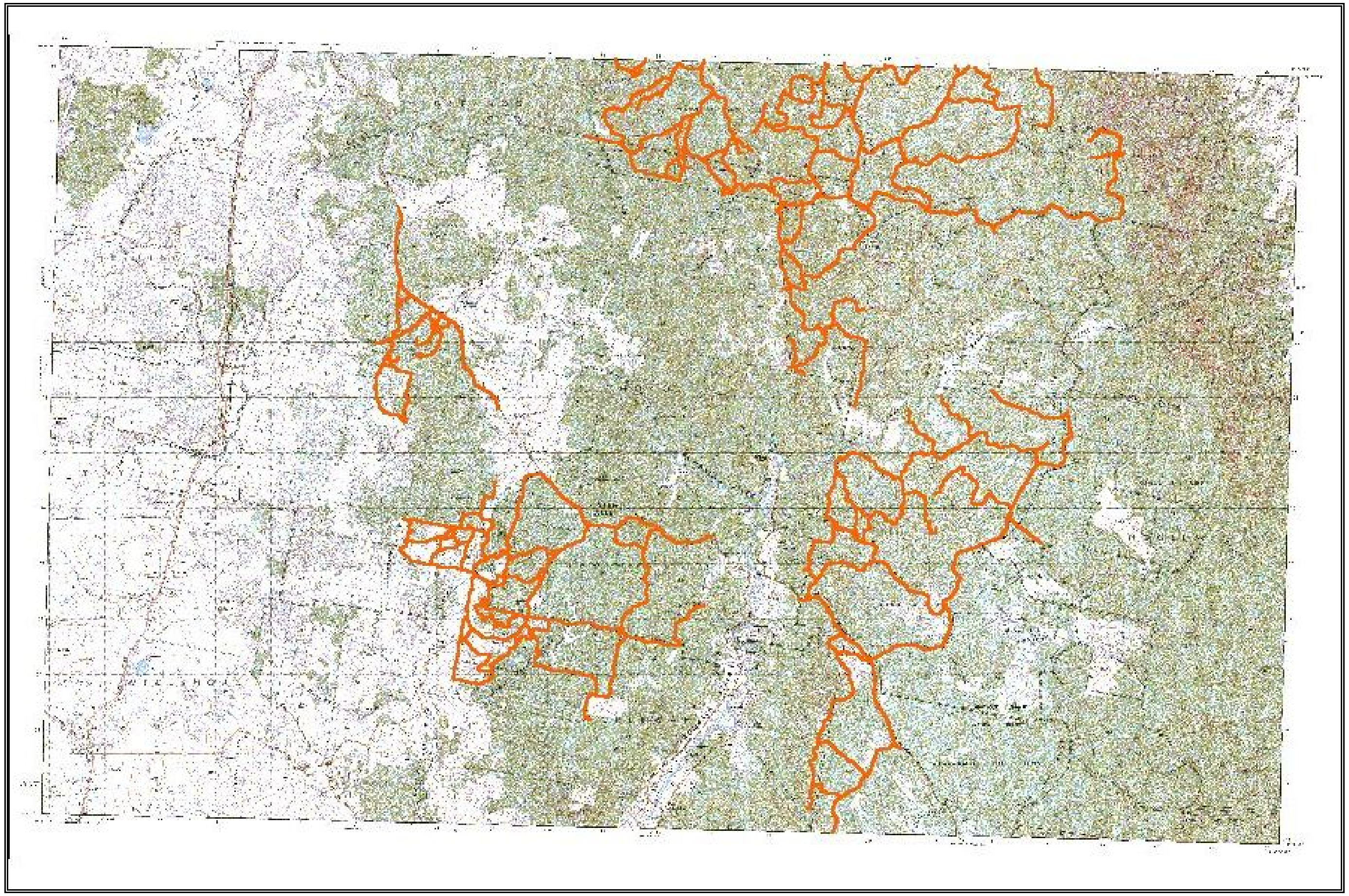
NSW Forests Data integrated with Yambulla 1:25000 Topographic Map

Appendix K-5: Nimmitabel (8724-1n)



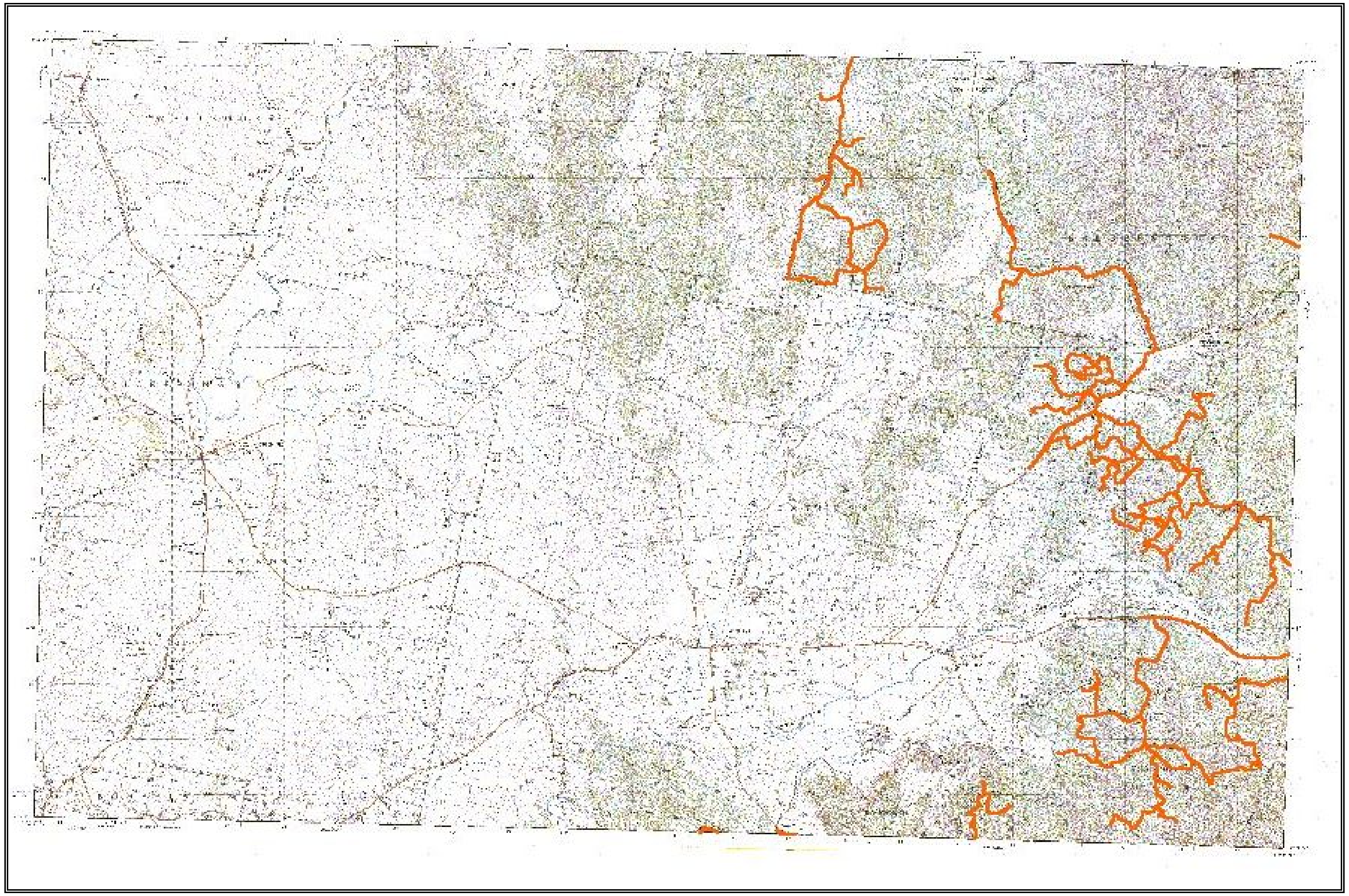
NSW Forests Data integrated with Nimmitabel 1:25000 Topographic Map

Appendix K-6: Glen Allen (8724-1s)



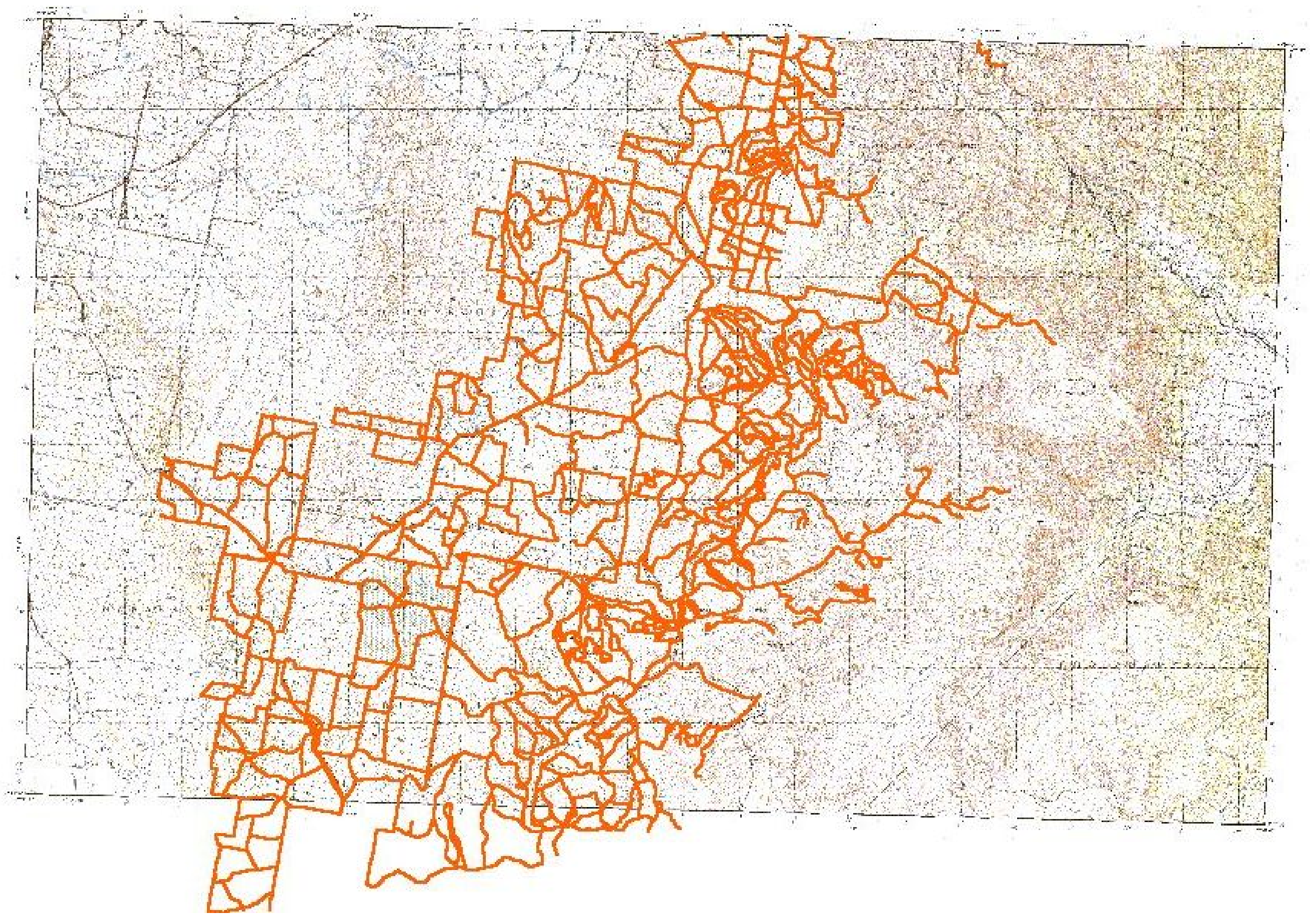
NSW Forests Data integrated with Glen Allen 1:25000 Topographic Map

Appendix K-7: Cathcart (8724-2n)



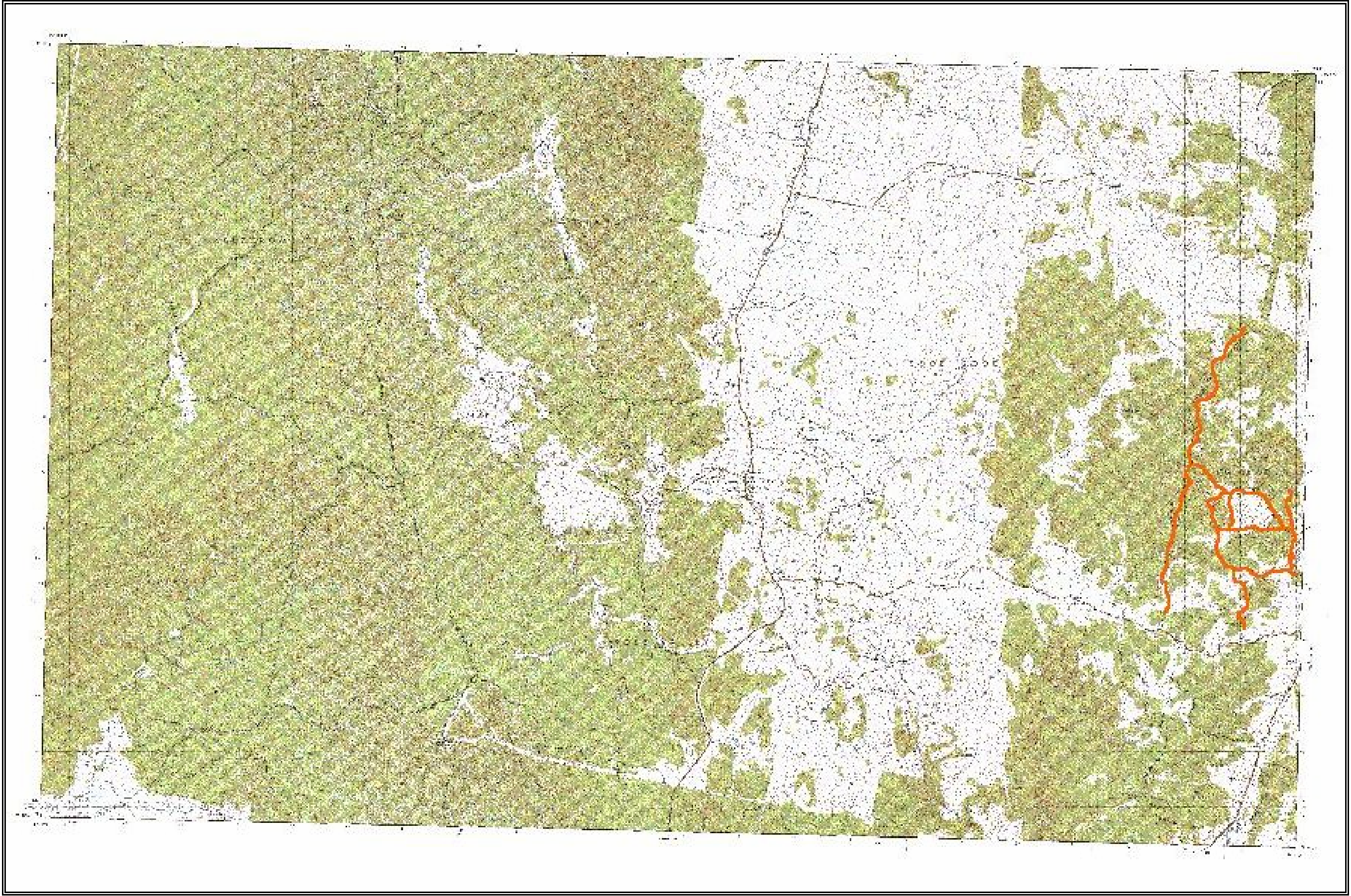
NSW Forests Data integrated with Cathcart 1:25000 Topographic Map

Appendix K-8: Coolumbooka (8724-2s)



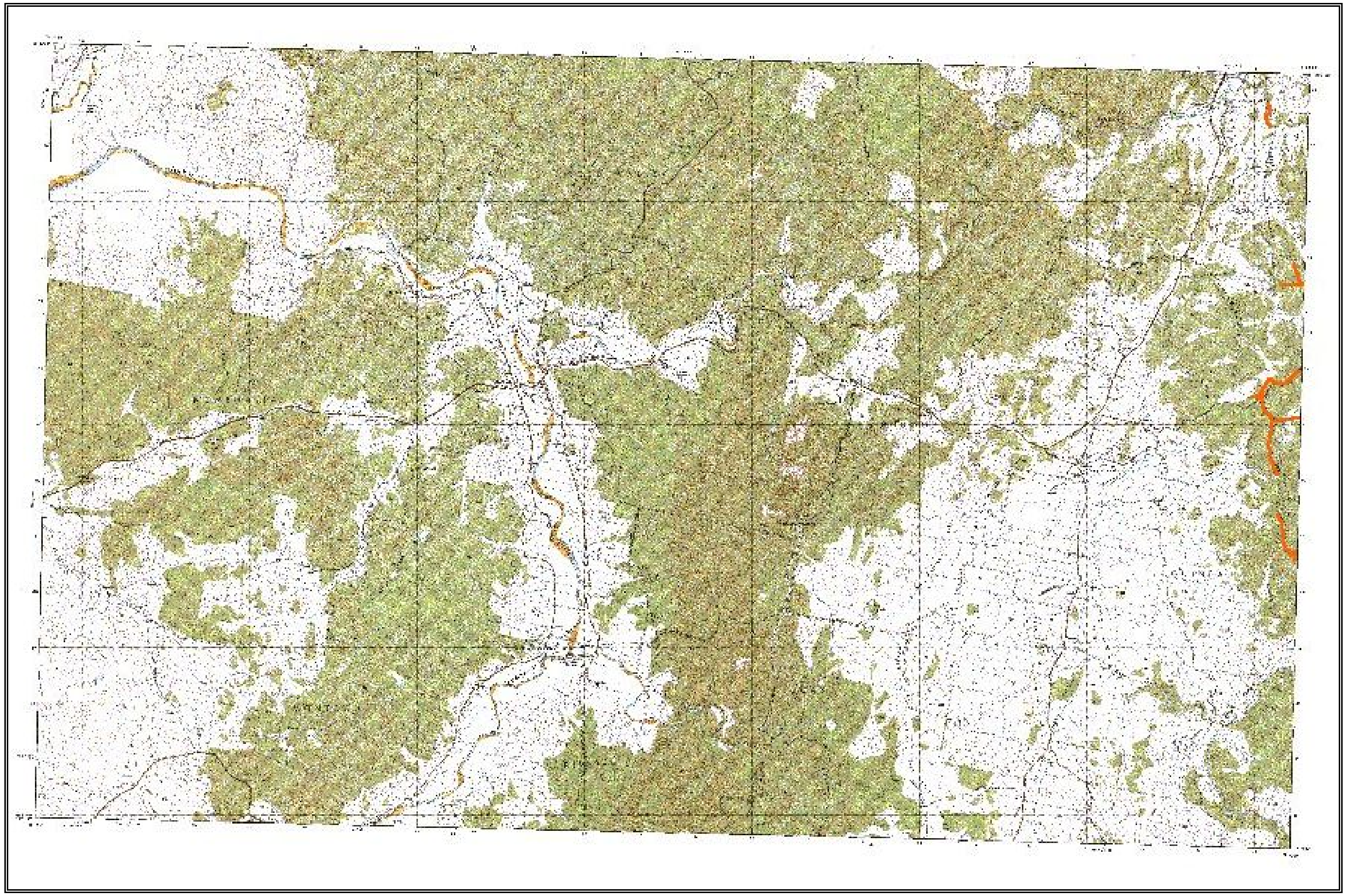
NSW Forests Data integrated with Coolumbooka 1:25000 Topographic Map

Appendix K-9: Cowra Creek (8725-1n)



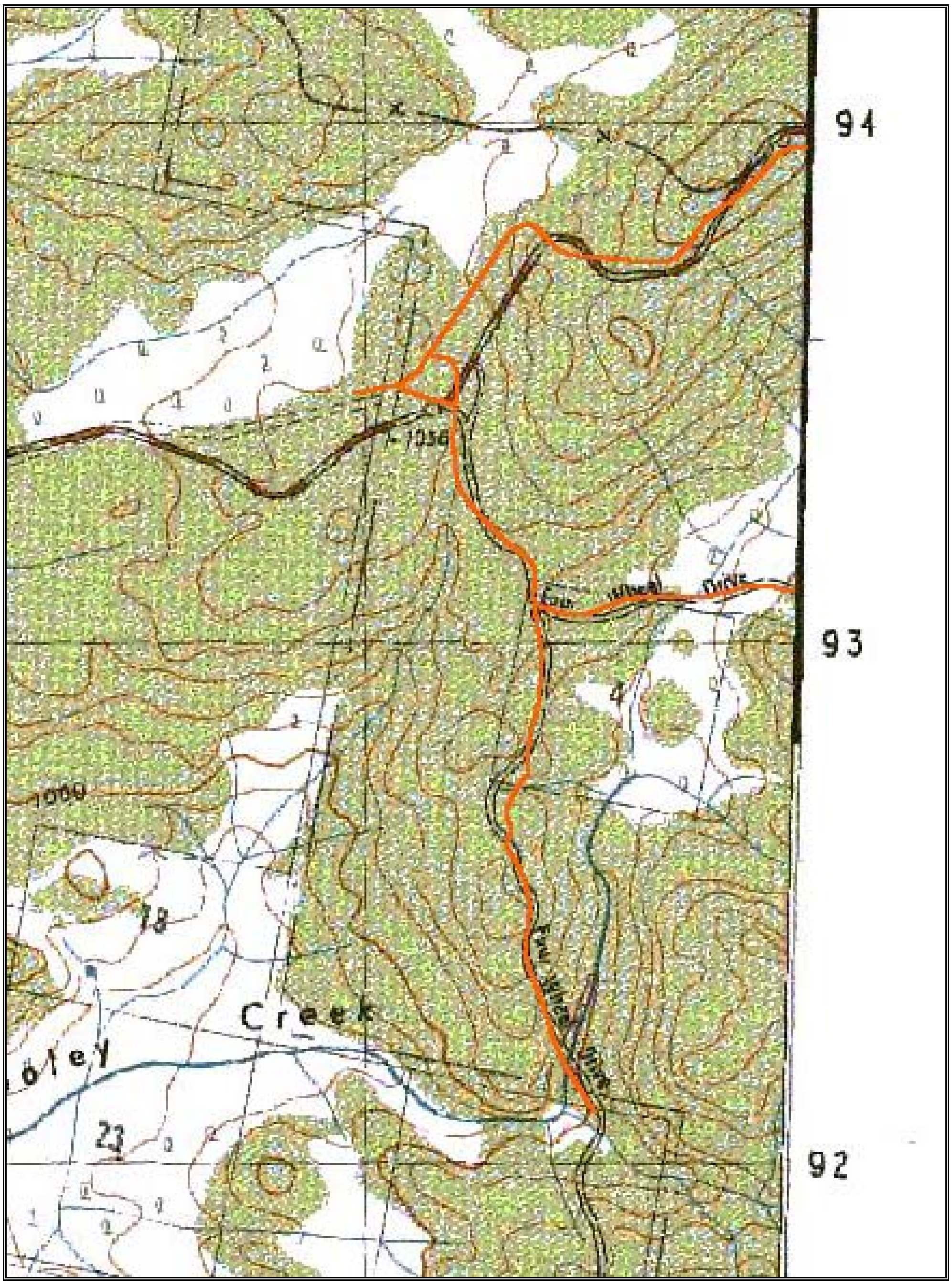
NSW Forests Data integrated with Cowra Creek 1:25000 Topographic Map

Appendix K-10: Numerella (8725-1s)



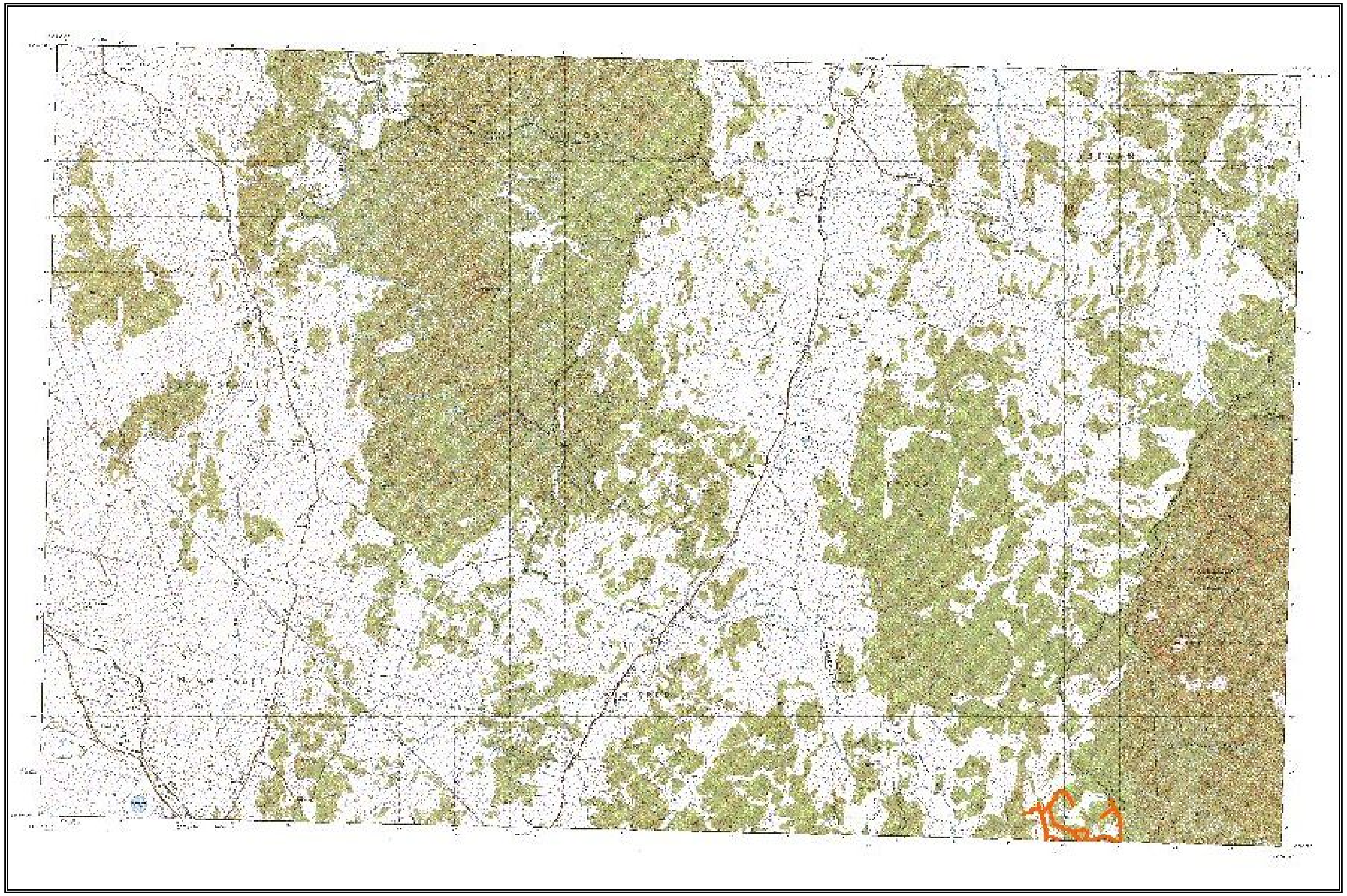
NSW Forests Data integrated with Numerella 1:25000 Topographic Map

Appendix K-11



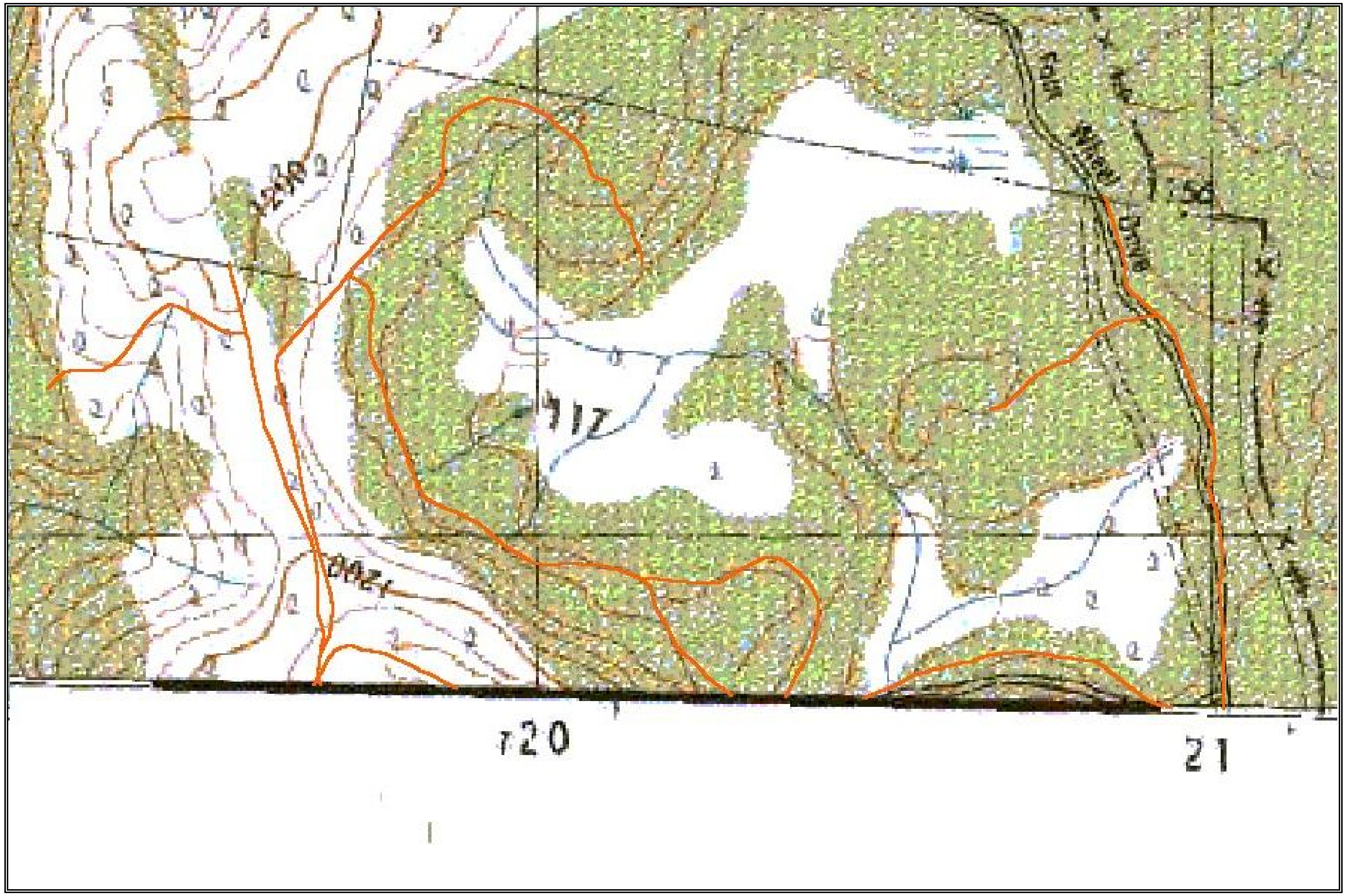
Inset of NSW Forests Data integrated with Numerella 1:25000 Topographic Map

Appendix K-12: Kydra (8725-2s)



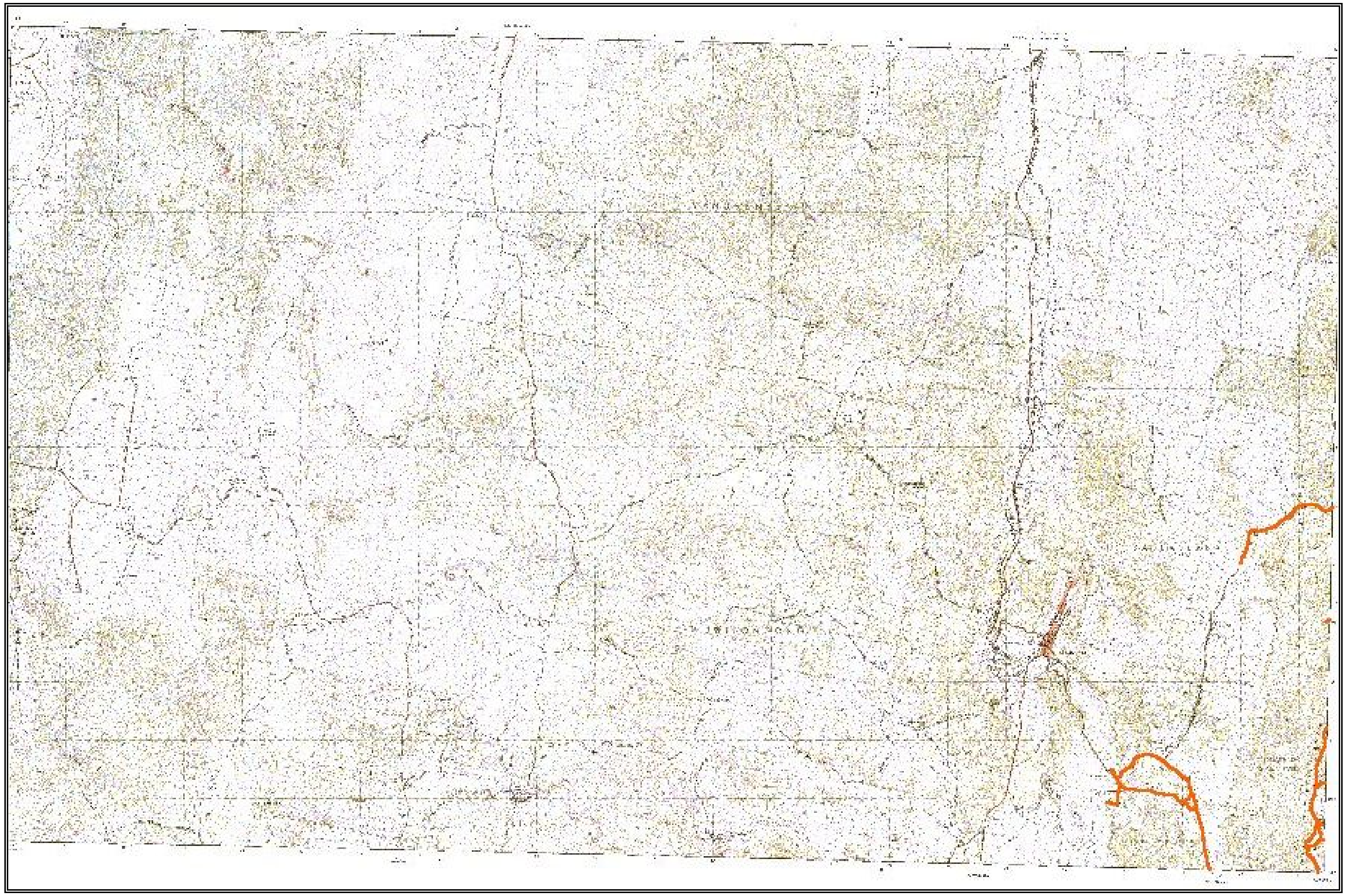
NSW Forests Data integrated with Kydra 1:25000 Topographic Map

Appendix K-13



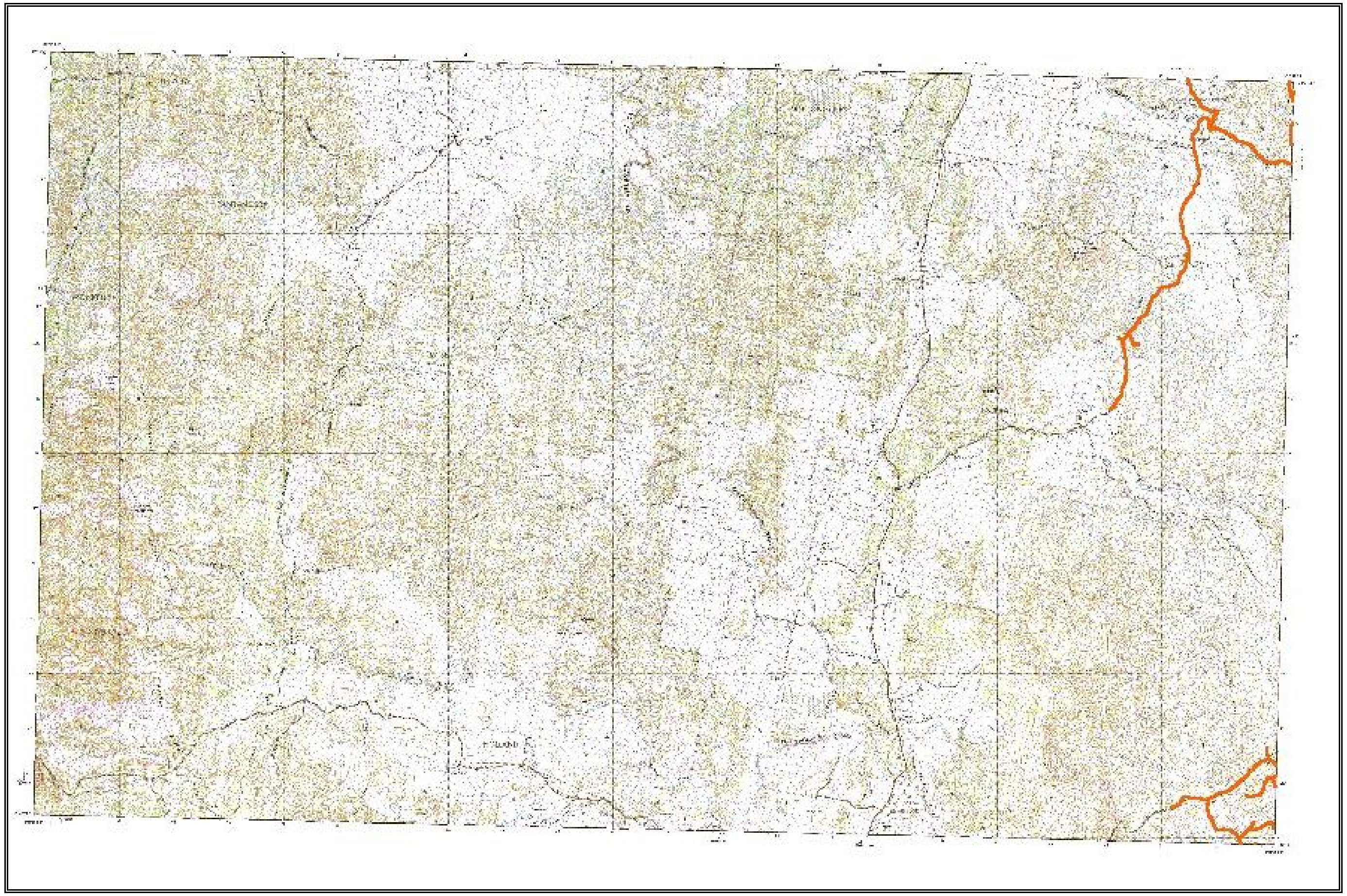
Inset of NSW Forests Data integrated with Kydra 1:25000 Topographic Map

Appendix K-14: Captains Flat (8726-1n)



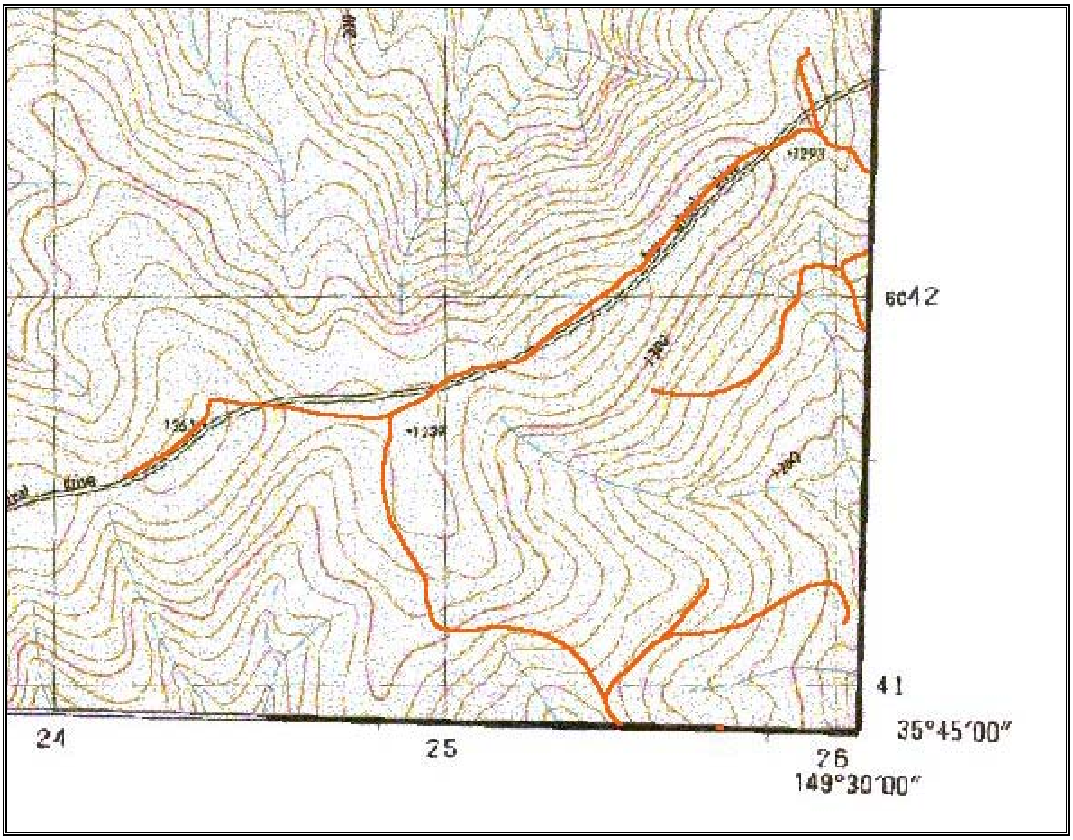
NSW Forests Data integrated with Captains Flat 1:25000 Topographic Map

Appendix K-15: Tinderry (8726-1s)



NSW Forests Data integrated with Tinderry 1:25000 Topographic Map

Appendix K-16



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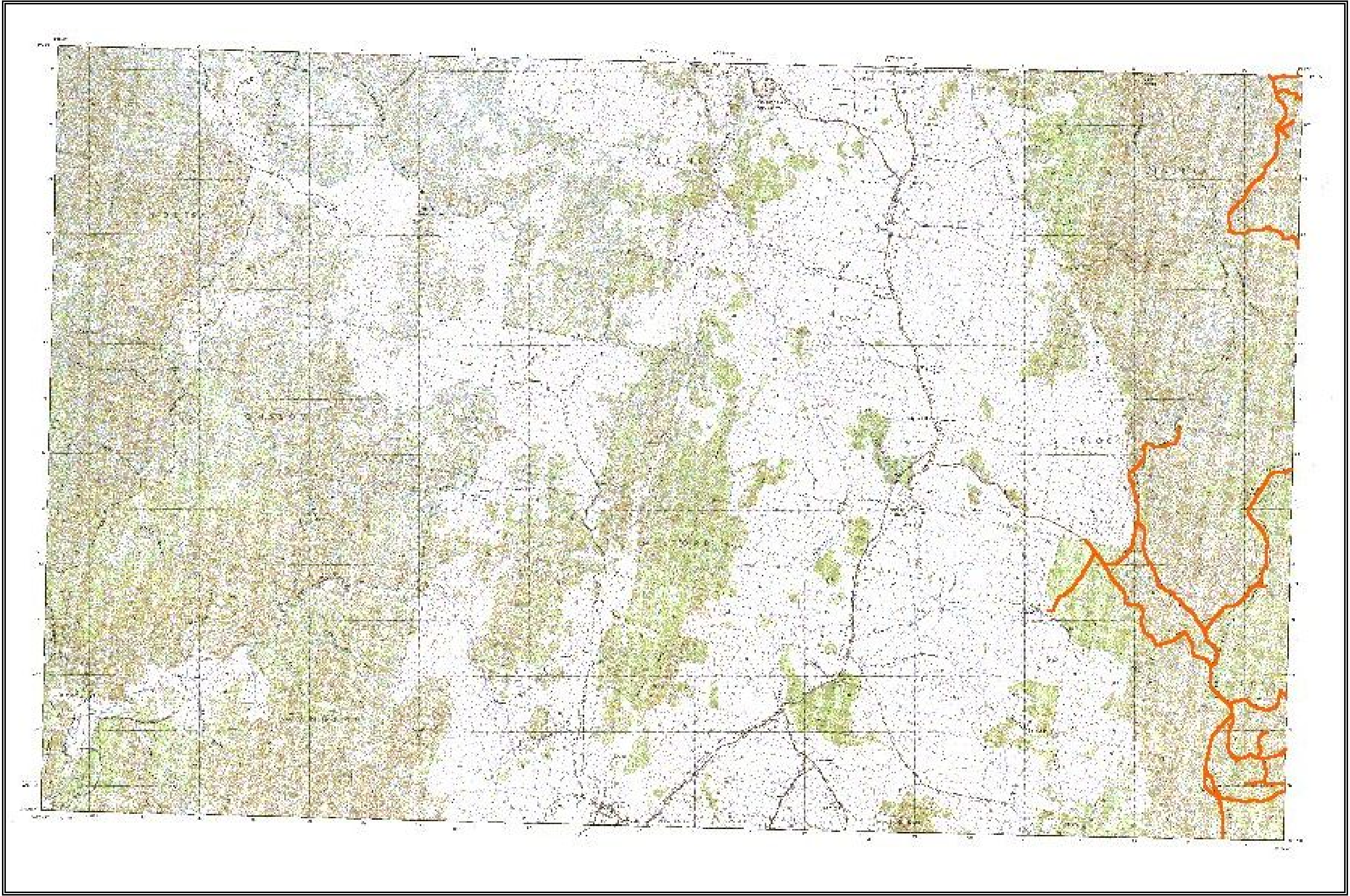
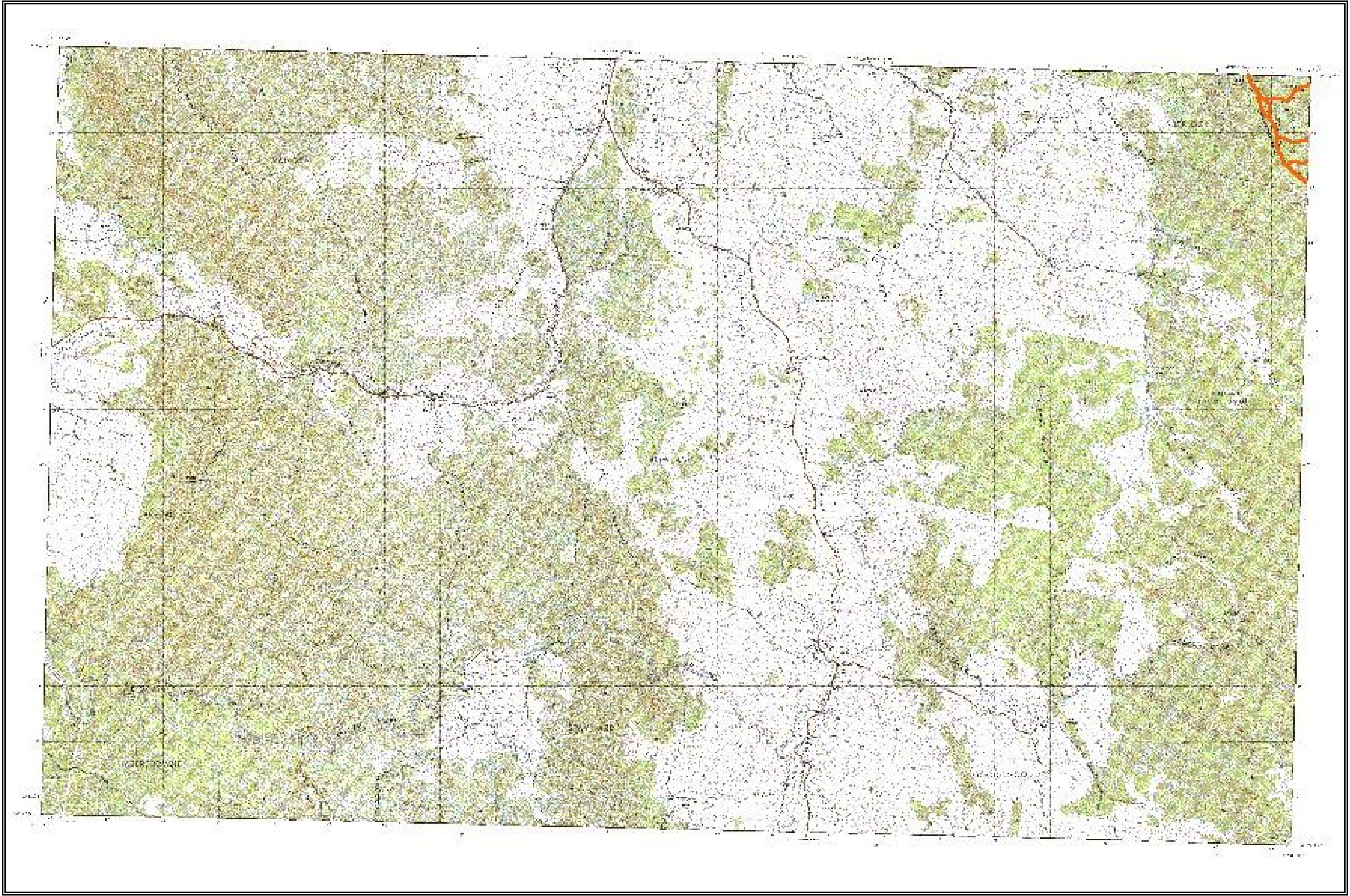
Inset of NSW Forests Data integrated with Tinderry 1:25000 Topographic Map

Appendix K-17: Jerangle (8726-2n)



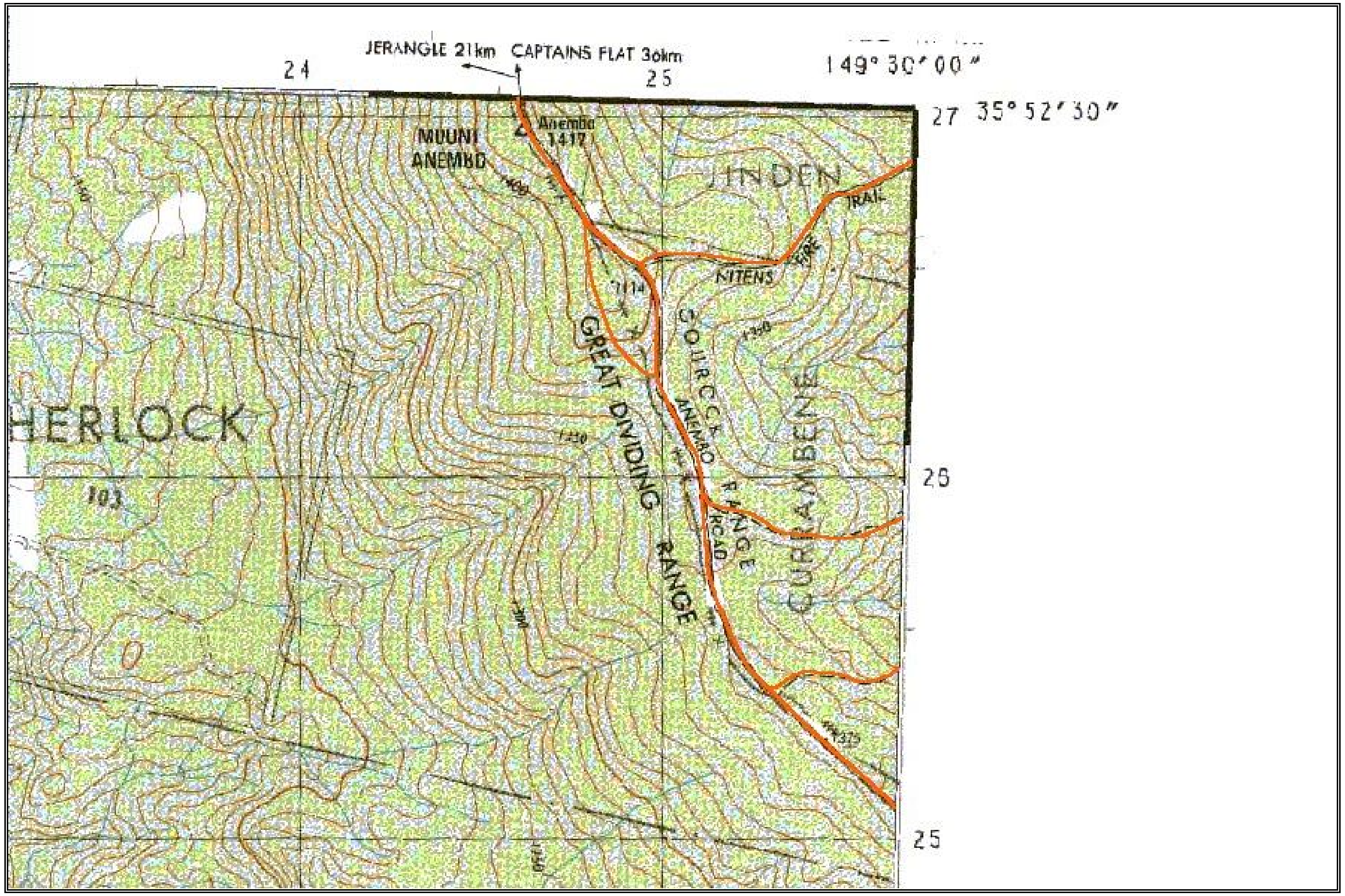
NSW Forests Data integrated with Jerangle 1:25000 Topographic Map

Appendix K-18: Whinstone (8726-2s)



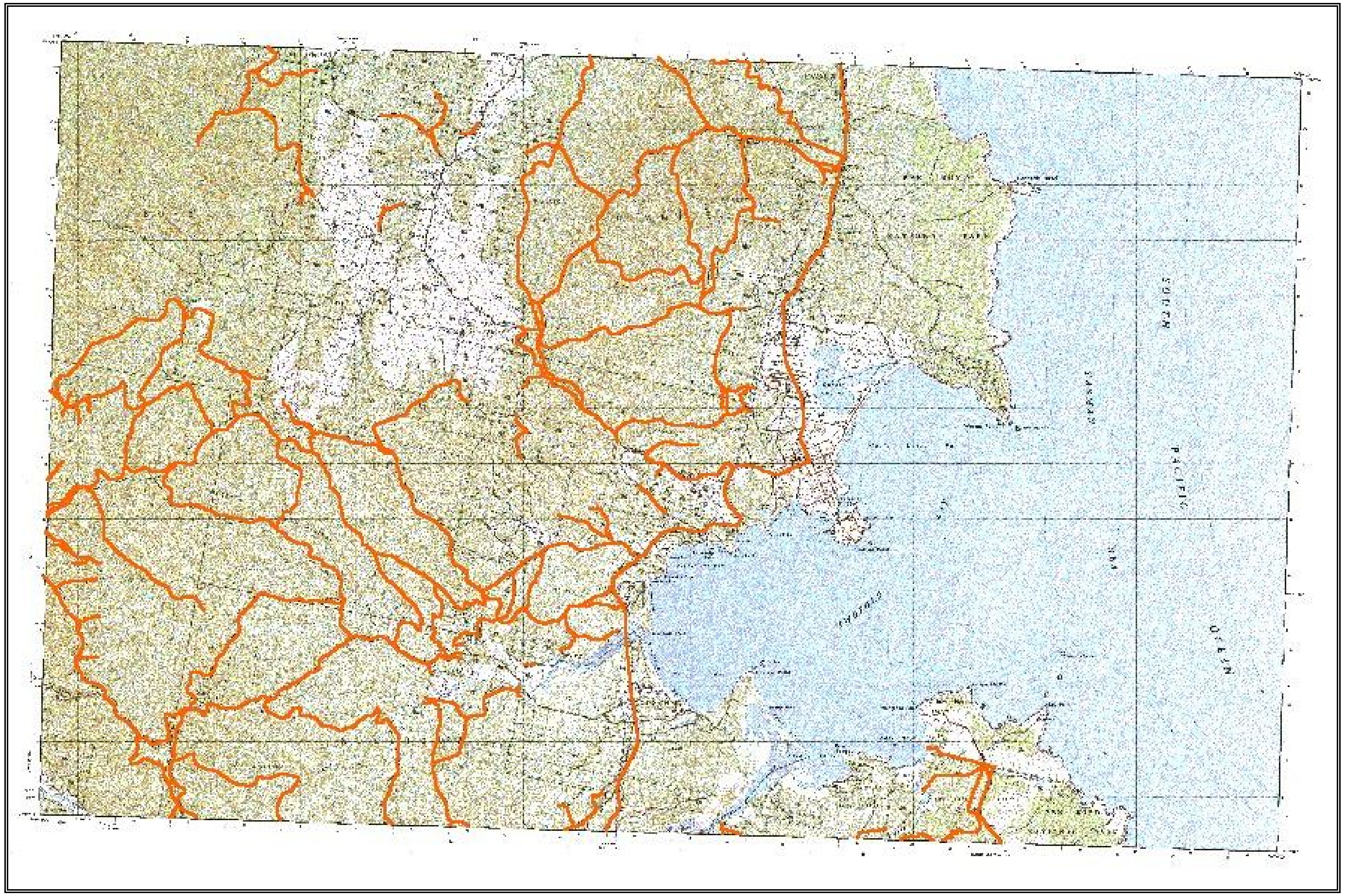
NSW Forests Data integrated with Whinstone 1:25000 Topographic Map

Appendix K-19



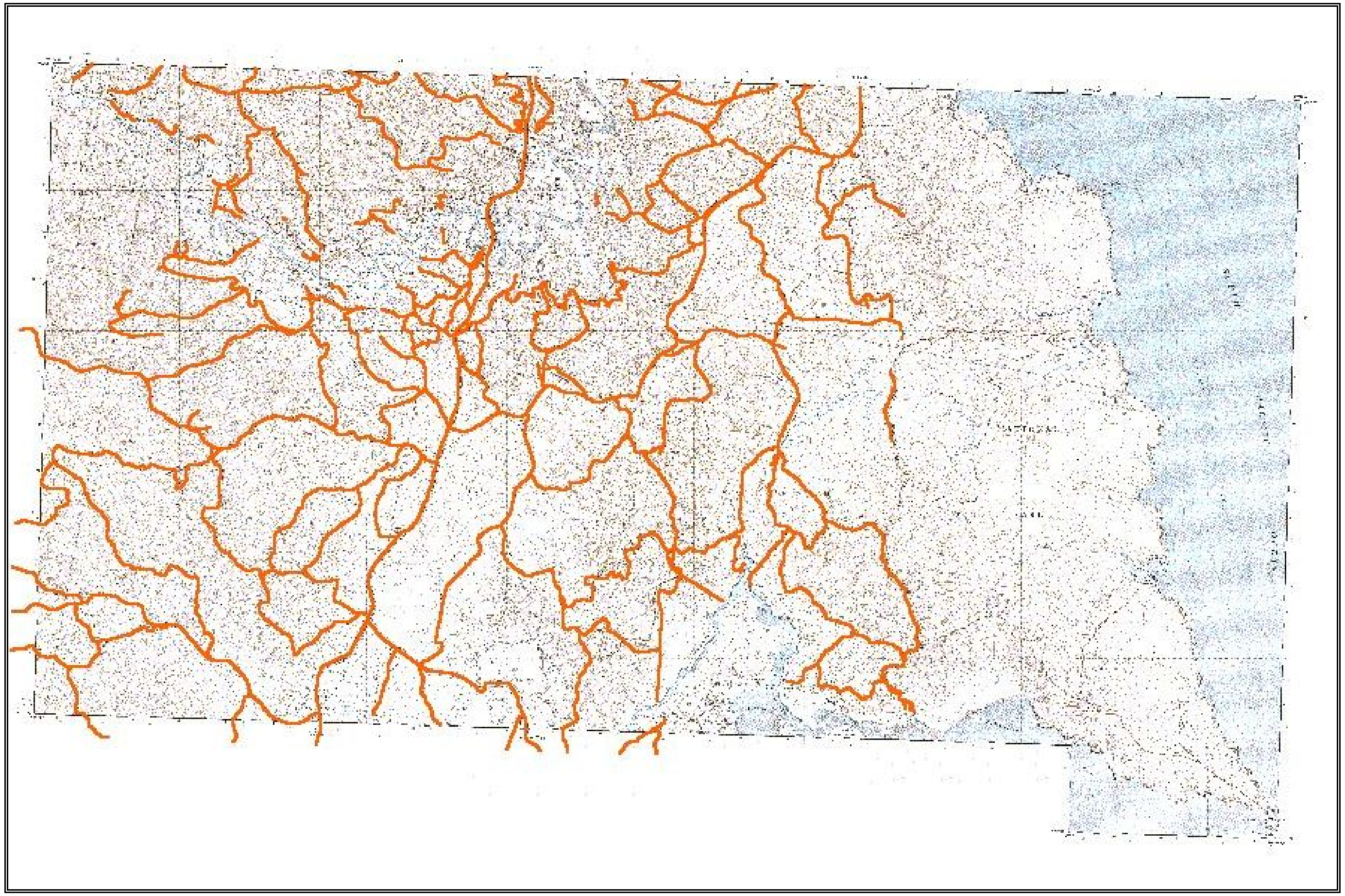
Inset of NSW Forests Data integrated with Whinstone 1:25000 Topographic Map

Appendix K-20: Eden (8823-1n)



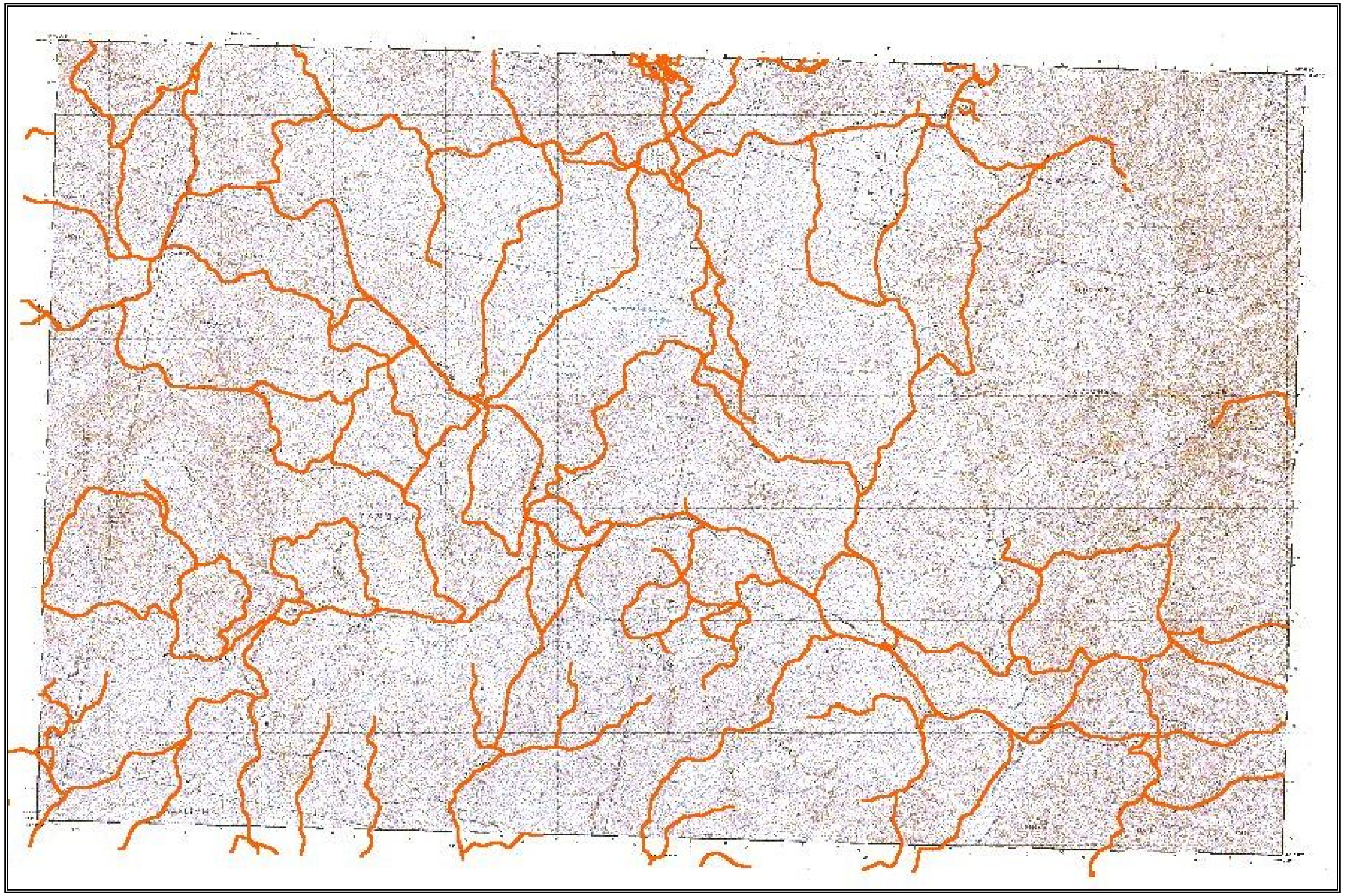
NSW Forests Data integrated with Eden 1:25000 Topographic Map

Appendix K-21: Kiah (8823-1s)



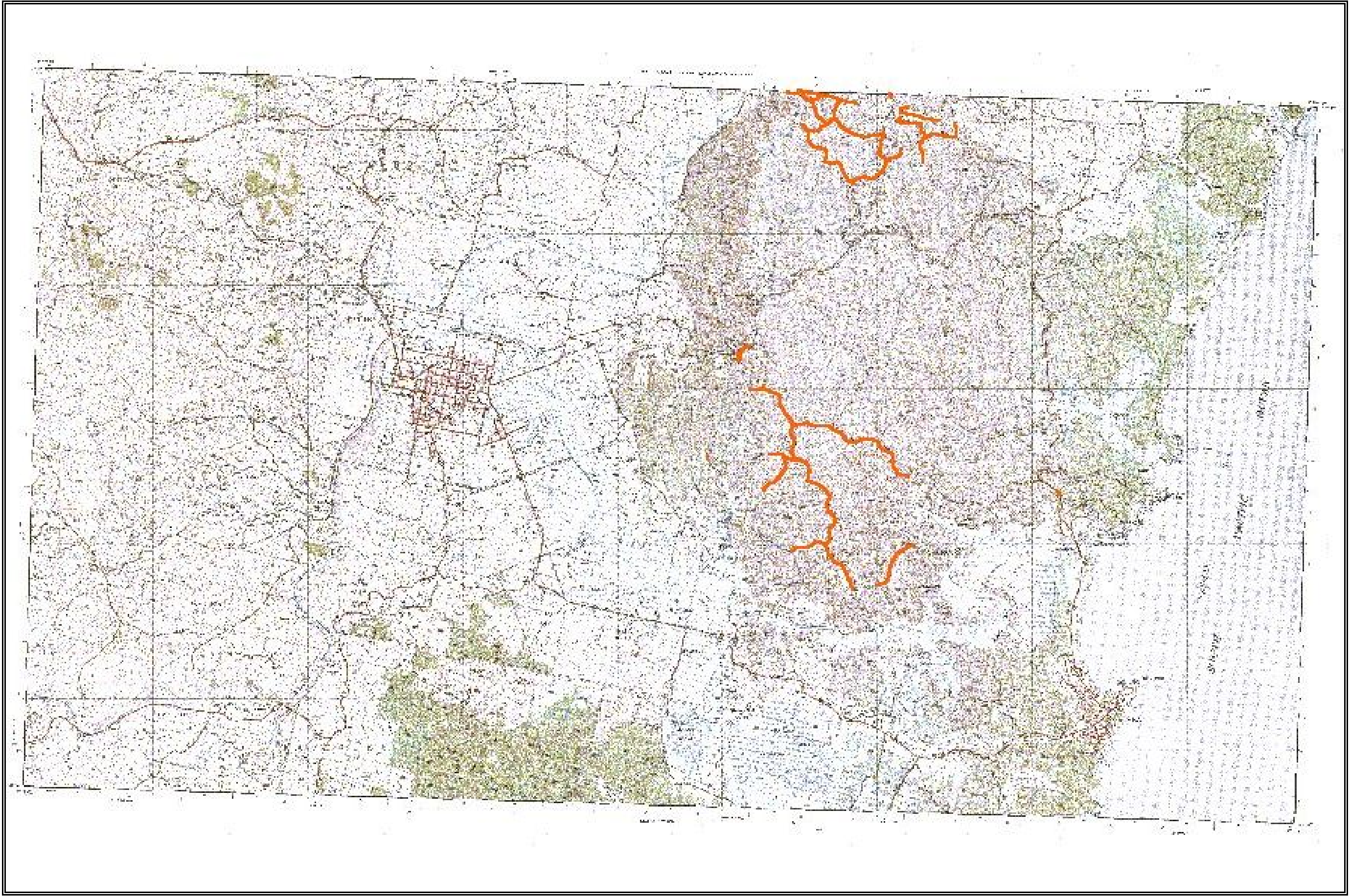
NSW Forests Data integrated with Kiah 1:25000 Topographic Map

Appendix K-22: Mt Imlay (8823-4s)



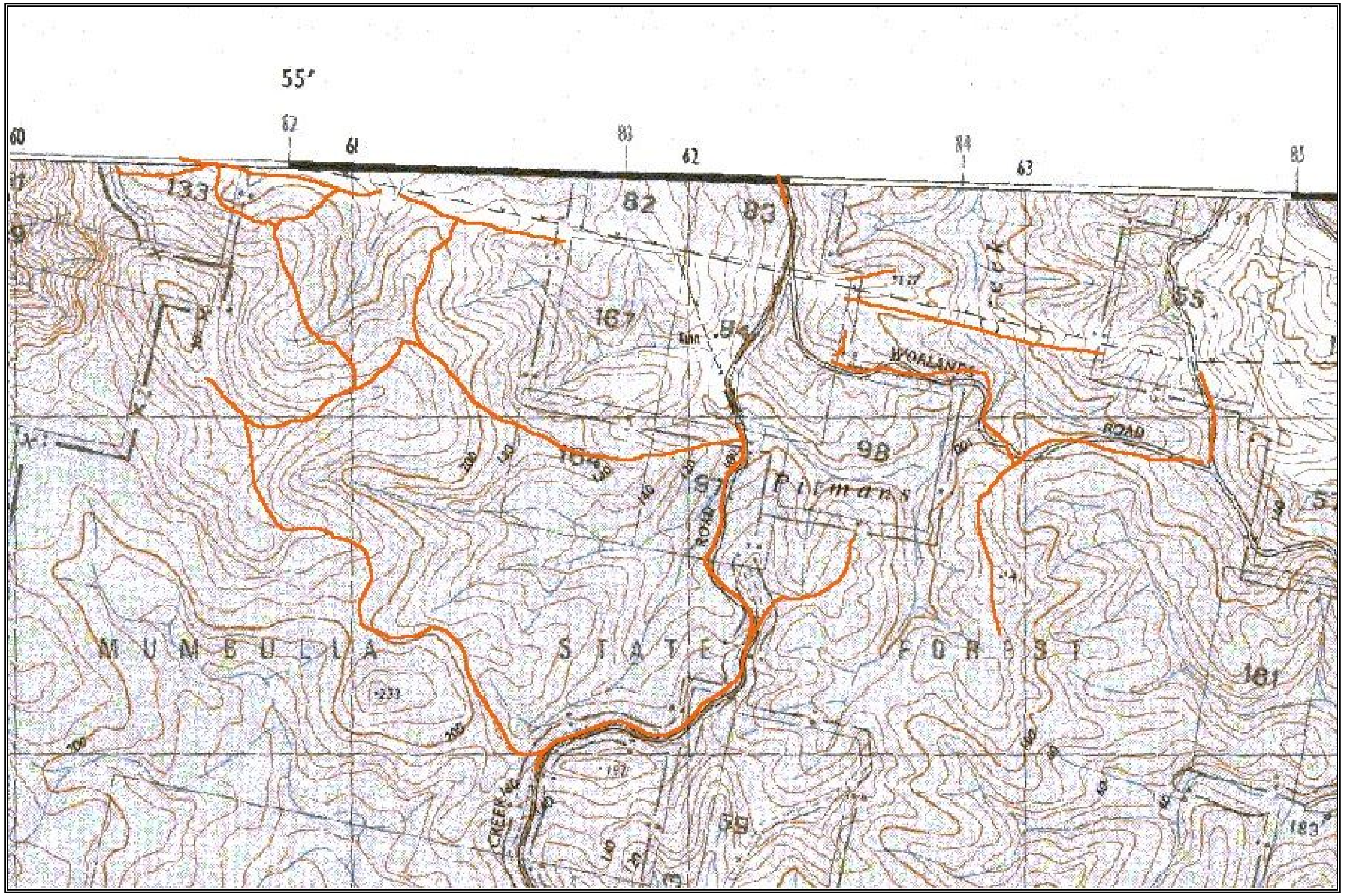
NSW Forests Data integrated with Mt Imlay 1:25000 Topographic Map

Appendix K-23: Bega (8824-1s)



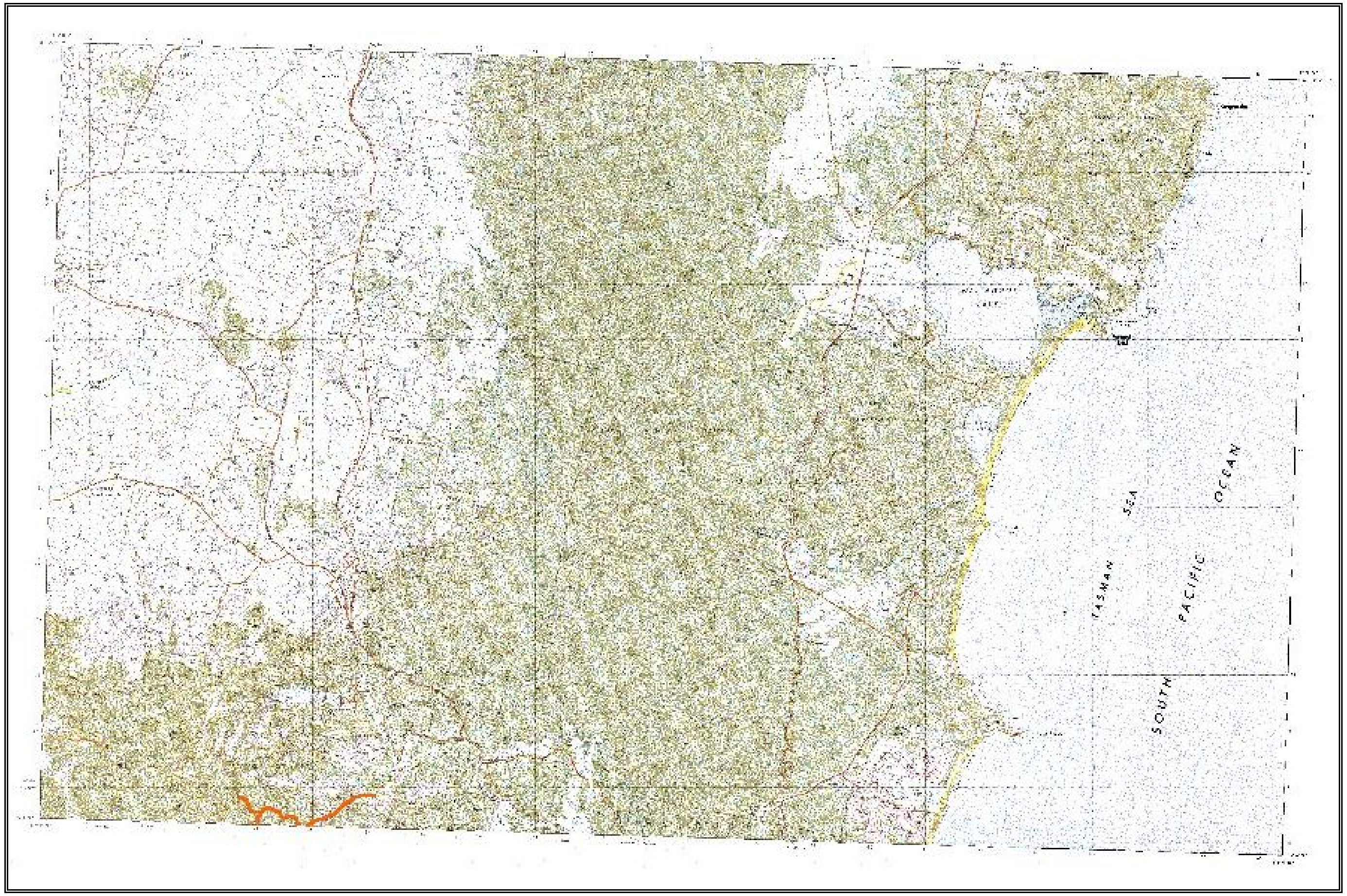
NSW Forests Data integrated with Bega 1:25000 Topographic Map

Appendix K-24



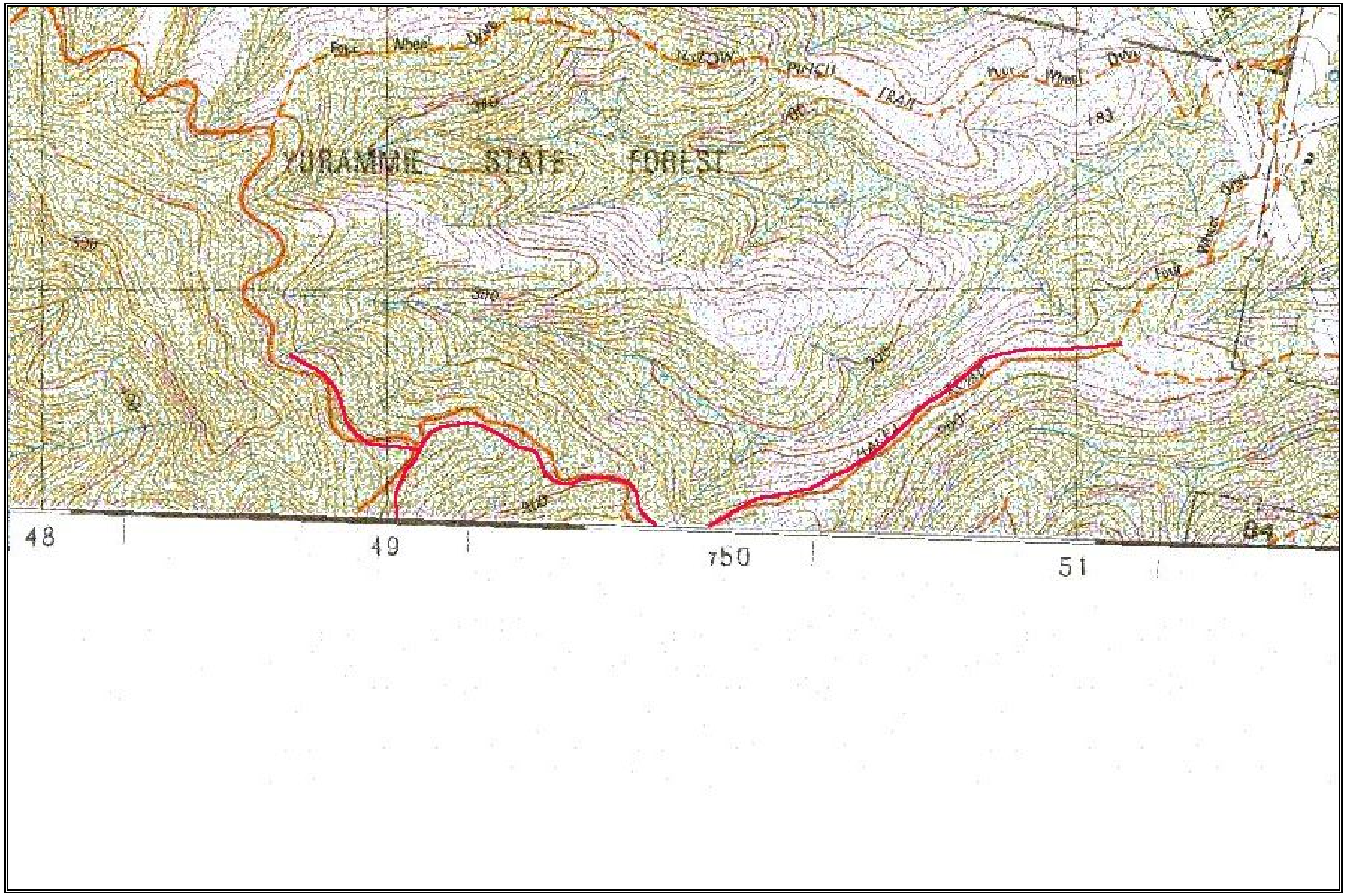
Inset of NSW Forests Data integrated with Bega 1:25000 Topographic Map

Appendix K-25: Wolumla (8824-2n)



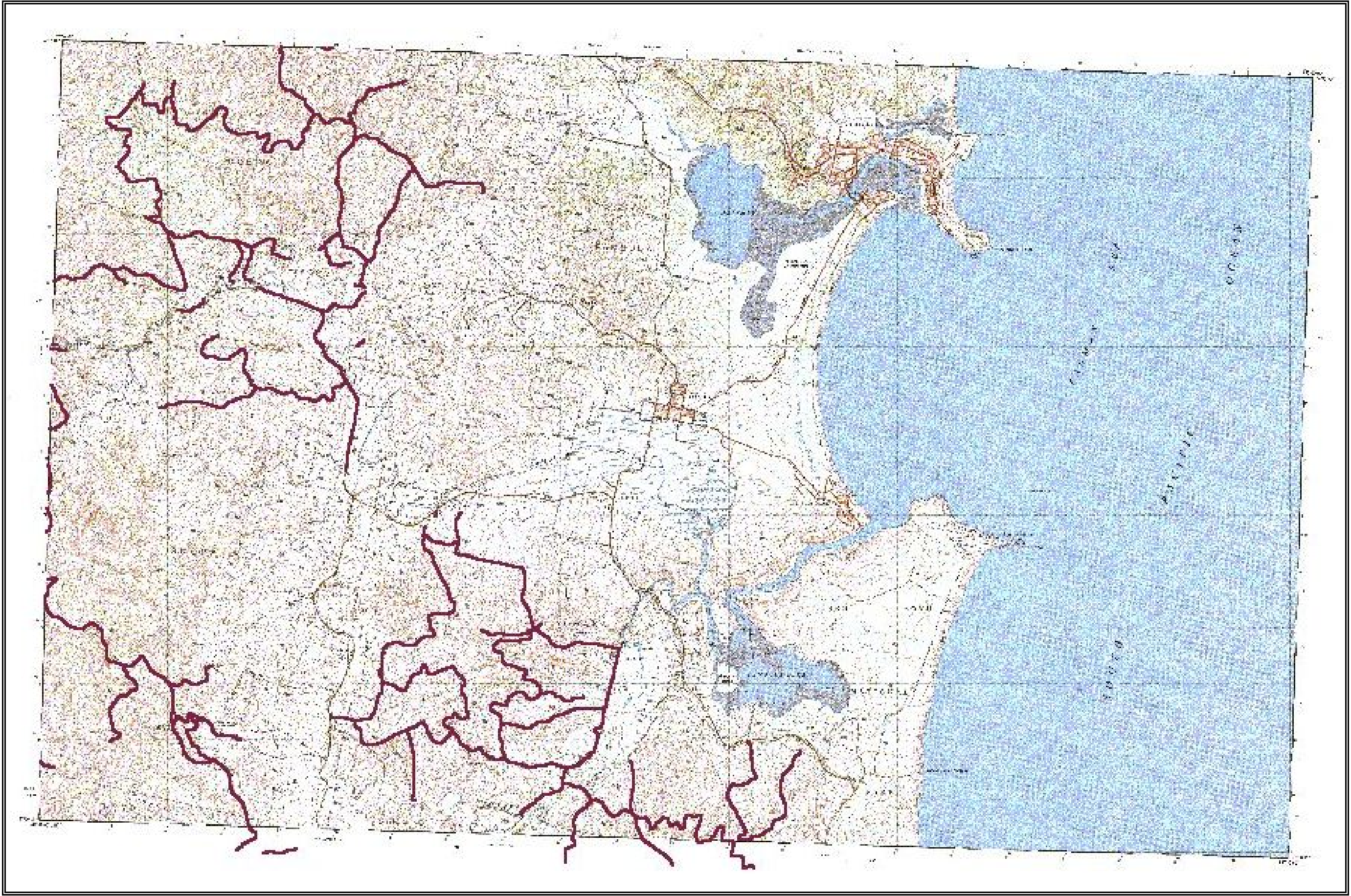
NSW Forests Data integrated with Wolumla 1:25000 Topographic Map

Appendix K-26



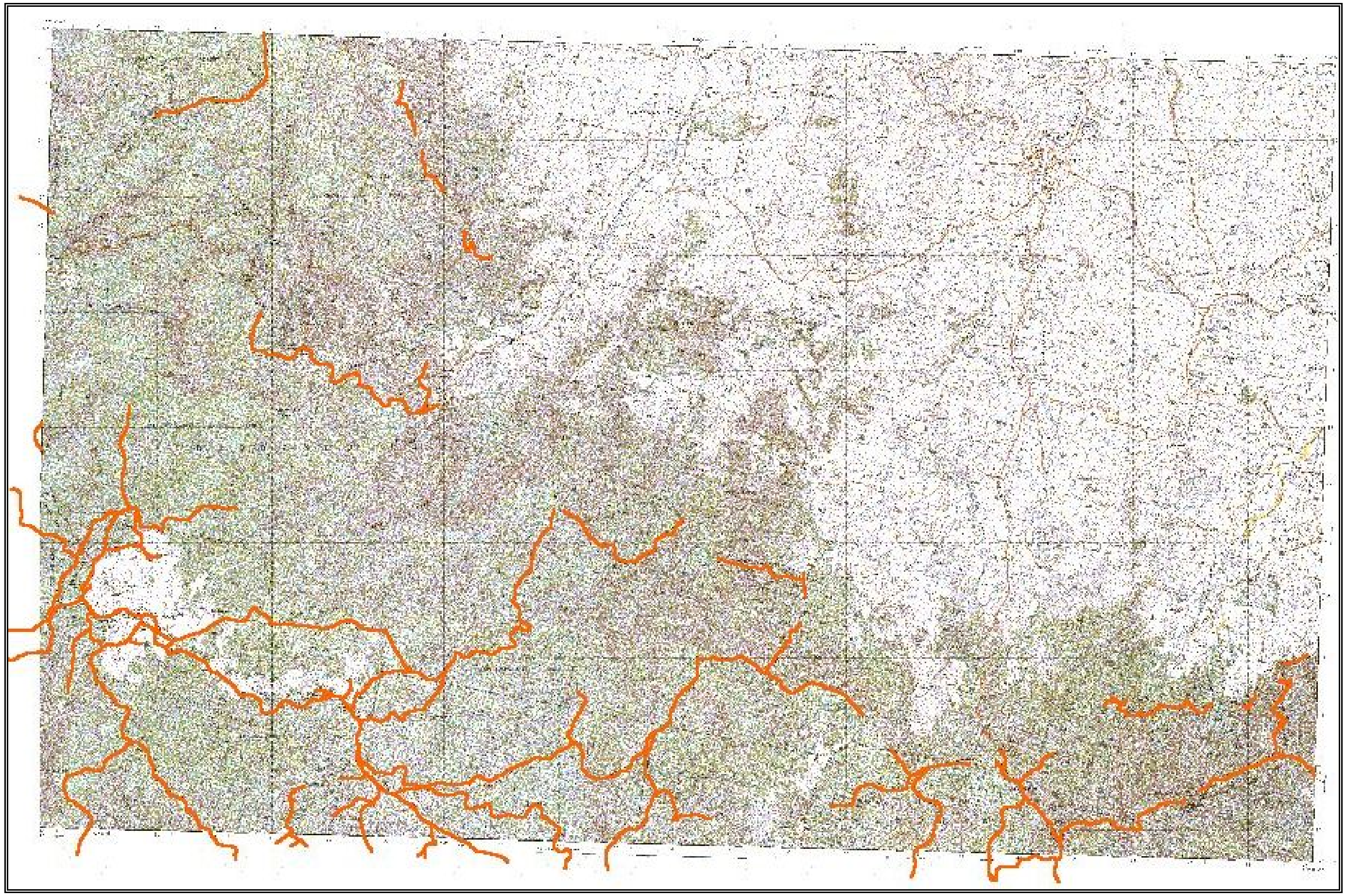
Inset of NSW Forests Data integrated with Wolumla 1:25000 Topographic Map

Appendix K-27: Pambula (8824-2s)



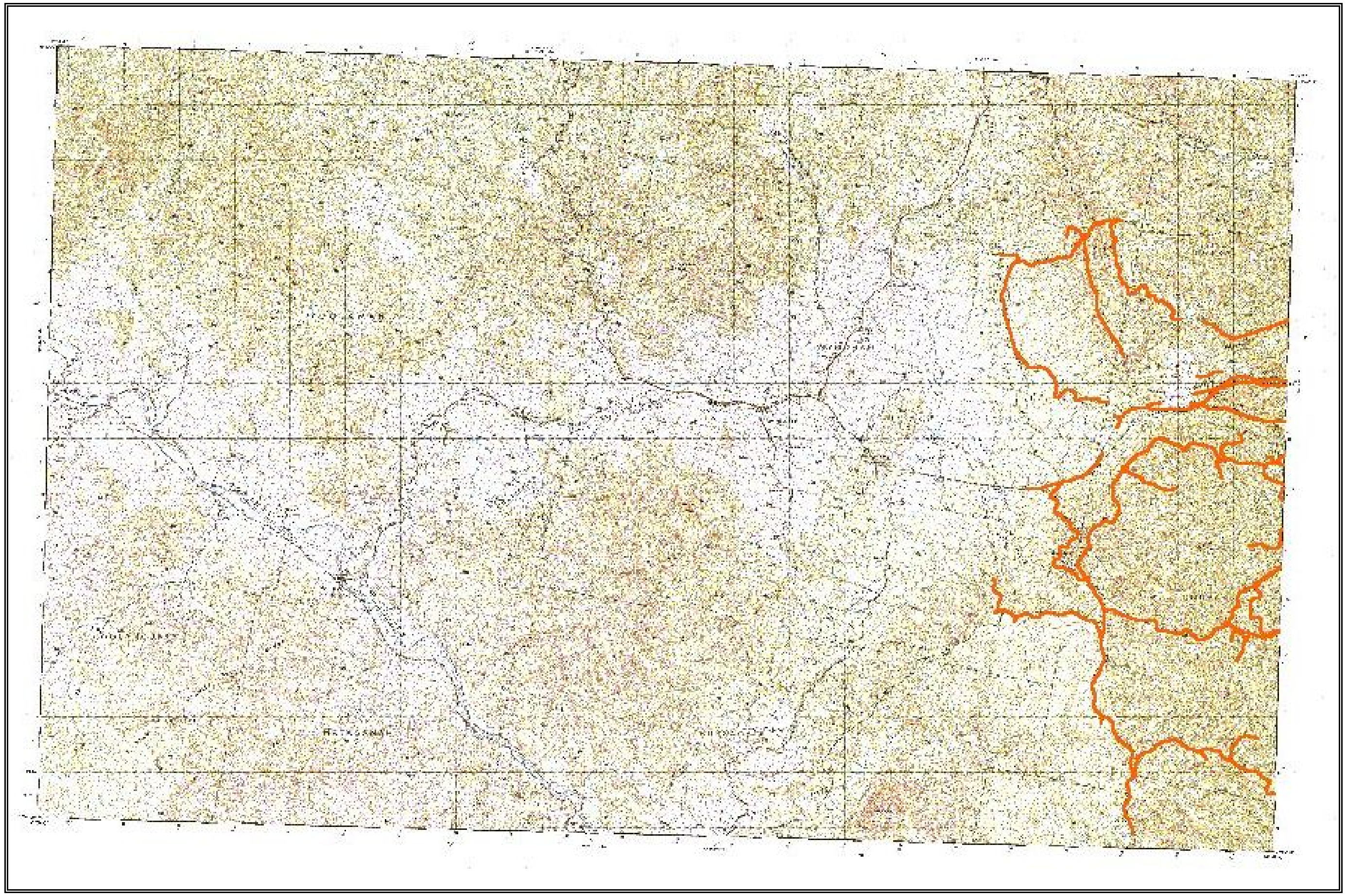
NSW Forests Data integrated with Pambula 1:25000 Topographic Map

Appendix K-28: Candelo (8824-3n)



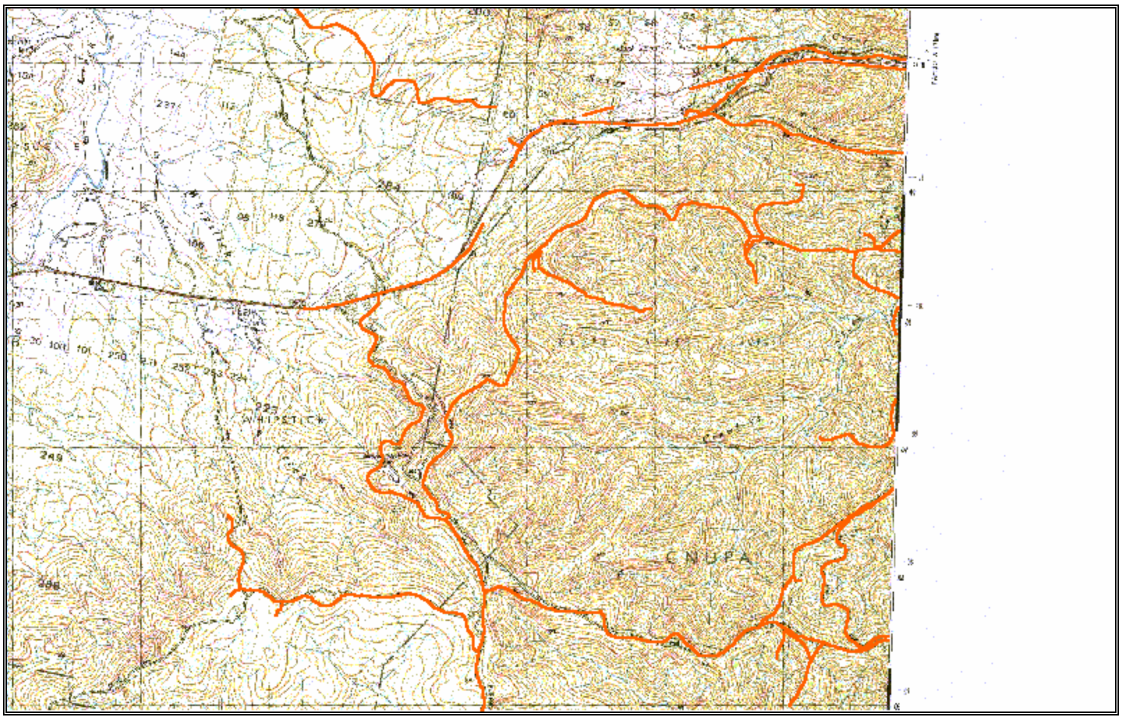
NSW Forests Data integrated with Candelo 1:25000 Topographic Map

Appendix K-29: Wyndham (8824-3s)



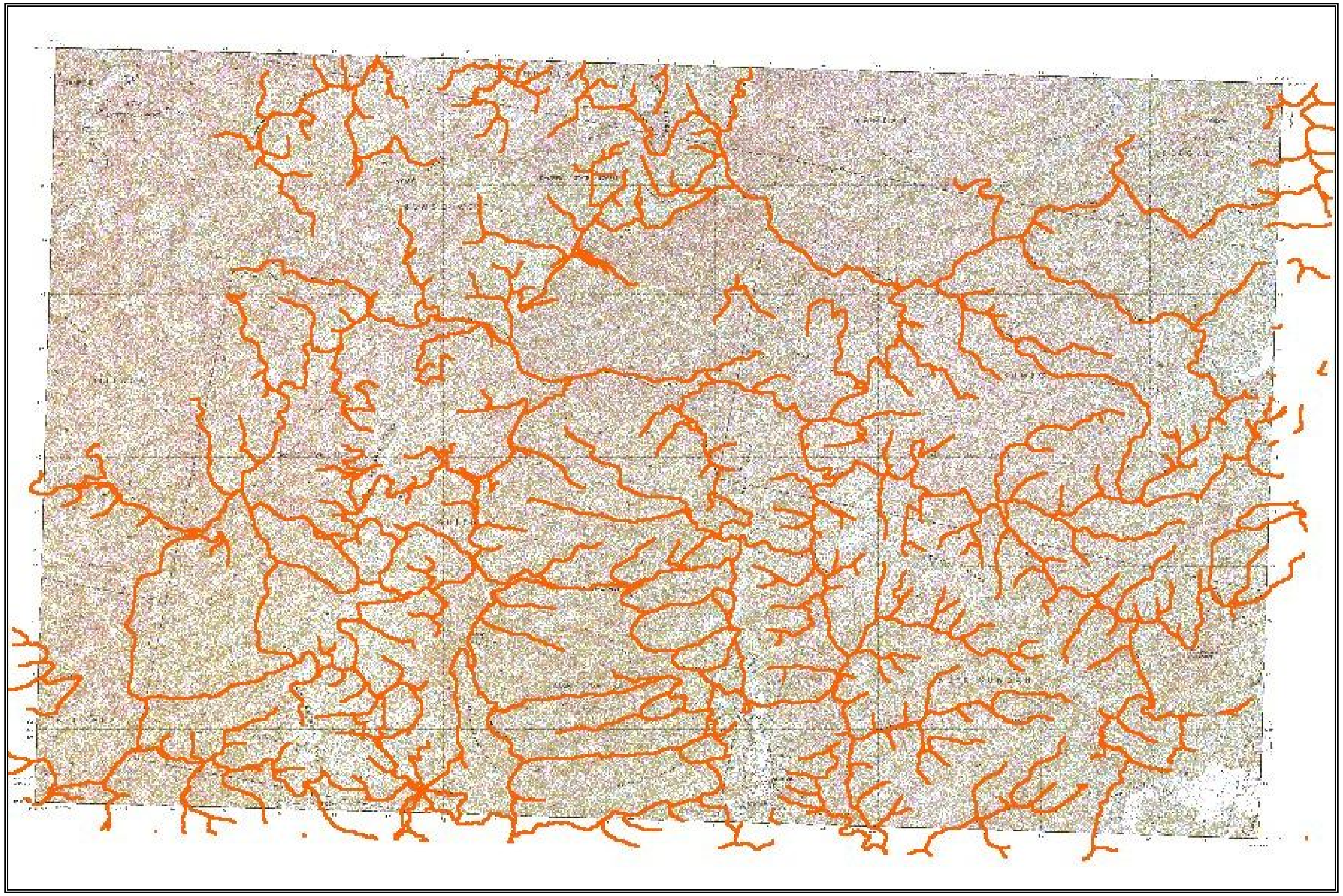
NSW Forests Data integrated with Wyndham 1:25000 Topographic Map

Appendix K-30



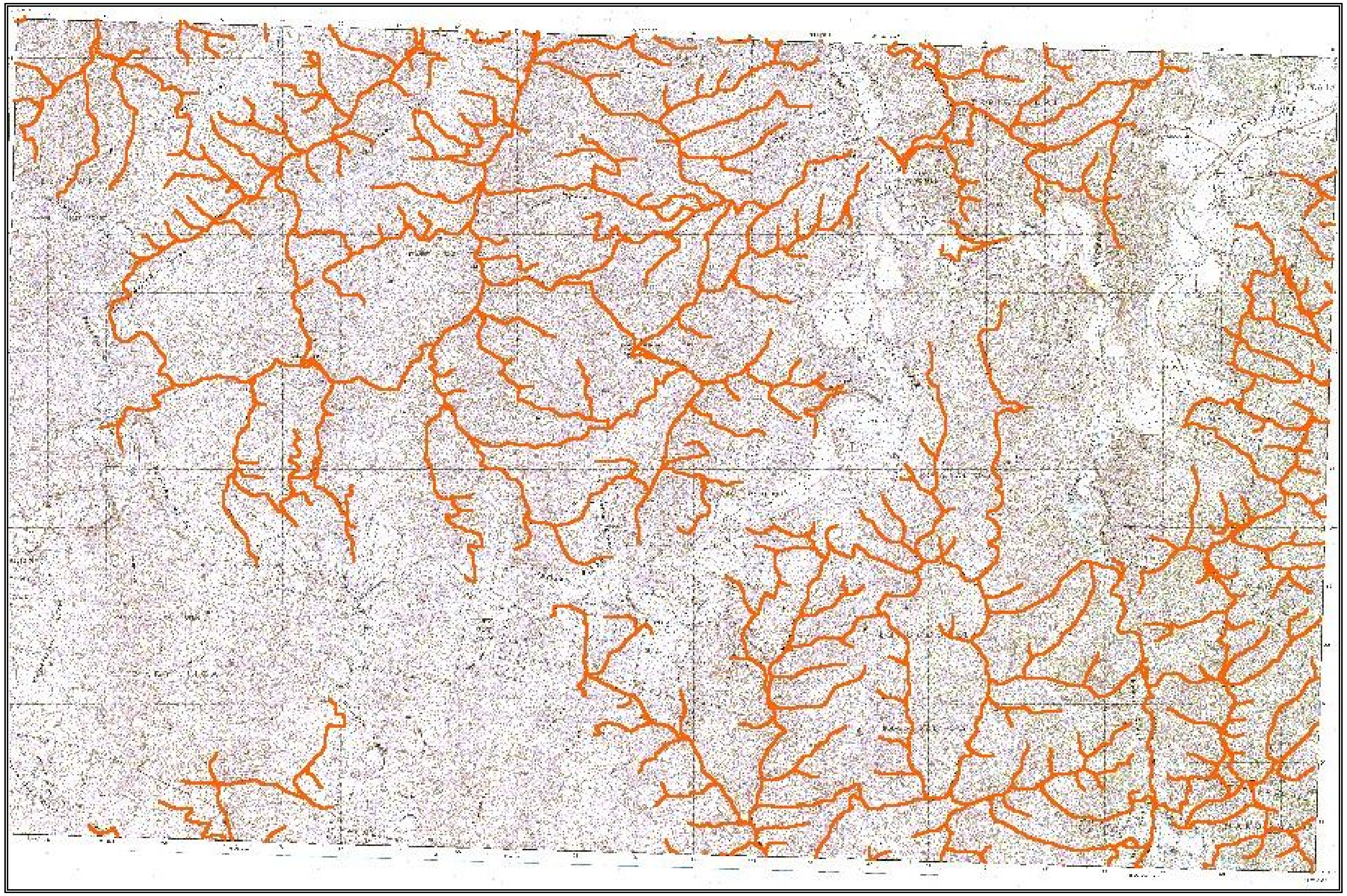
Inset of NSW Forests Data integrated with Wyndham 1:25000 Topographic Map

Appendix K-31: Nerrigundah (8825-1n)



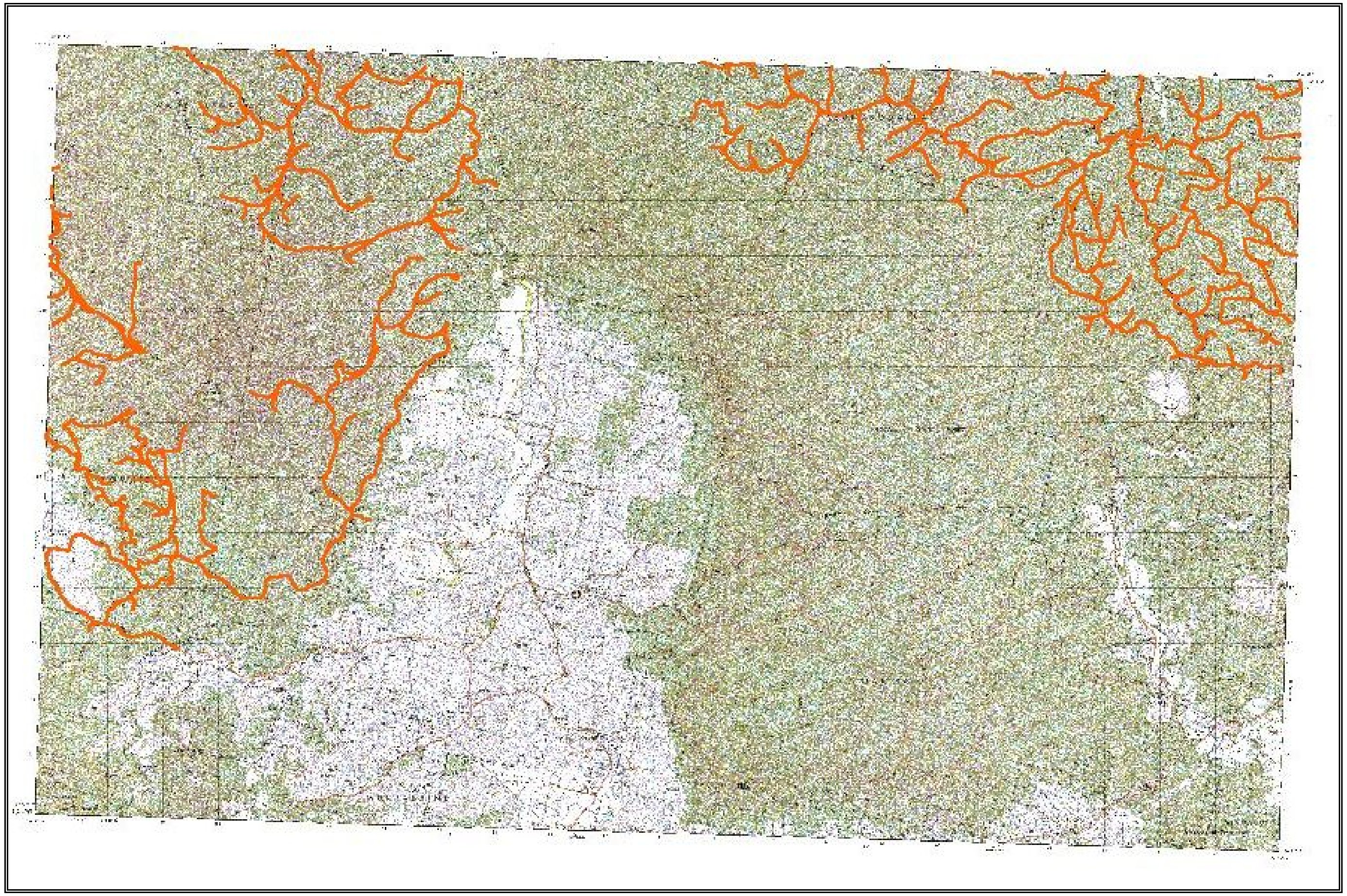
NSW Forests Data integrated with Nerrigundah 1:25000 Topographic Map

Appendix K-32: Cadgee (8825-1s)



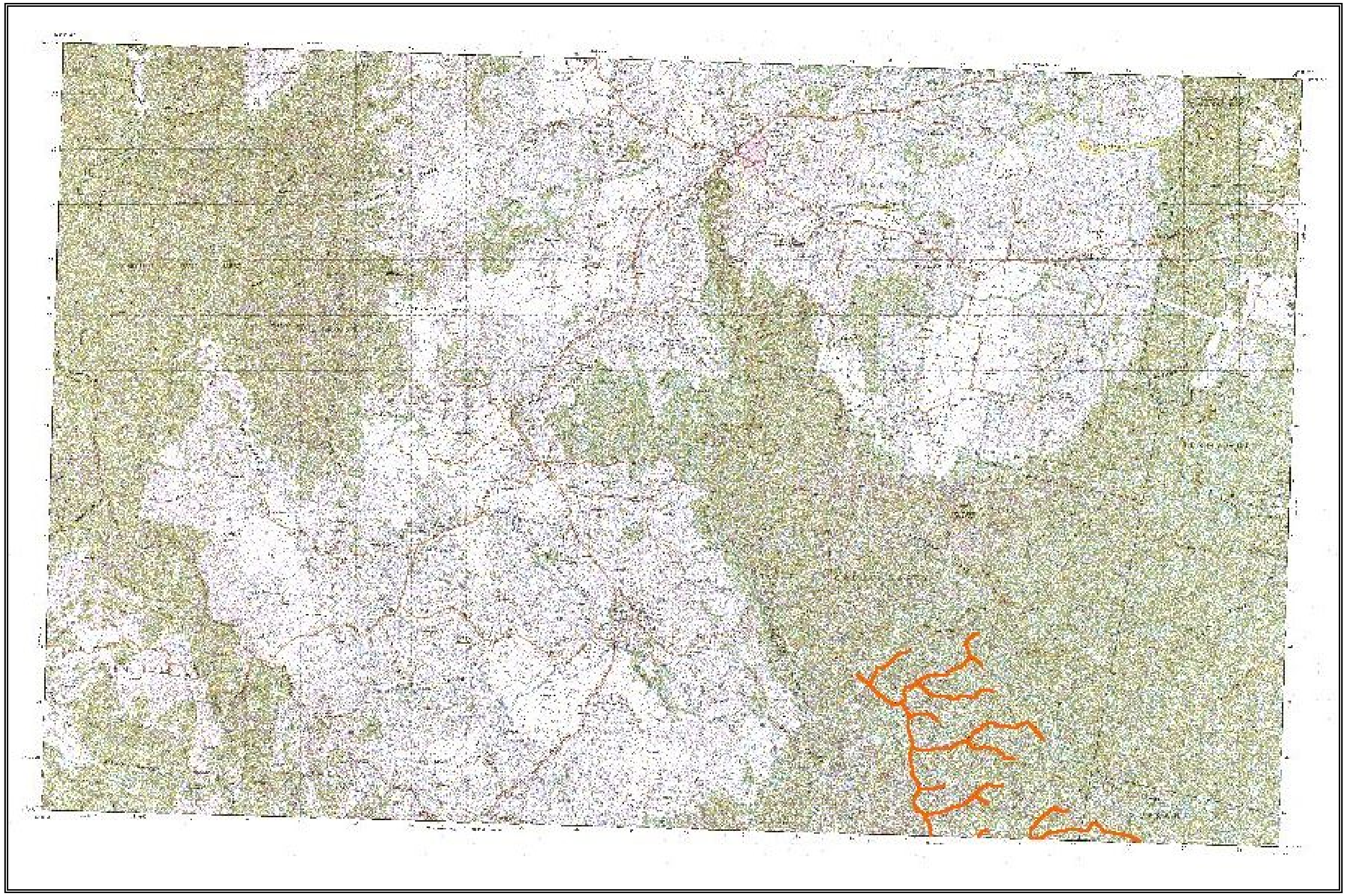
NSW Forests Data integrated with Cadgee 1:25000 Topographic Map

Appendix K-33: Wandella (8825-2n)



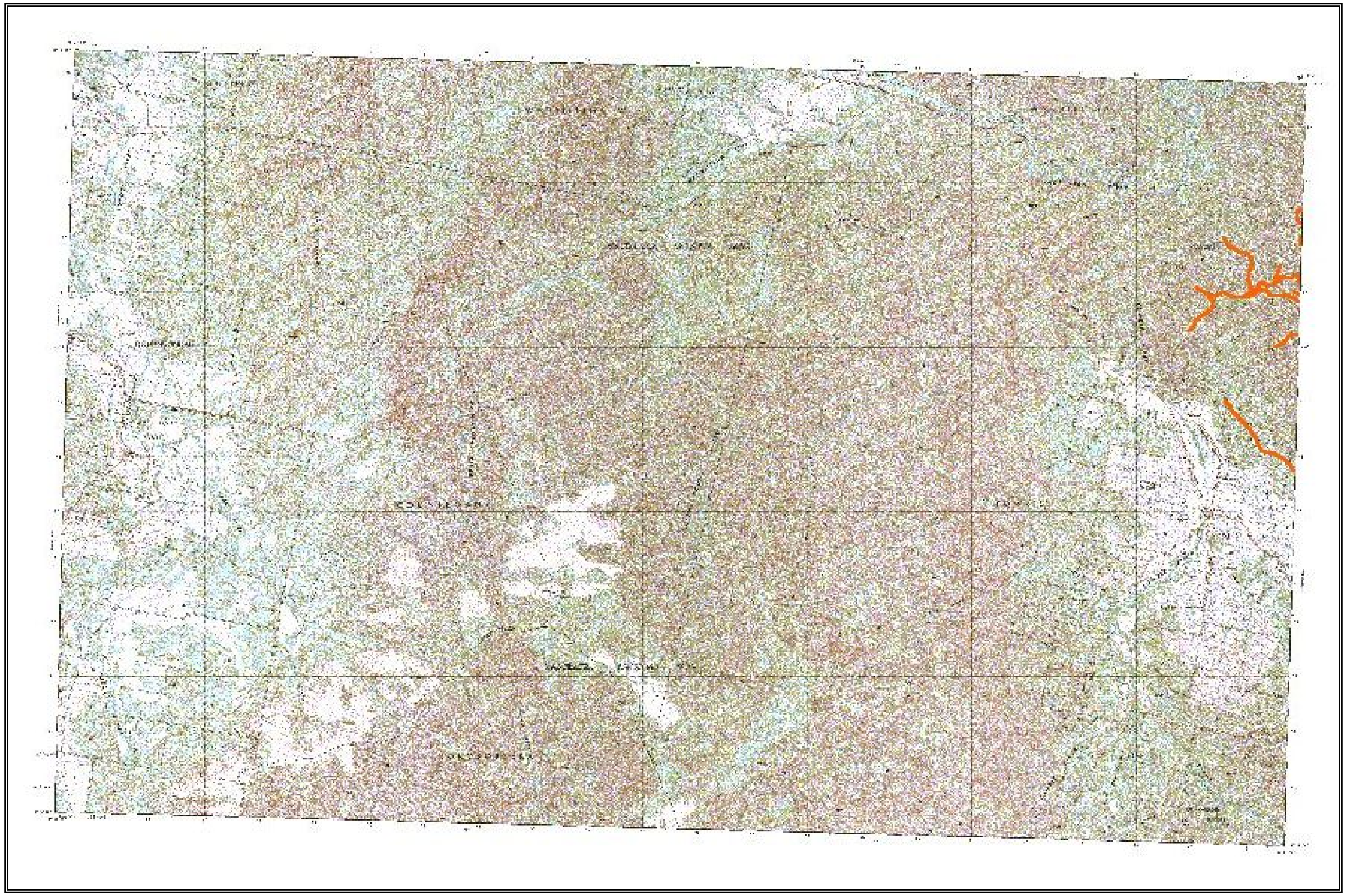
NSW Forests Data integrated with Wandella 1:25000 Topographic Map

Appendix K-35: Cobargo (8825-2s)



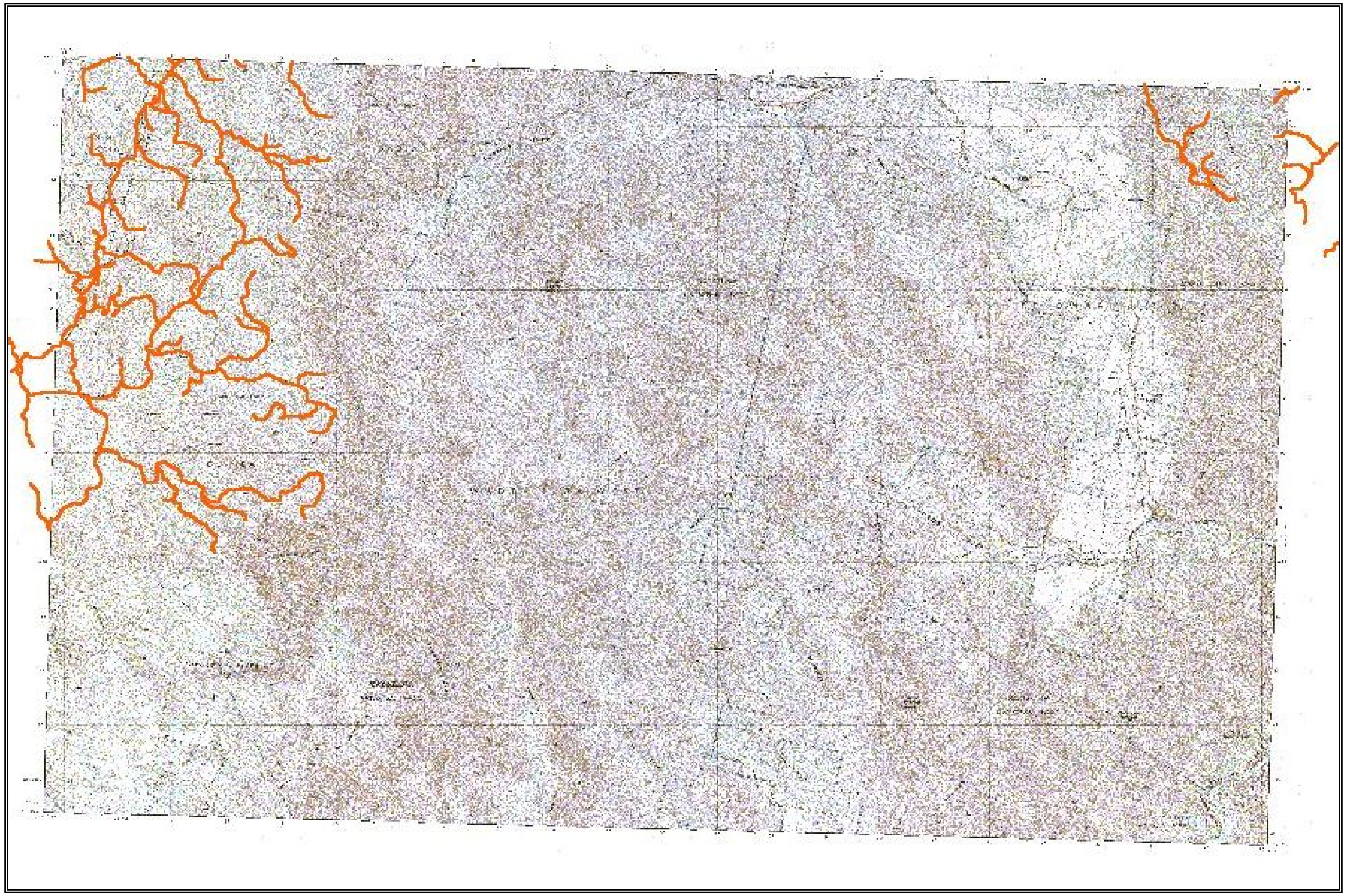
NSW Forests Data integrated with Cobargo 1:25000 Topographic Map

Appendix K-36: Yowrie (8825-3n)



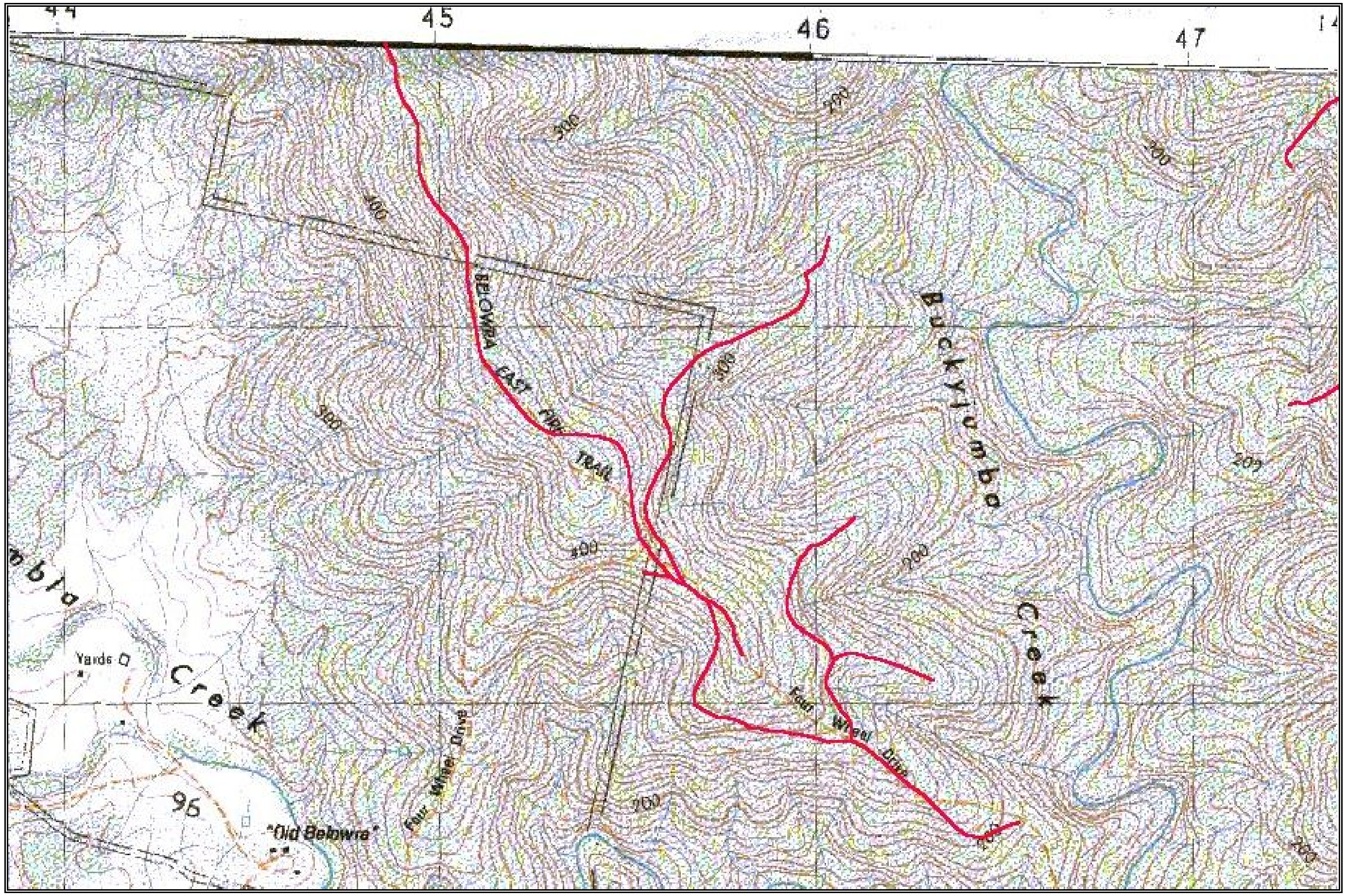
NSW Forests Data integrated with Yowrie 1:25000 Topographic Map

Appendix K-37: Belowra (8825-4s)



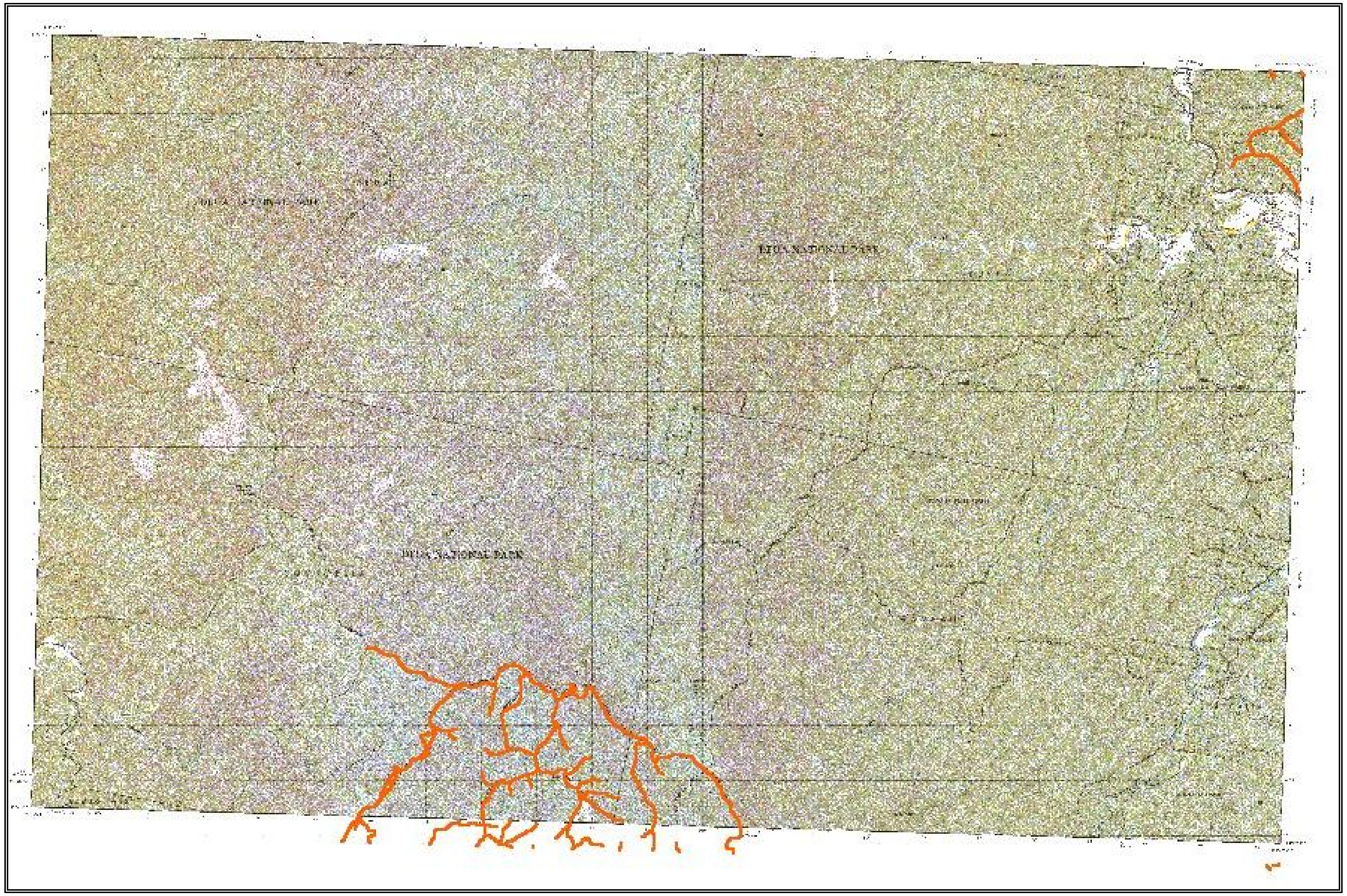
NSW Forests Data integrated with Belowra 1:25000 Topographic Map

Appendix K-38



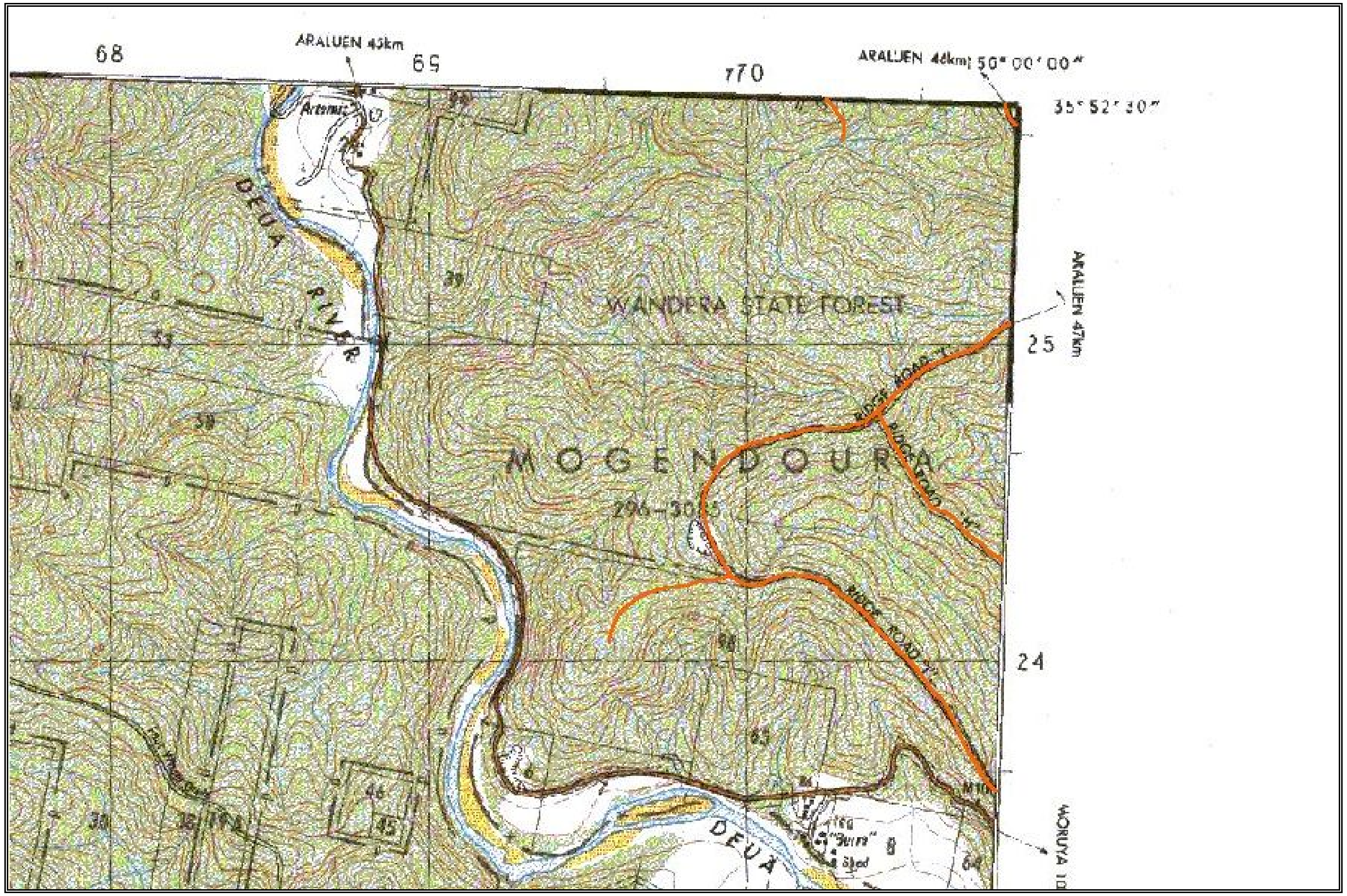
Inset of NSW Forests Data integrated with Belowra 1:25000 Topographic Map

Appendix K-39: Bendethera (8826-2s)



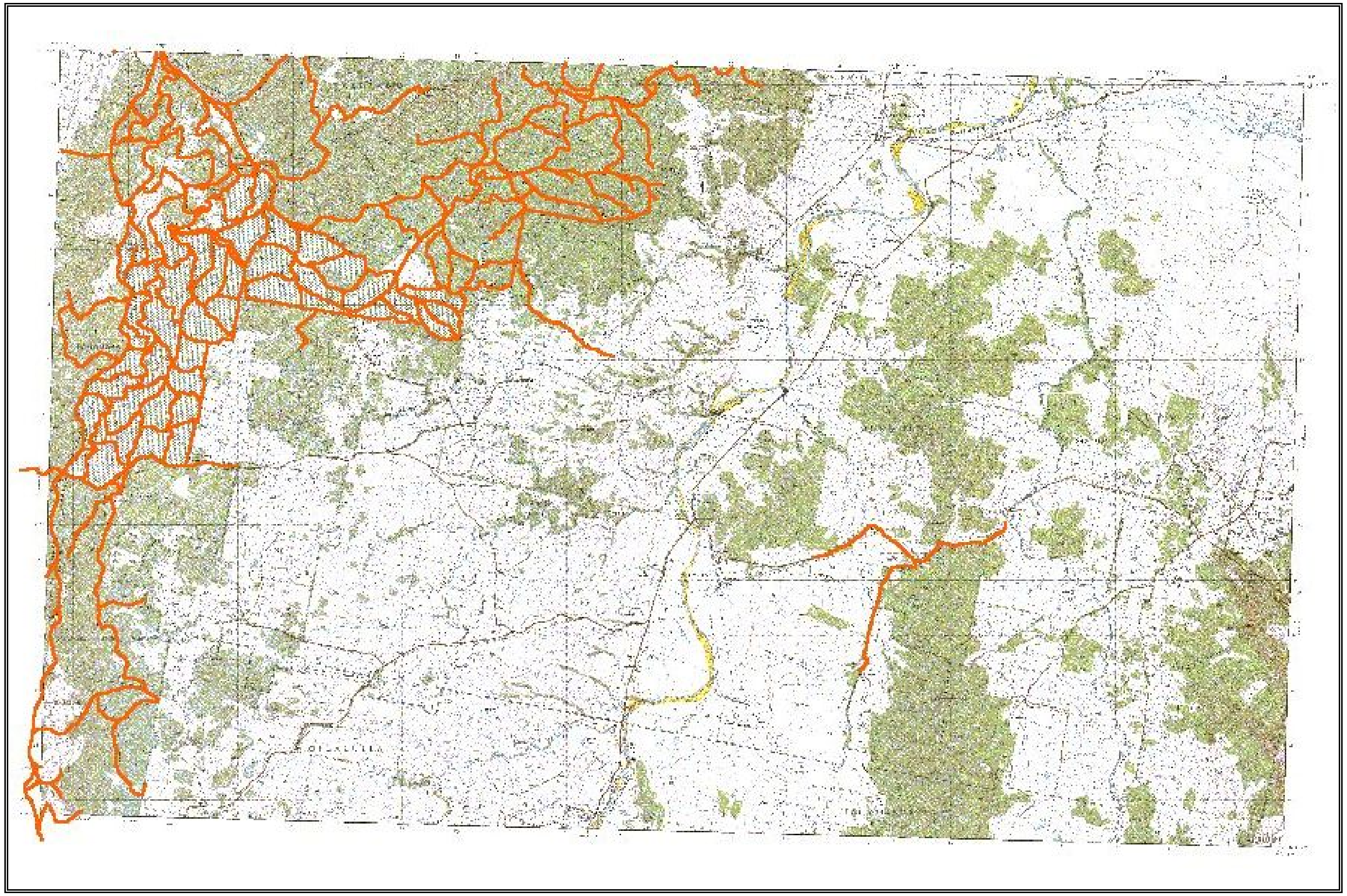
NSW Forests Data integrated with Bendethera 1:25000 Topographic Map

Appendix K-40



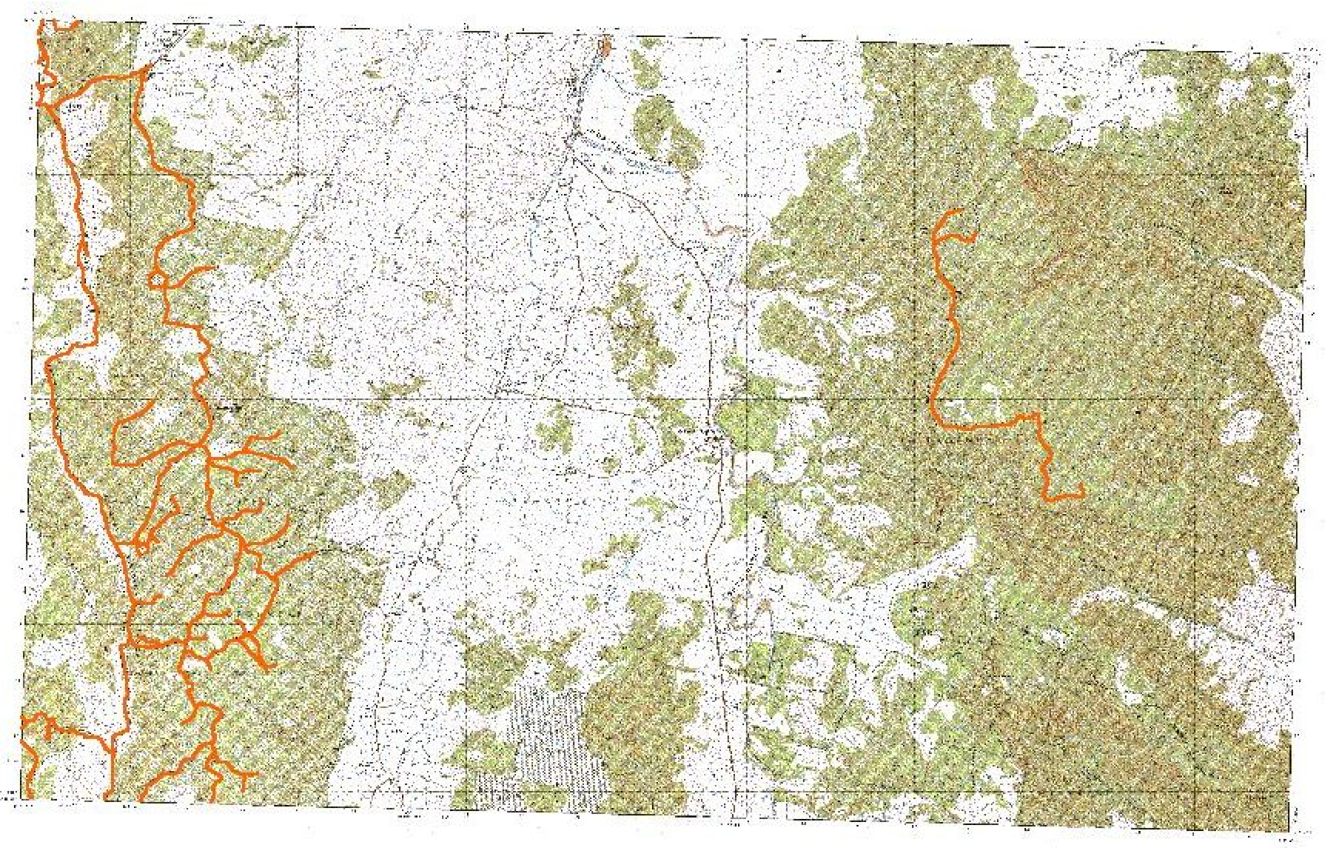
Inset of NSW Forests Data integrated with Bendethera 1:25000 Topographic Map

Appendix K-41: Bendoura (8826-4n)



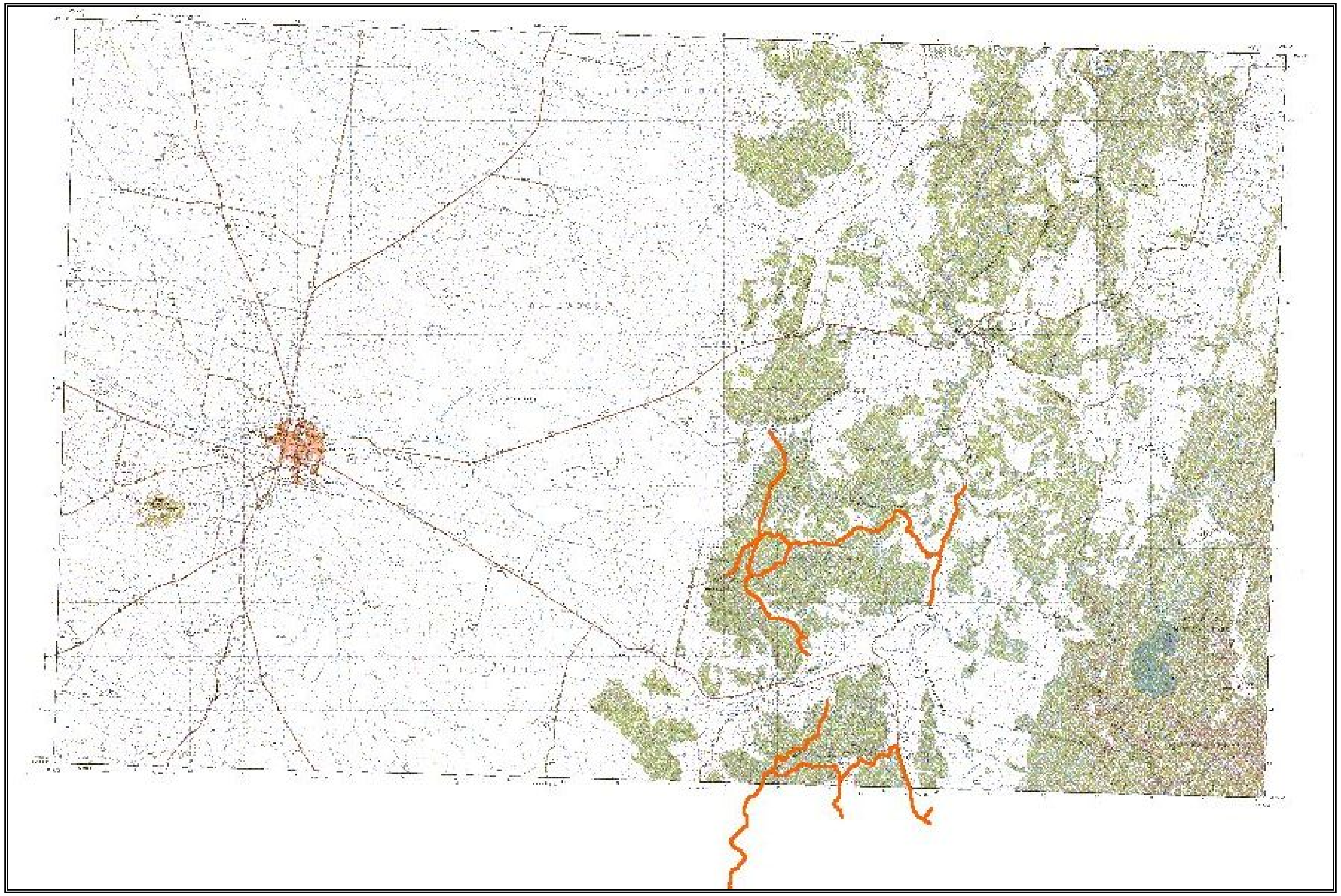
NSW Forests Data integrated with Bendoura 1:25000 Topographic Map

Appendix K-42: Kain (8826-4s)



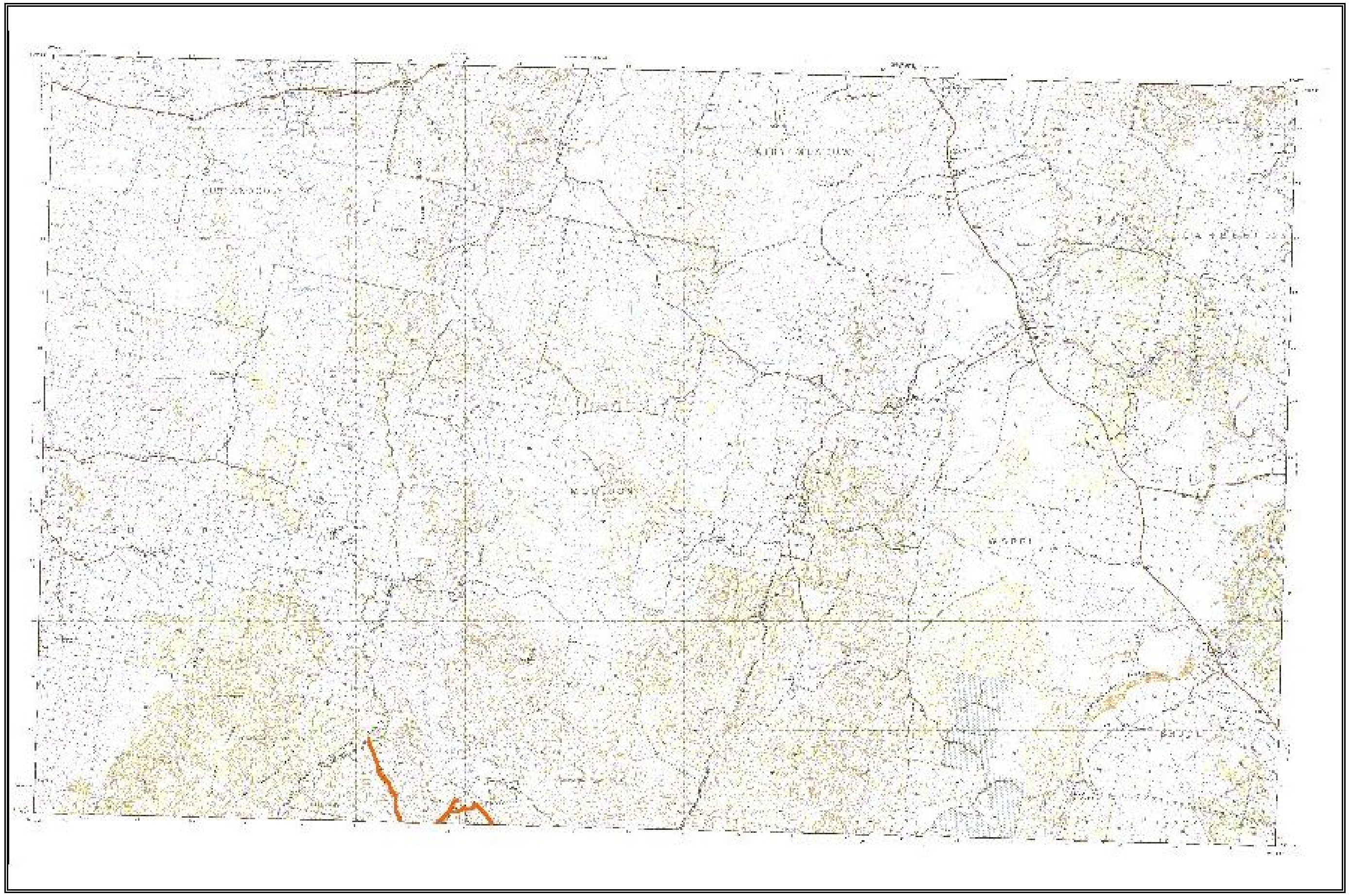
NSW Forests Data integrated with Kain 1:25000 Topographic Map

Appendix K-43: Braidwood (8827-2s)



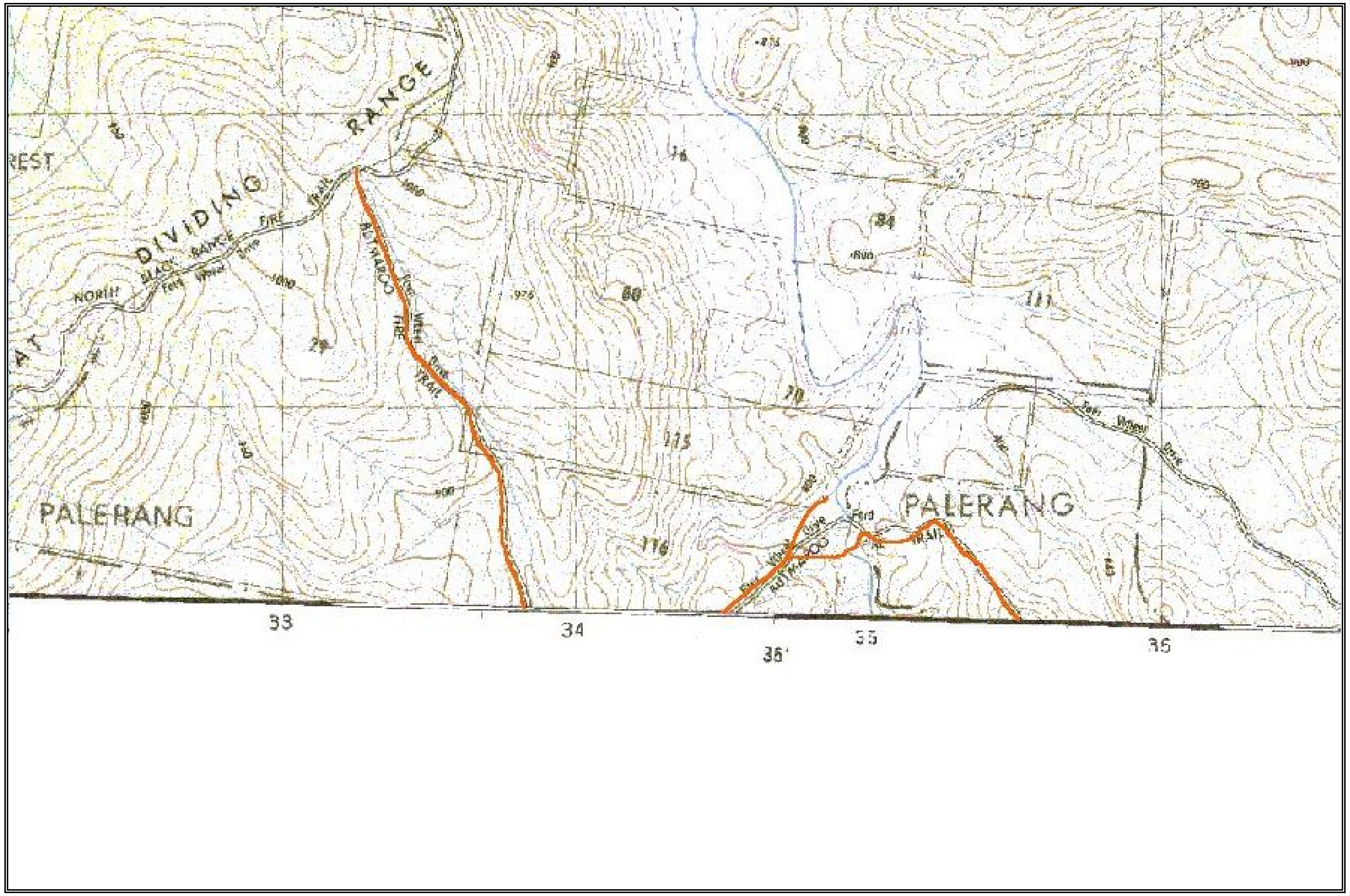
NSW Forests Data integrated with Braidwood 1:25000 Topographic Map

Appendix K-44: Manar (8827-3n)



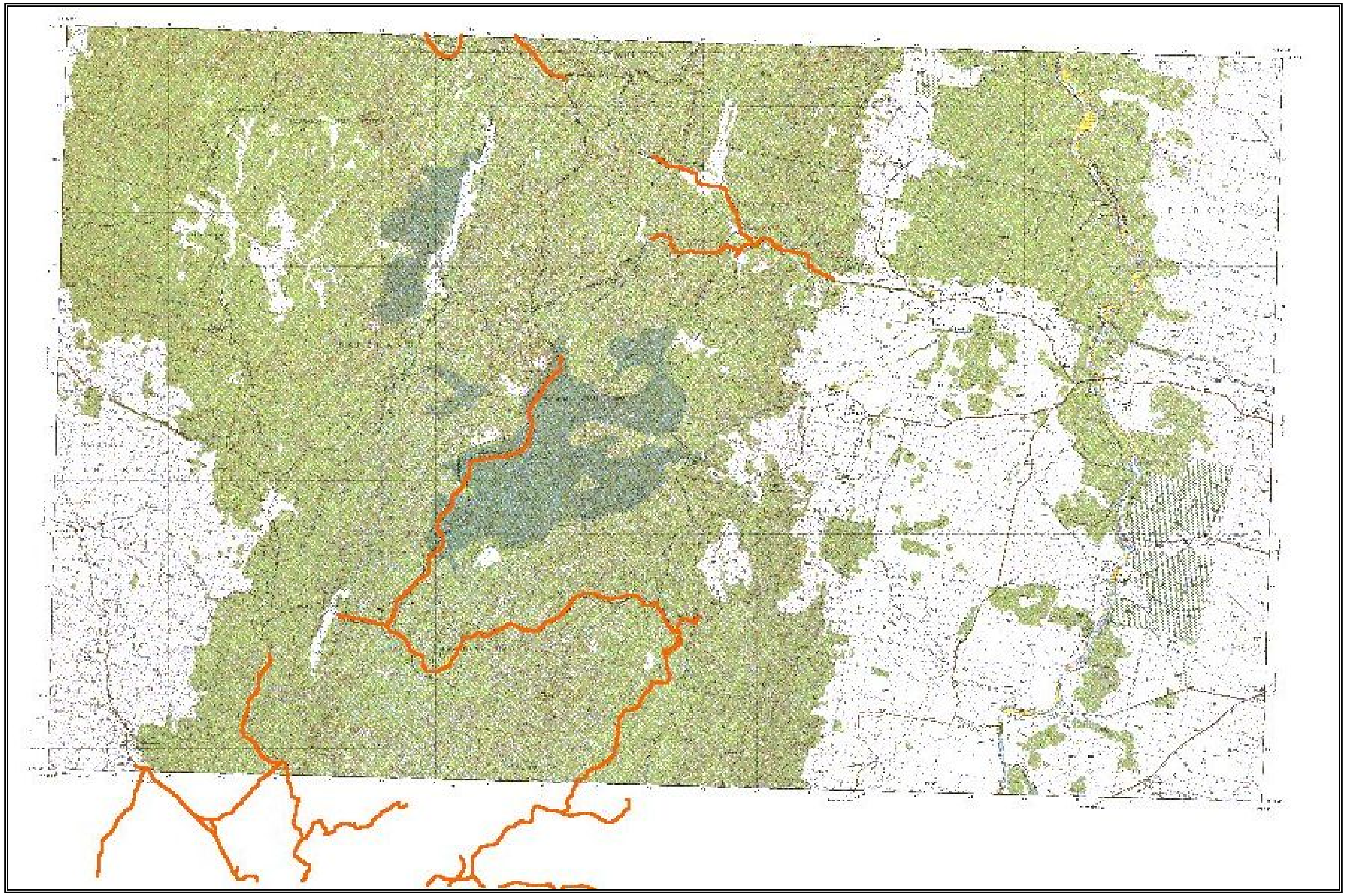
NSW Forests Data integrated with Manar 1:25000 Topographic Map

Appendix K-45



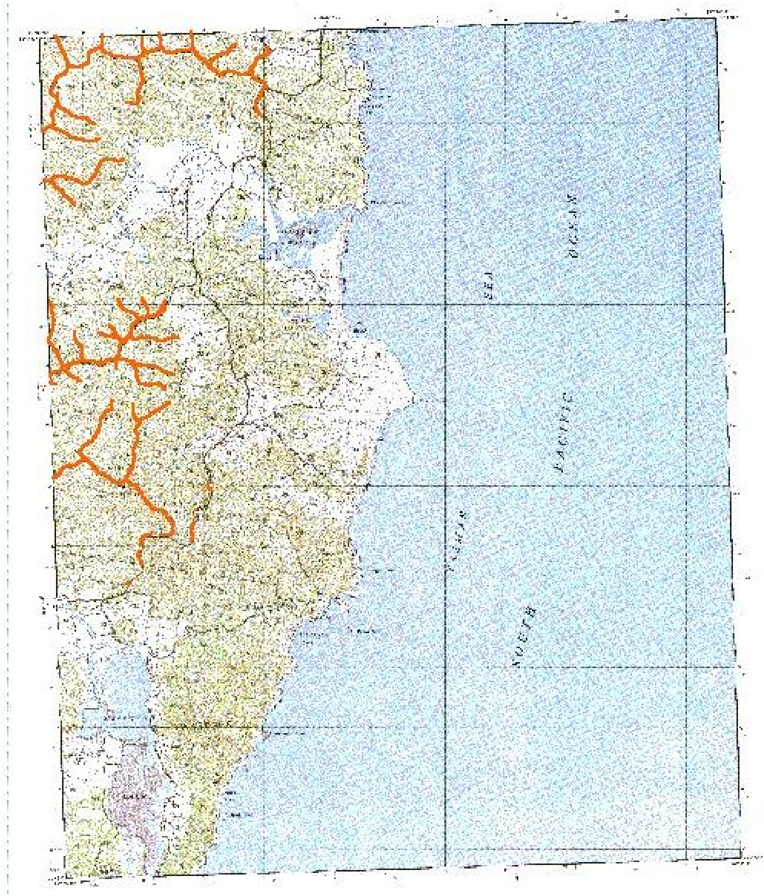
Inset of NSW Forests Data integrated with Manar 1:25000 Topographic Map

Appendix K-46: Bombay (8827-3s)



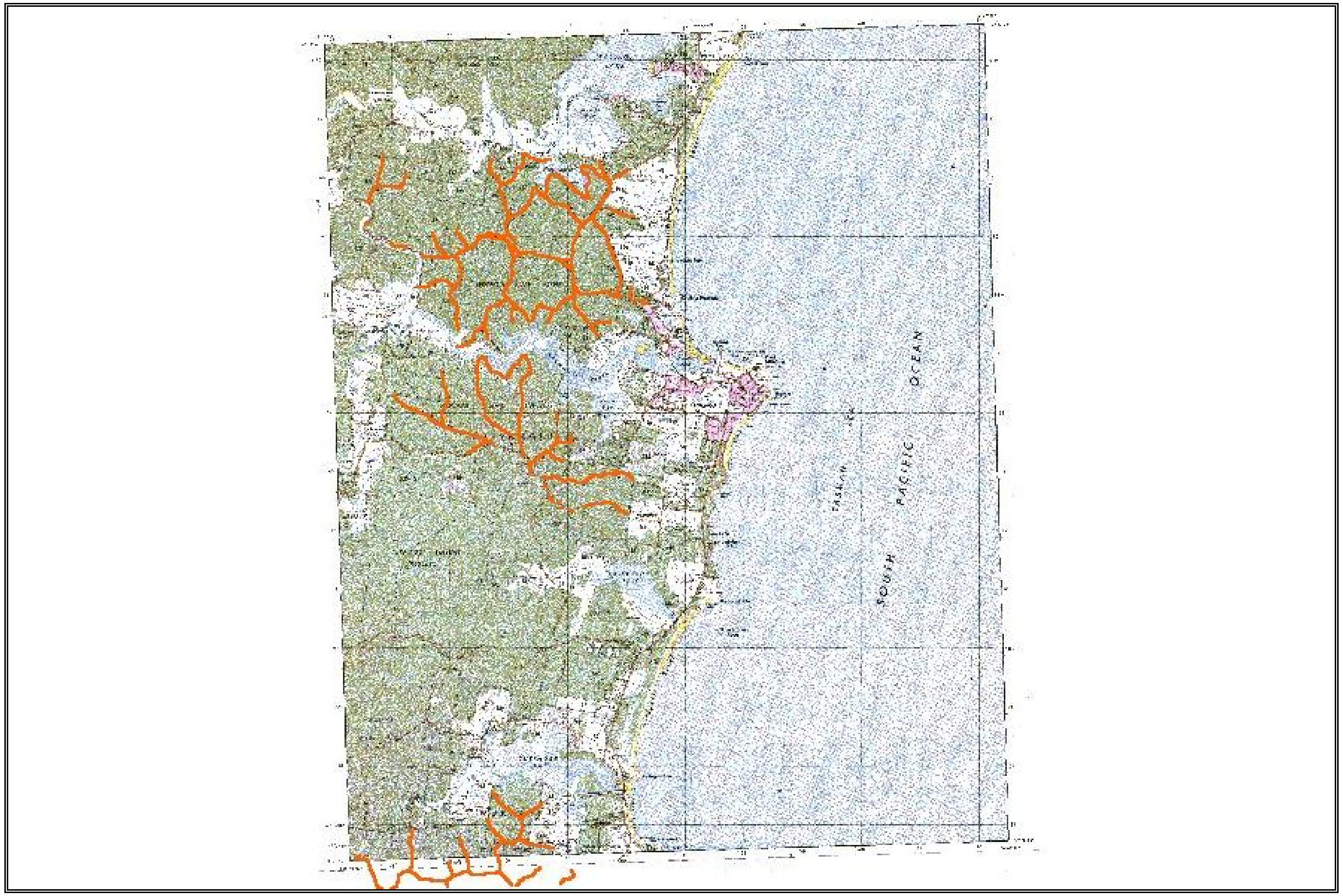
NSW Forests Data integrated with Bombay 1:25000 Topographic Map

Appendix K-47: Murrah (8924-4n)



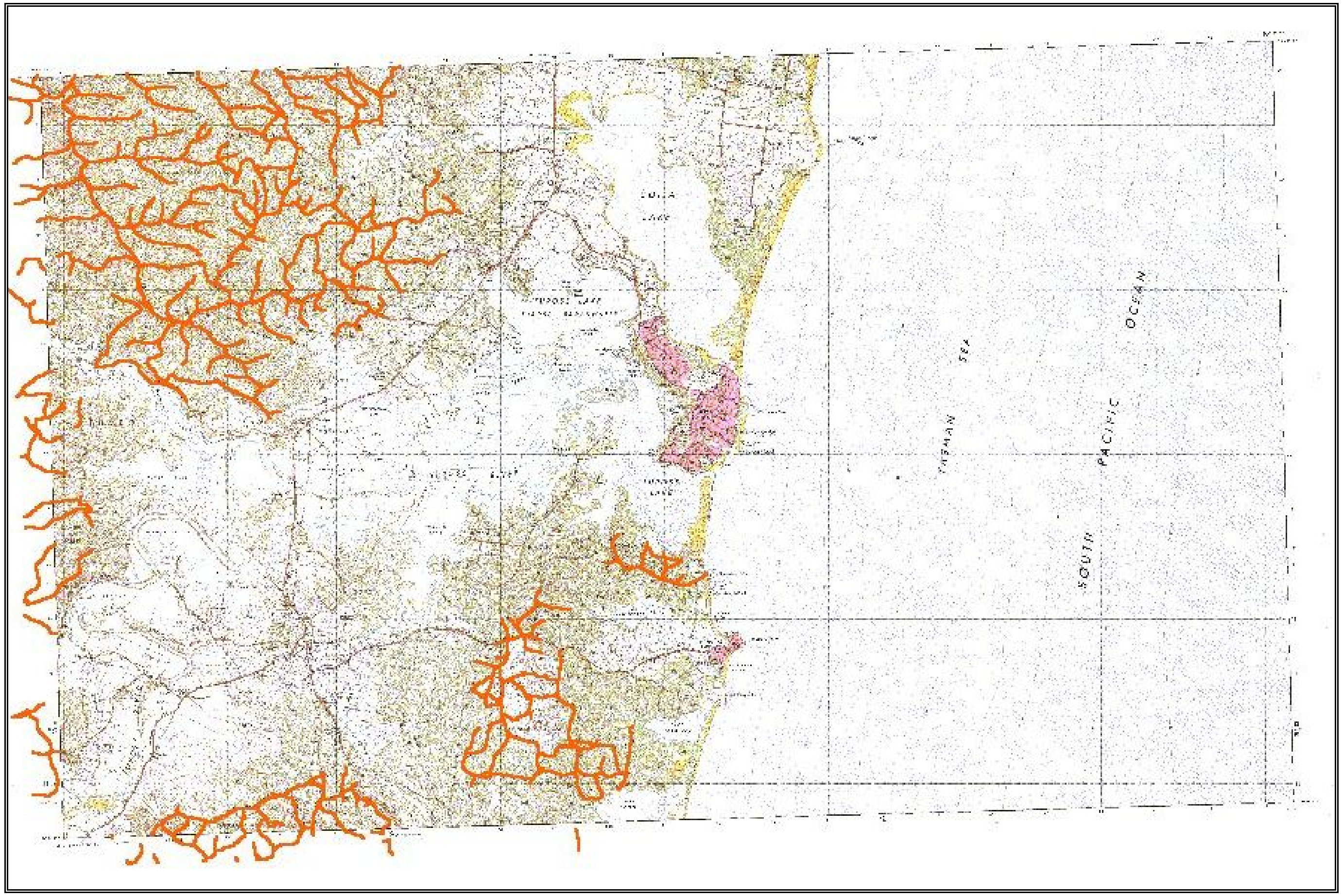
NSW Forests Data integrated with Murrah 1:25000 Topographic Map

Appendix K-48: Bermagui (8925-3s)



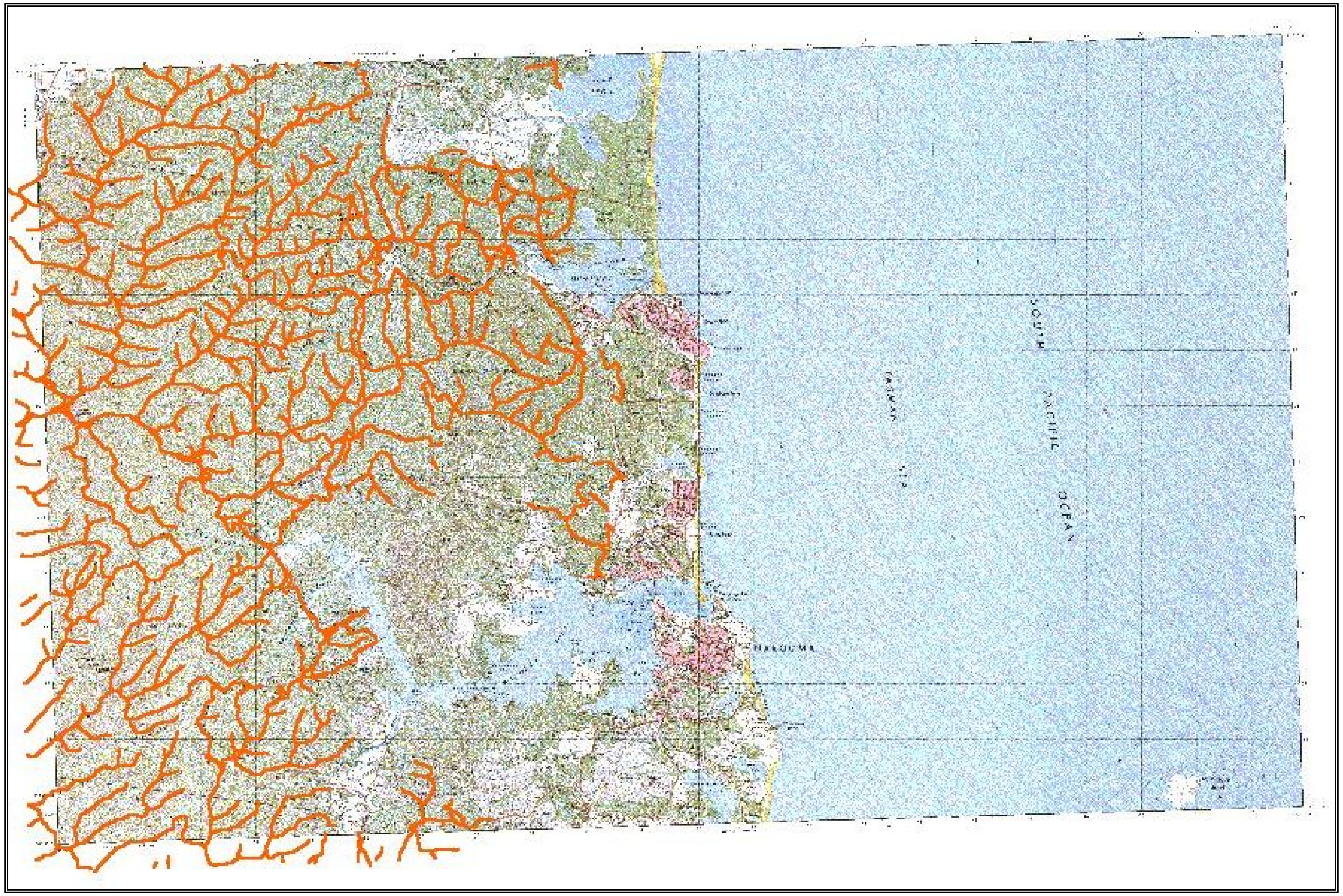
NSW Forests Data integrated with Bermagui 1:25000 Topographic Map

Appendix K-49: Bodalla (8925-4n)



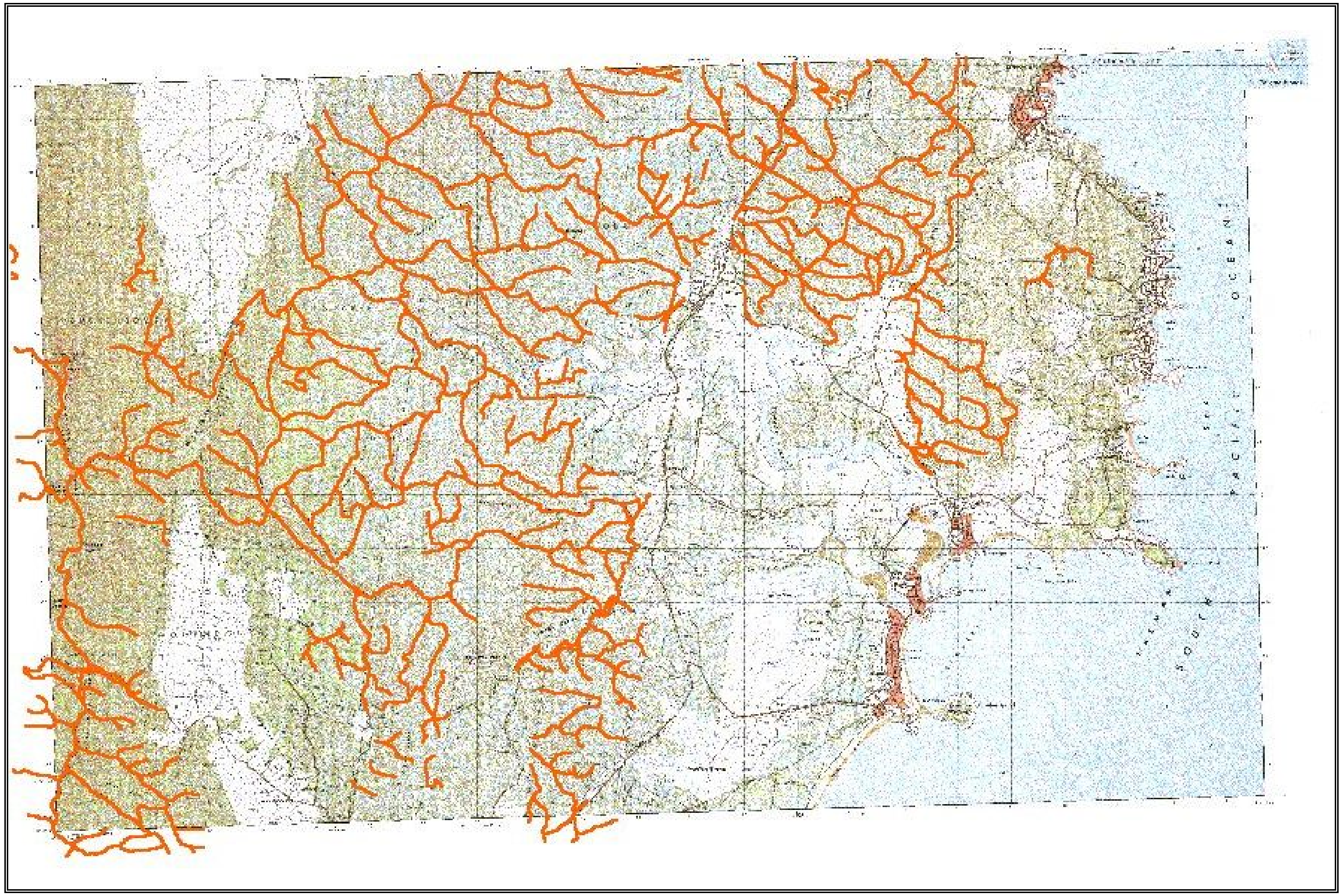
NSW Forests Data integrated with Bodalla 1:25000 Topographic Map

Appendix K-50: Narooma (8925-4s)



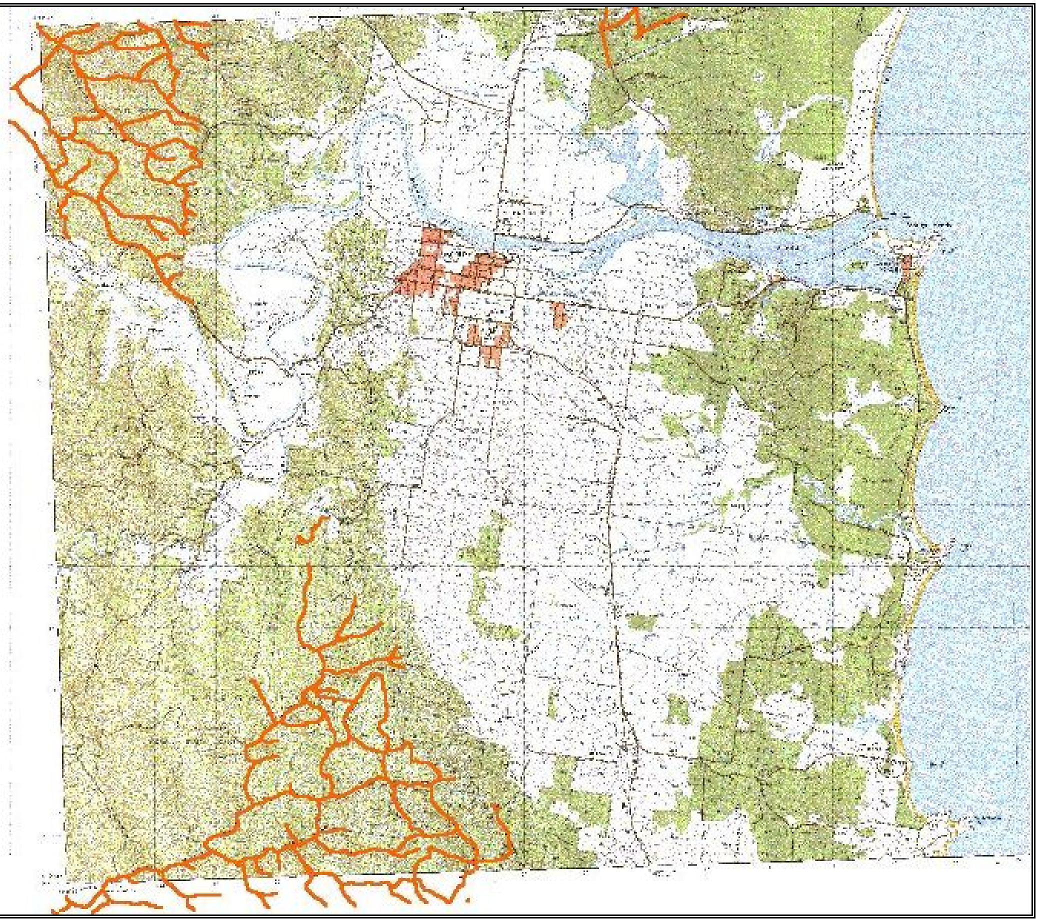
NSW Forests Data integrated with Narooma 1:25000 Topographic Map

Appendix K-51: Mogo (8926-3n)



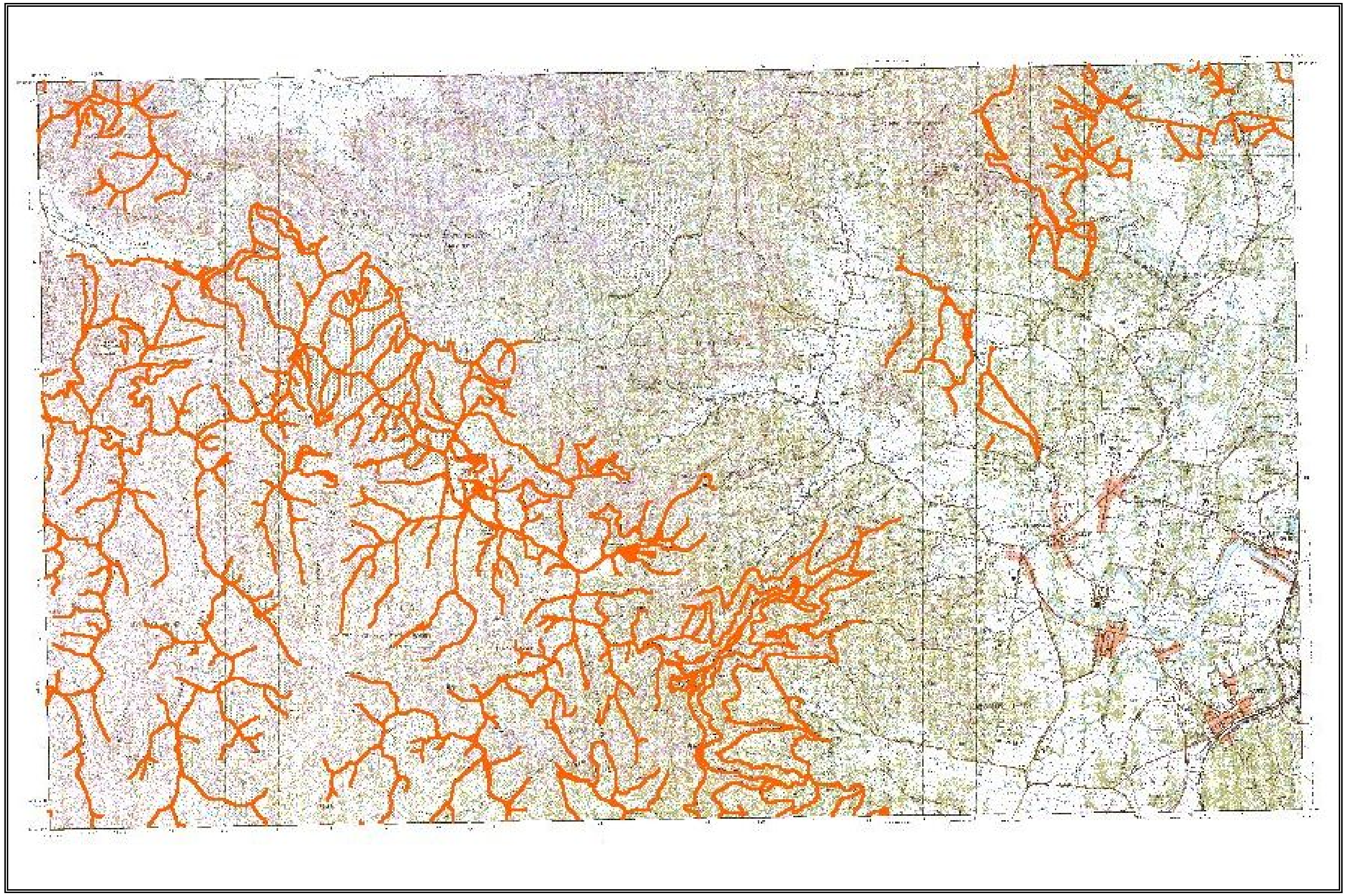
NSW Forests Data integrated with Mogo 1:25000 Topographic Map

Appendix K-52: Moruya (8926-3s)



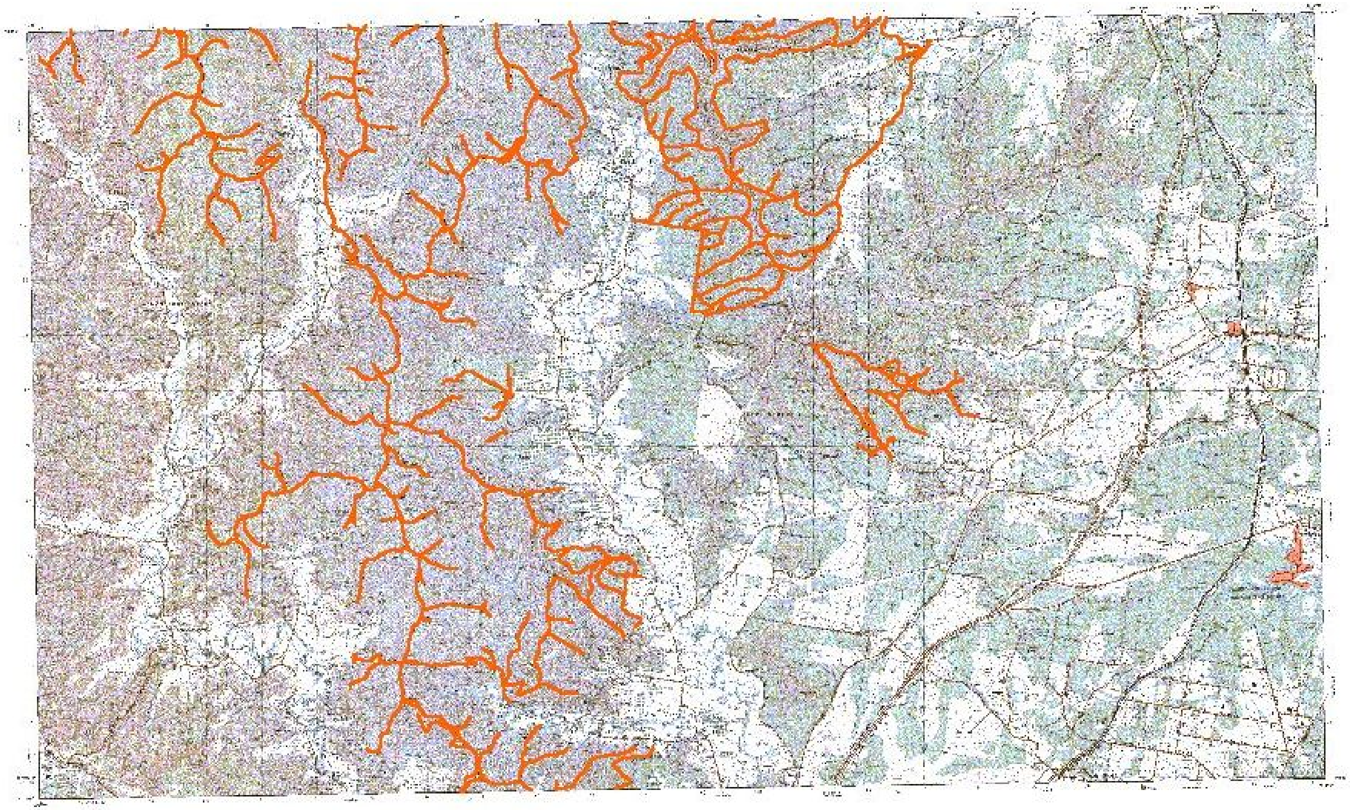
NSW Forests Data integrated with Moruya 1:25000 Topographic Map

Appendix K-53: Morriset (9131-1n)



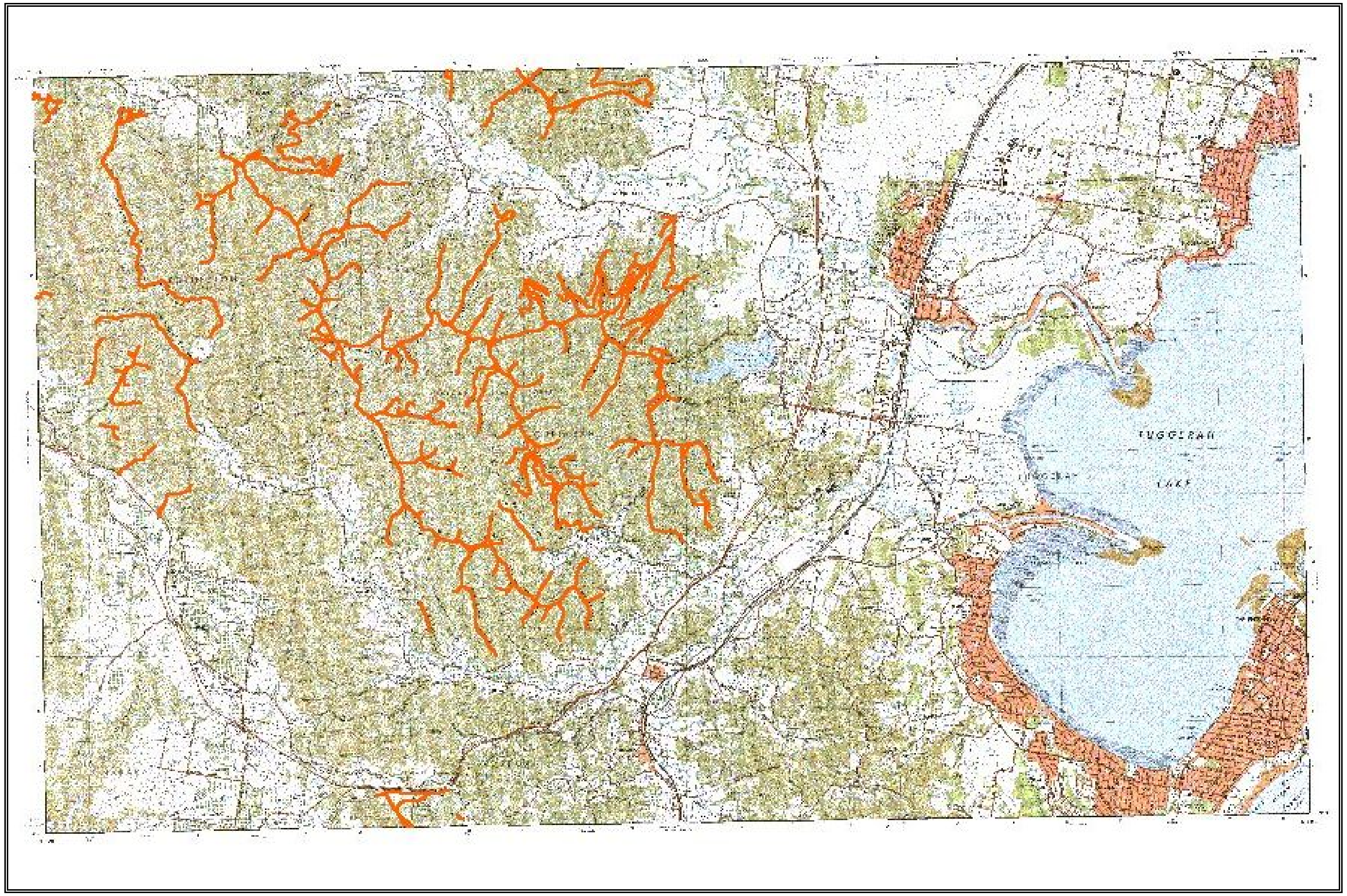
NSW Forests Data integrated with Morisset 1:25000 Topographic Map

Appendix K-54: Dooralong (9131-1s)



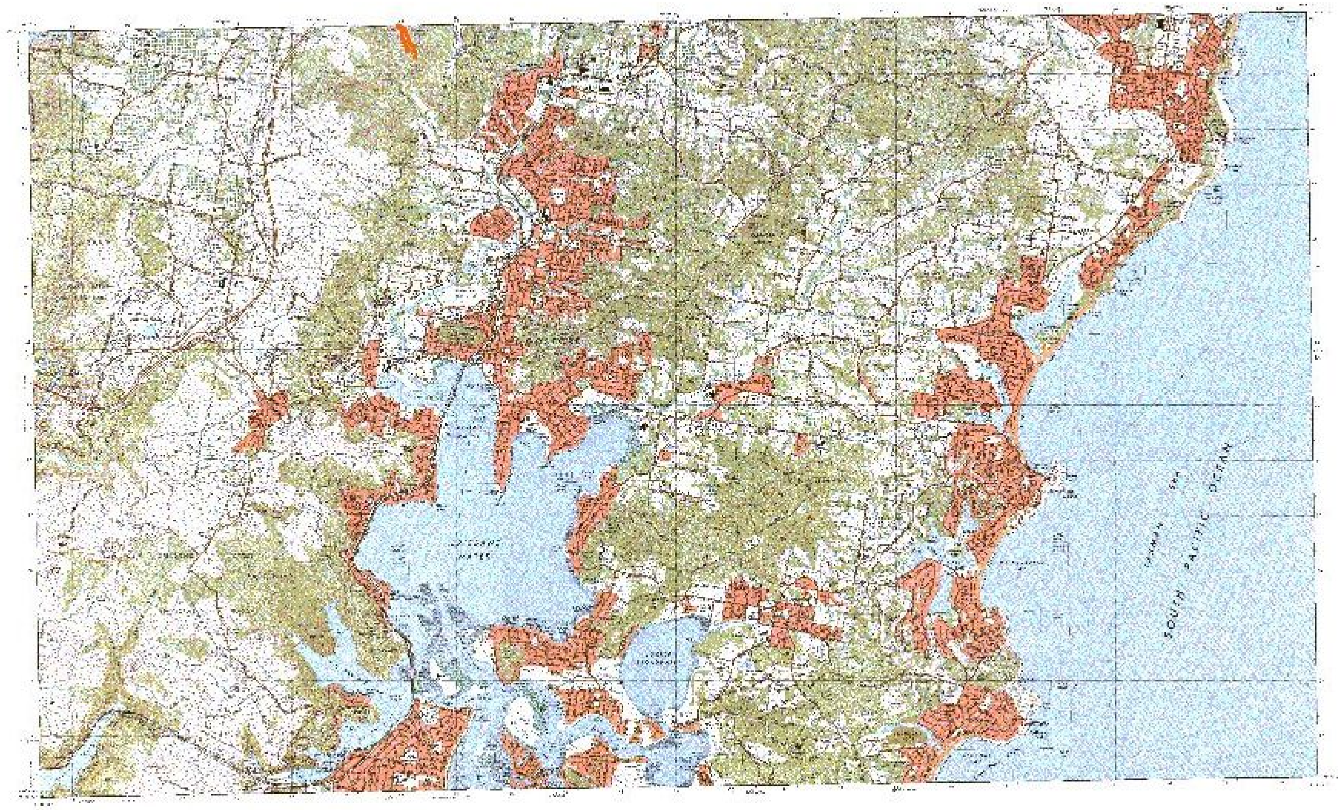
NSW Forests Data integrated with Dooralong 1:25000 Topographic Map

Appendix K-55: Wyong (9131-2n)



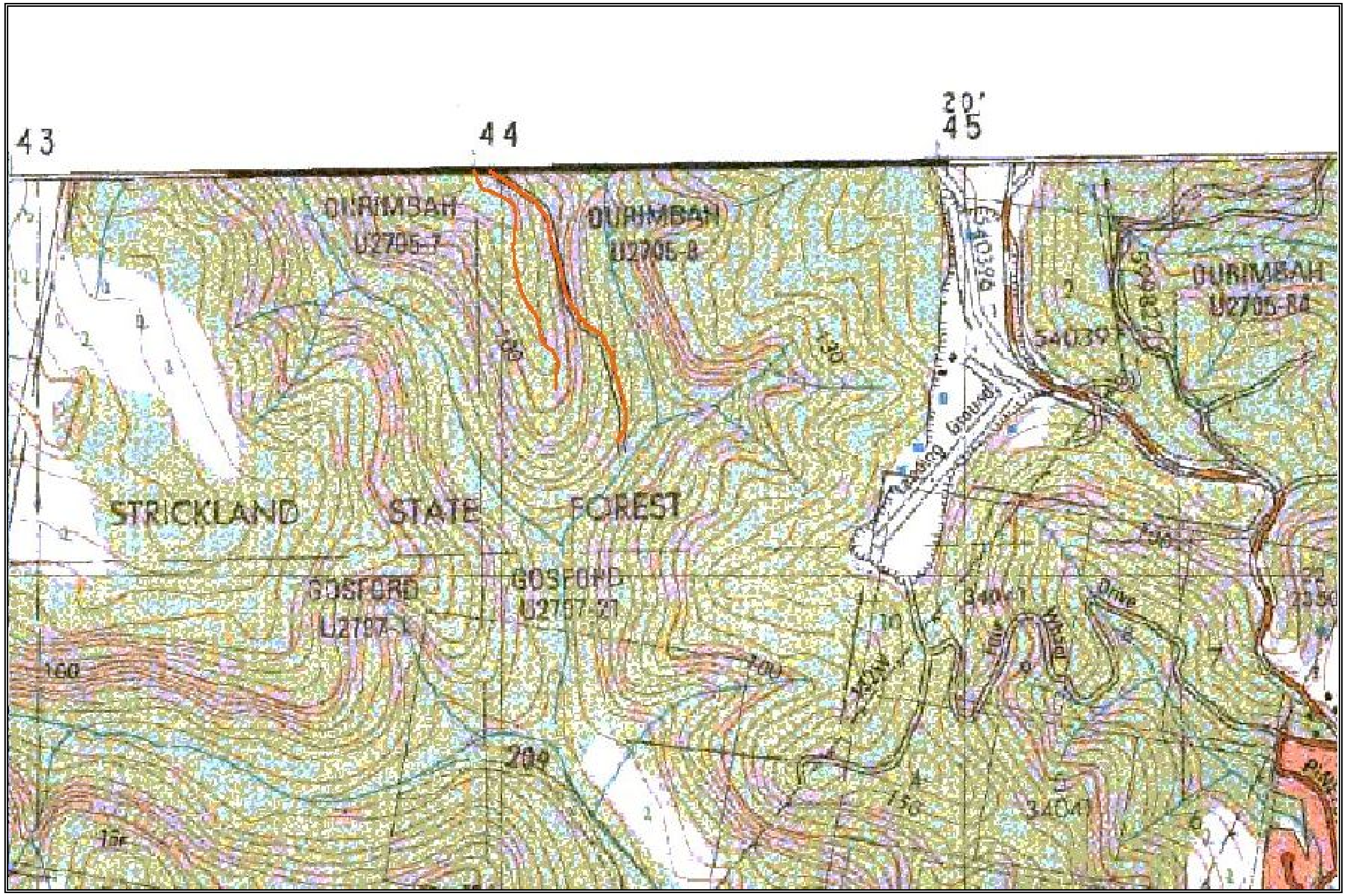
NSW Forests Data integrated with Wyong 1:25000 Topographic Map

Appendix K-56: Gosford (9131-2s)



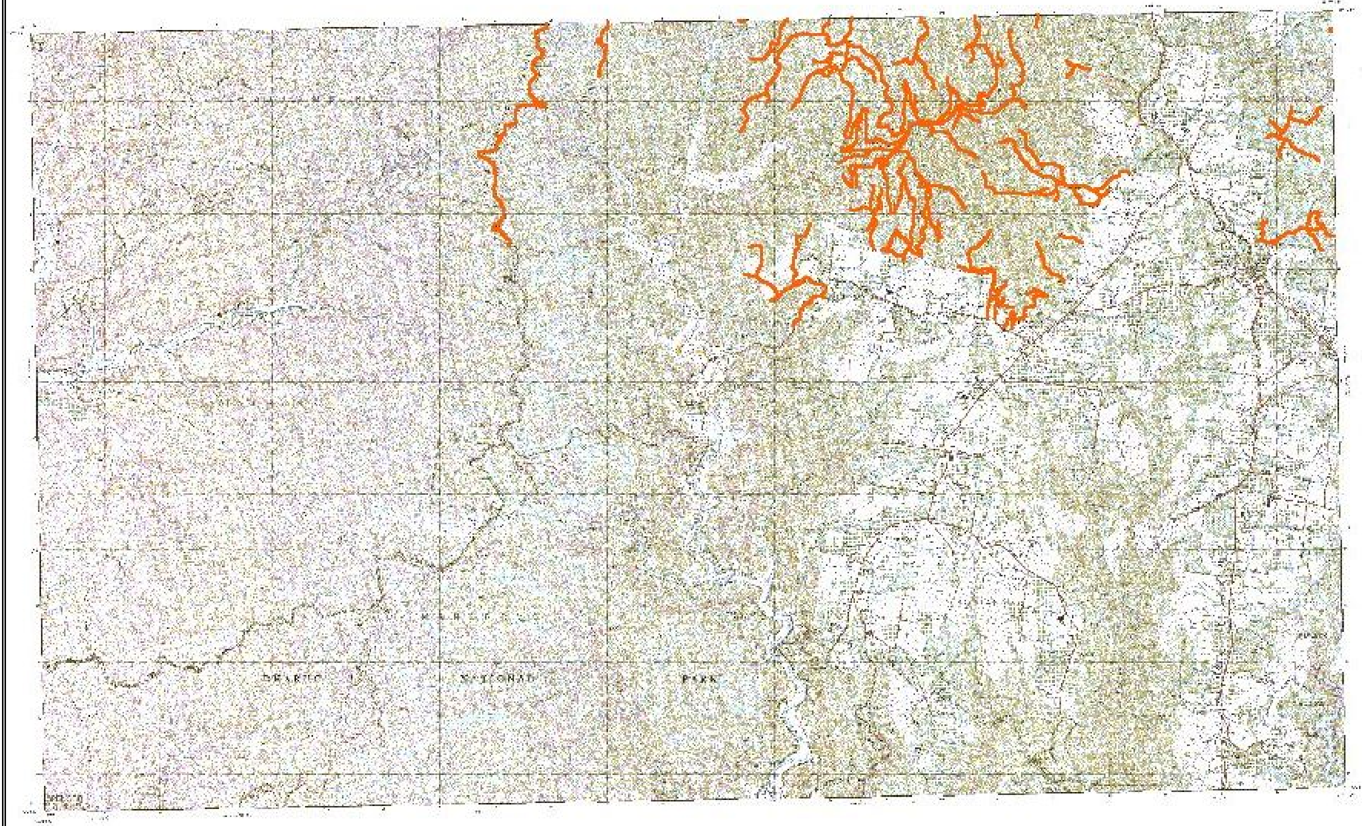
NSW Forests Data integrated with Gosford 1:25000 Topographic Map

Appendix K-57



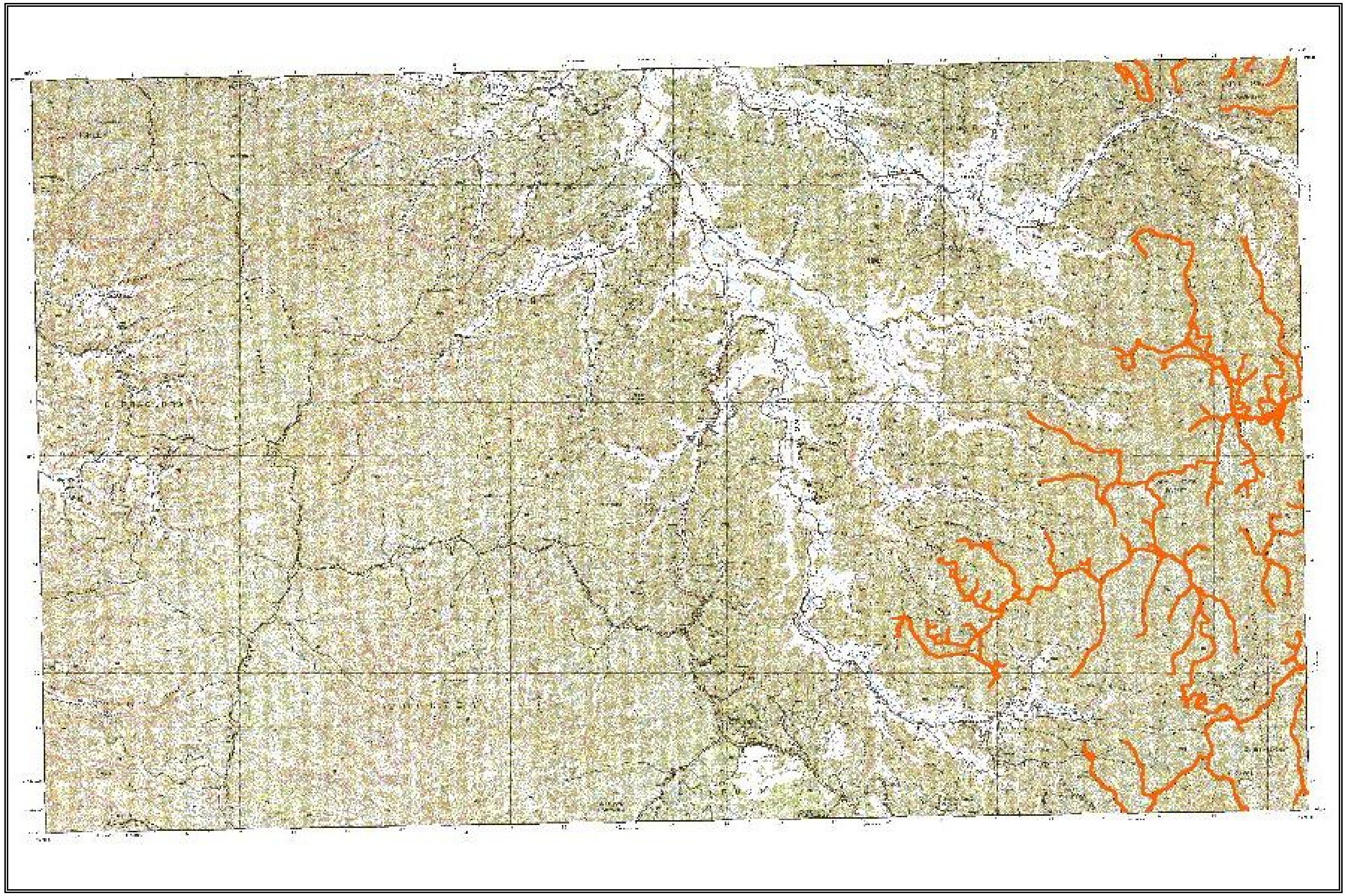
Inset of NSW Forests Data integrated with Gosford 1:25000 Topographic Map

Appendix K-58: Mangrove (9131-3n)



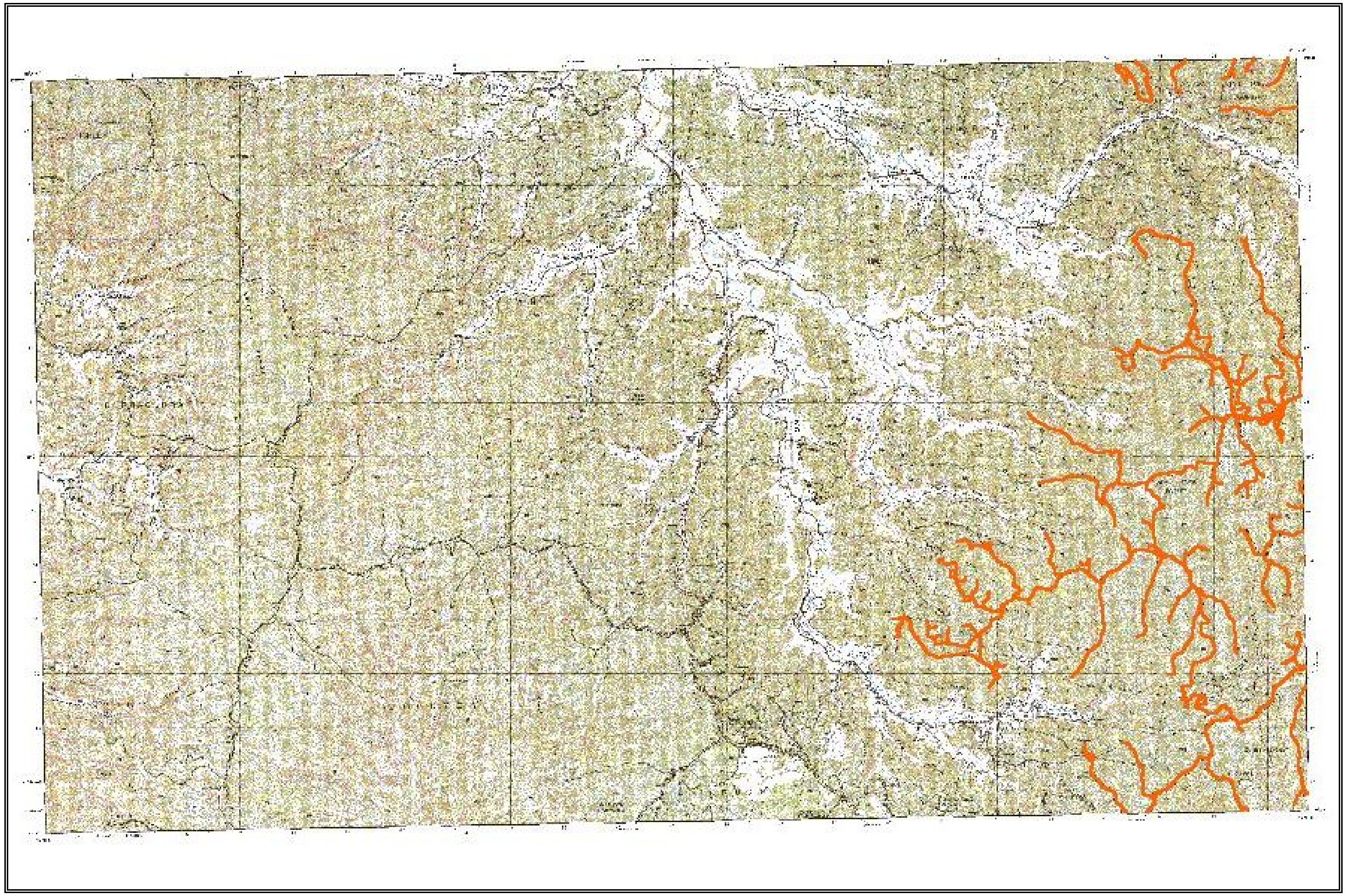
NSW Forests Data integrated with Mangrove 1:25000 Topographic Map

Appendix K-59: Murrays Run (9131-4n)



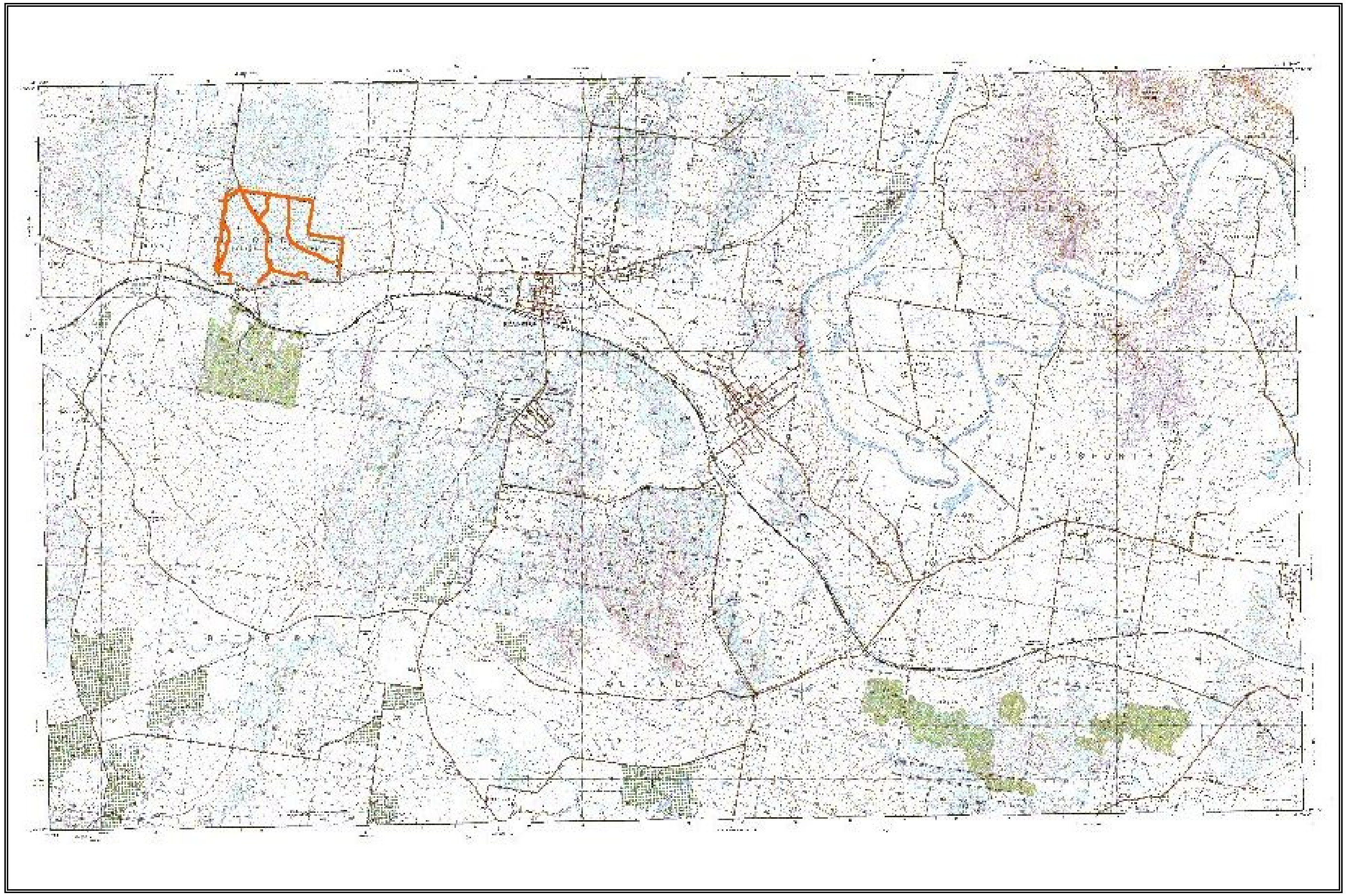
NSW Forests Data integrated with Murrays Run 1:25000 Topographic Map

Appendix K-60: Kulnura (9131-4s)



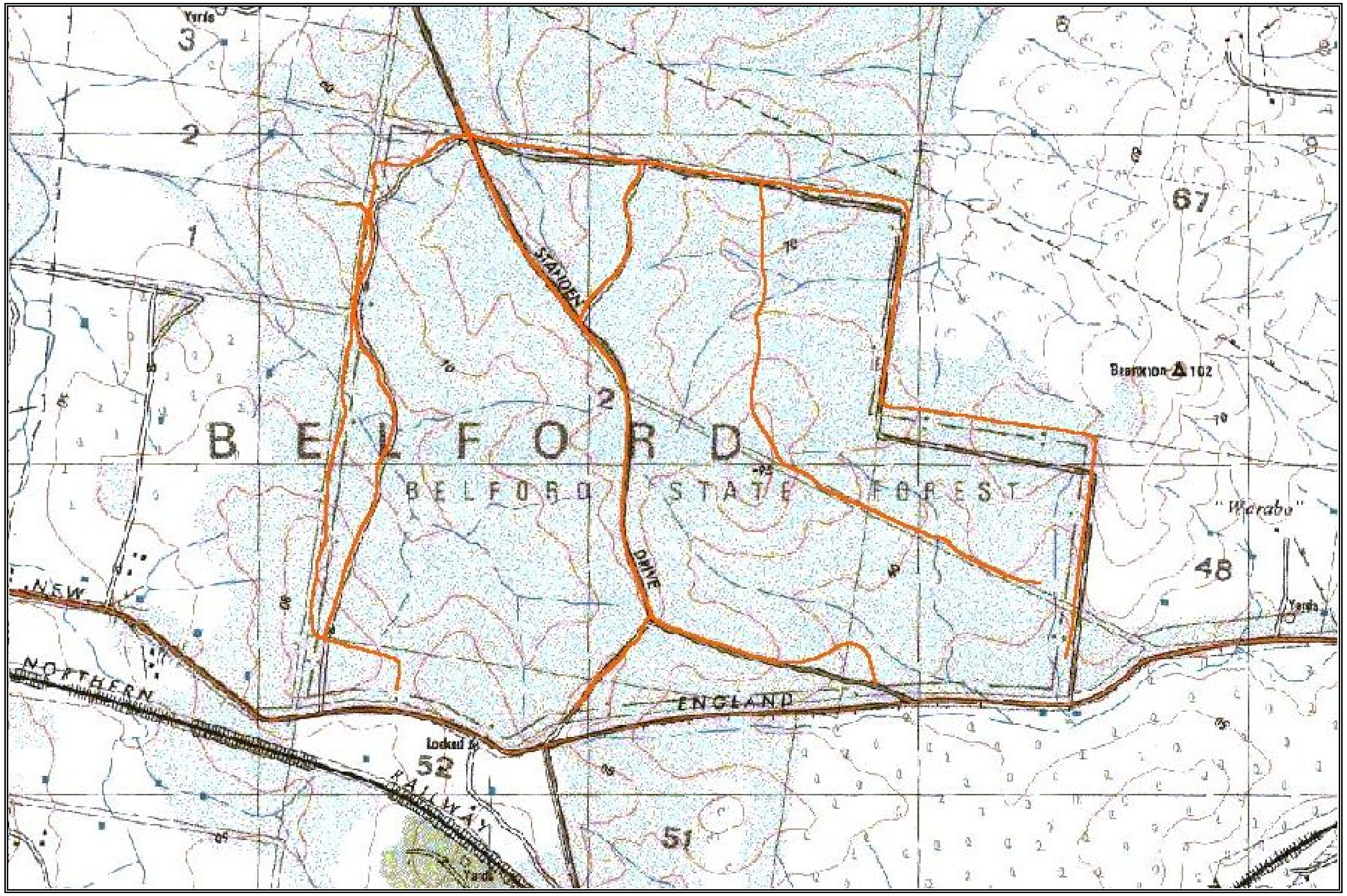
NSW Forests Data integrated with Kulnura 1:25000 Topographic Map

Appendix K-61: Greta (9132-1s)



NSW Forests Data integrated with Greta 1:25000 Topographic Map

Appendix K-62

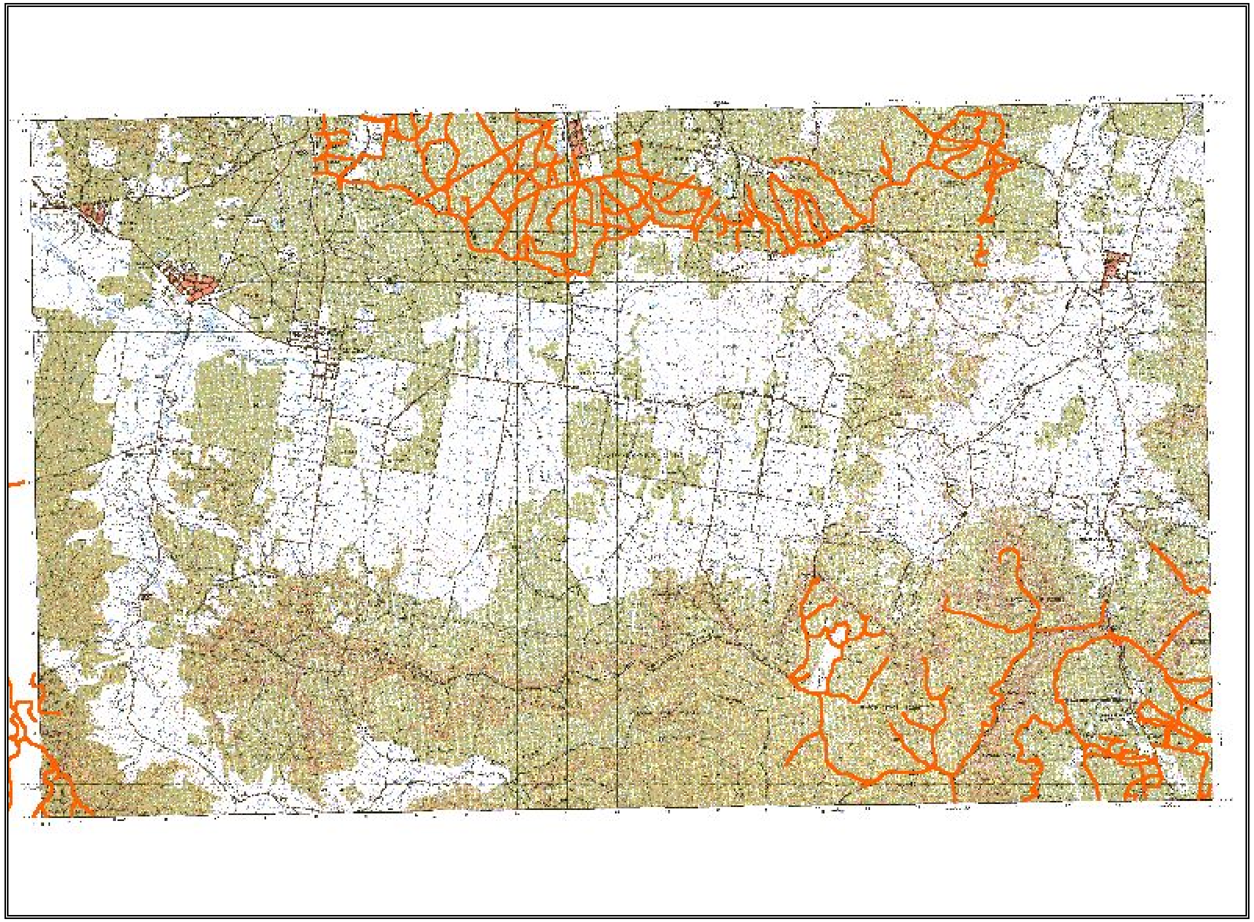


Inset of NSW Forests Data integrated with Greta 1:25000 Topographic Map

Appendix K-63: Cessnock (9132-2n)

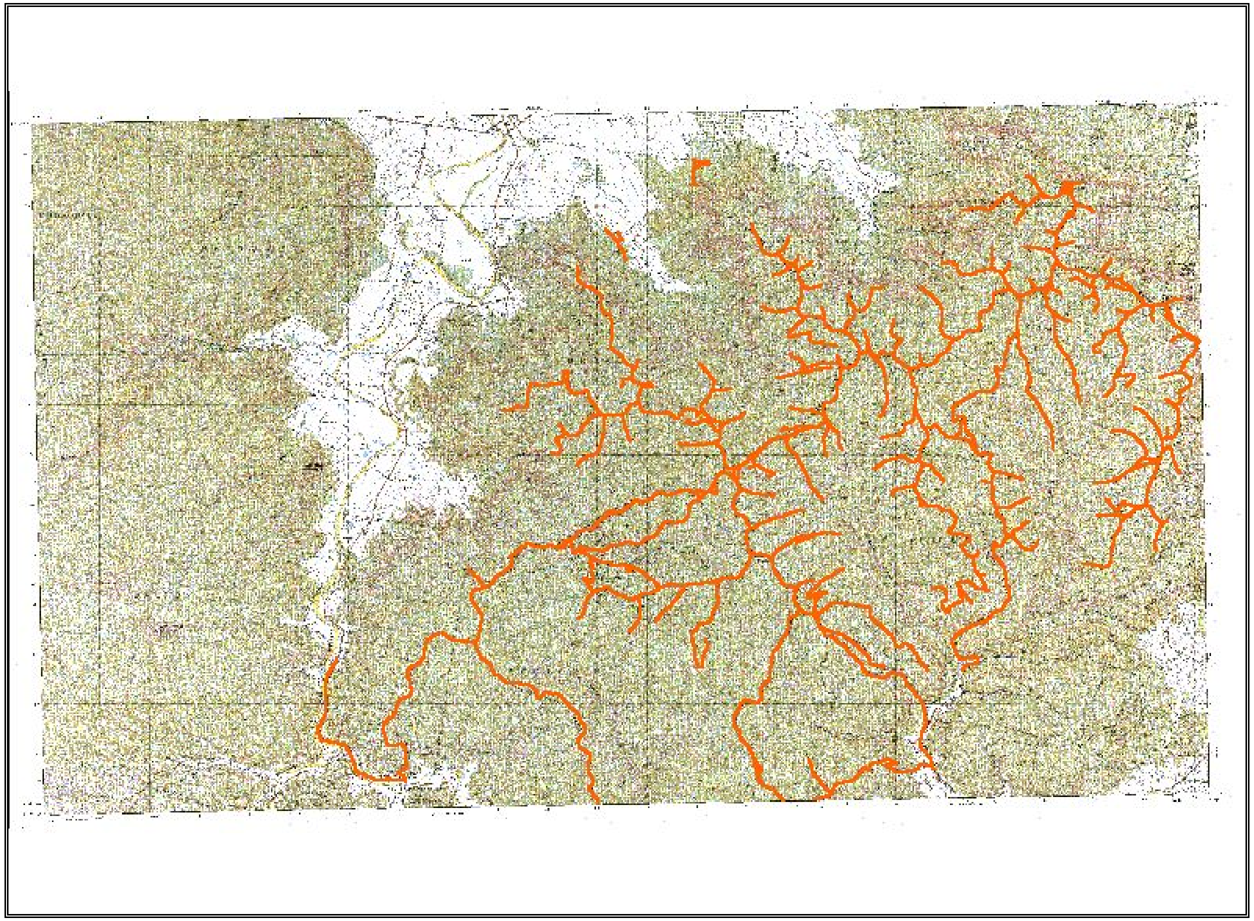
NSW Forests Data integrated with Cessnock 1:25000 Topographic Map

Appendix K-64: Quorrobolong (9132-2s)



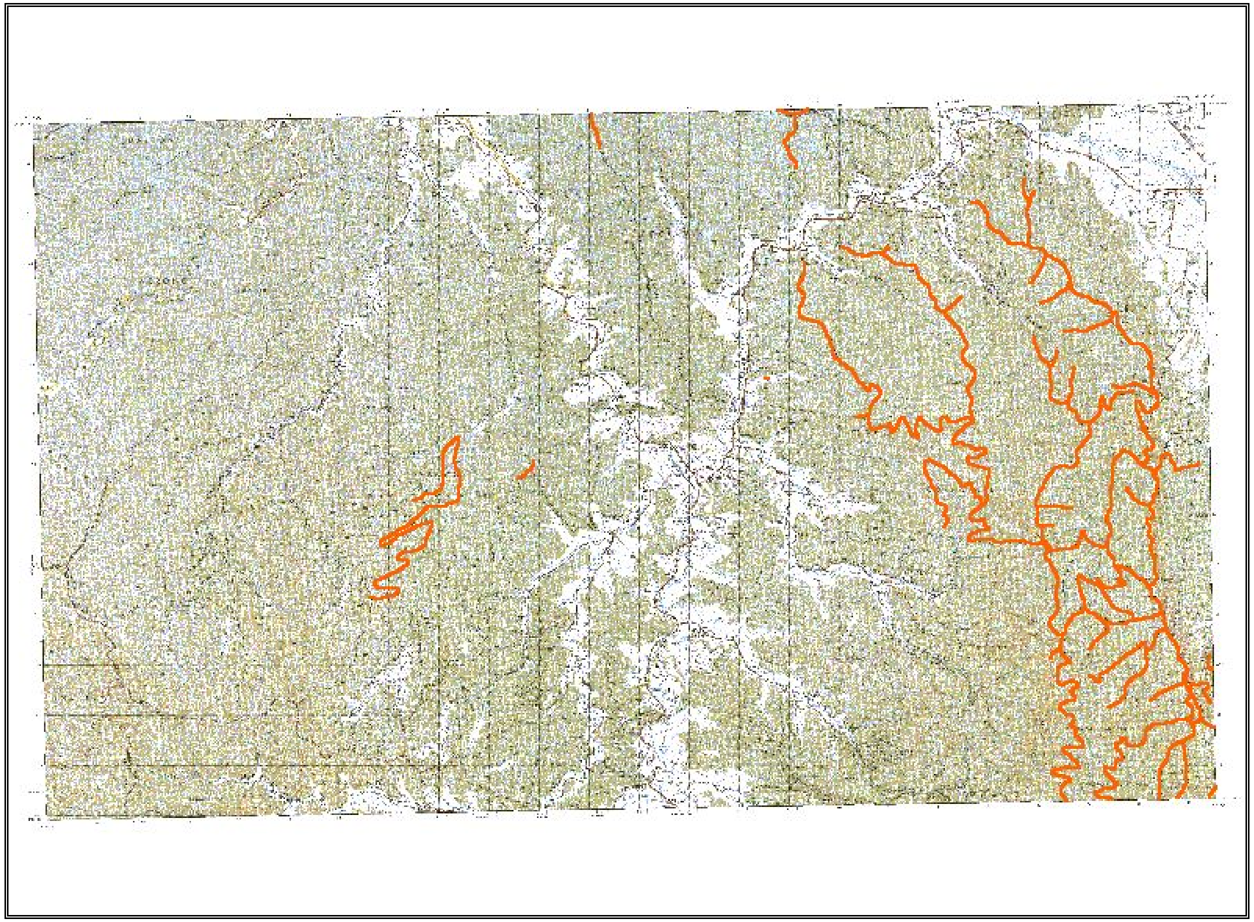
NSW Forests Data integrated with Quorrobolong 1:25000 Topographic Map

Appendix K-65: Broken Back (9132-3n)



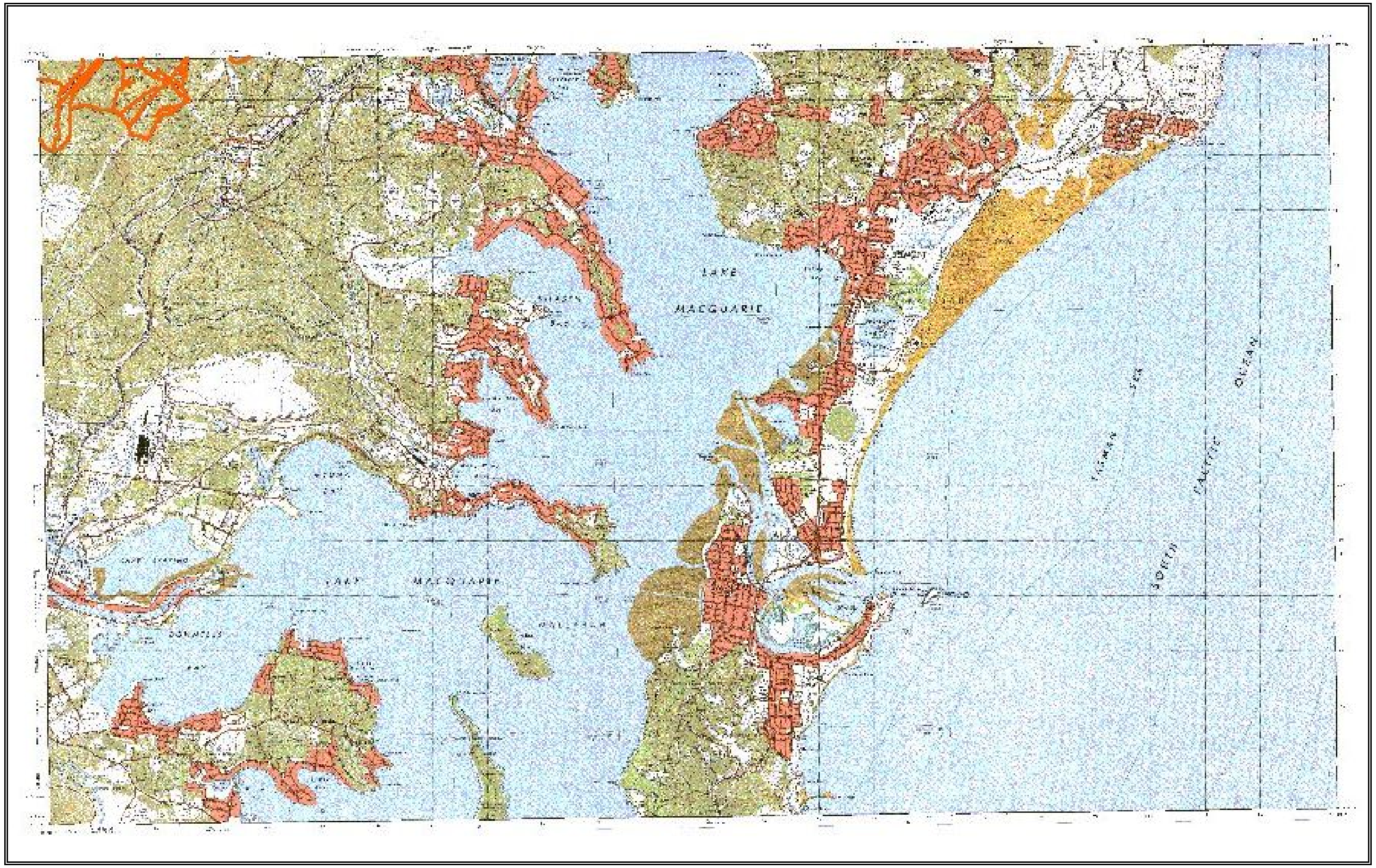
NSW Forests Data integrated with Broken Back 1:25000 Topographic Map

Appendix K-66: Wollombi (9132-3s)



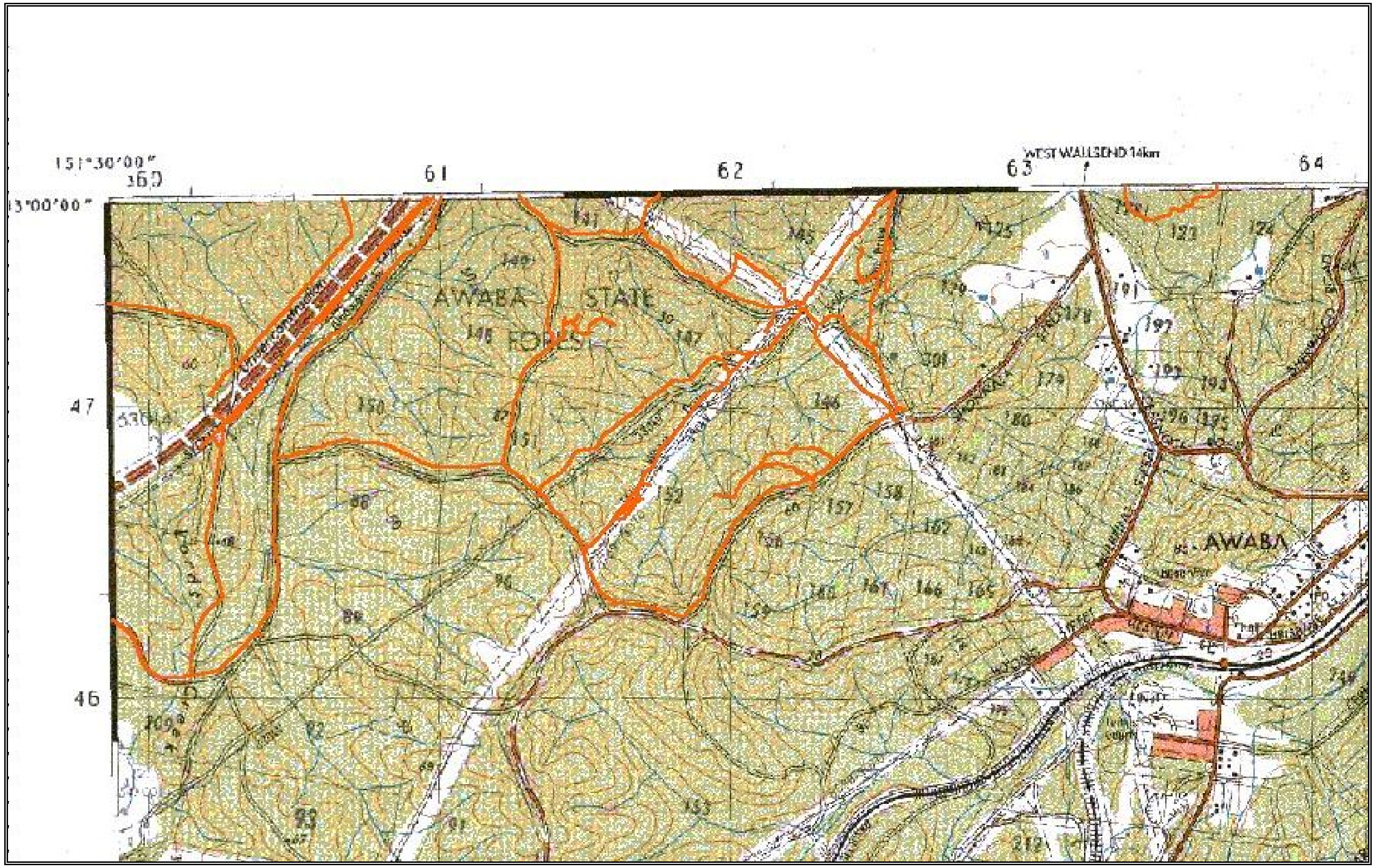
NSW Forests Data integrated with Wollombi 1:25000 Topographic Map

Appendix K-67: Swansea (9231-4n)



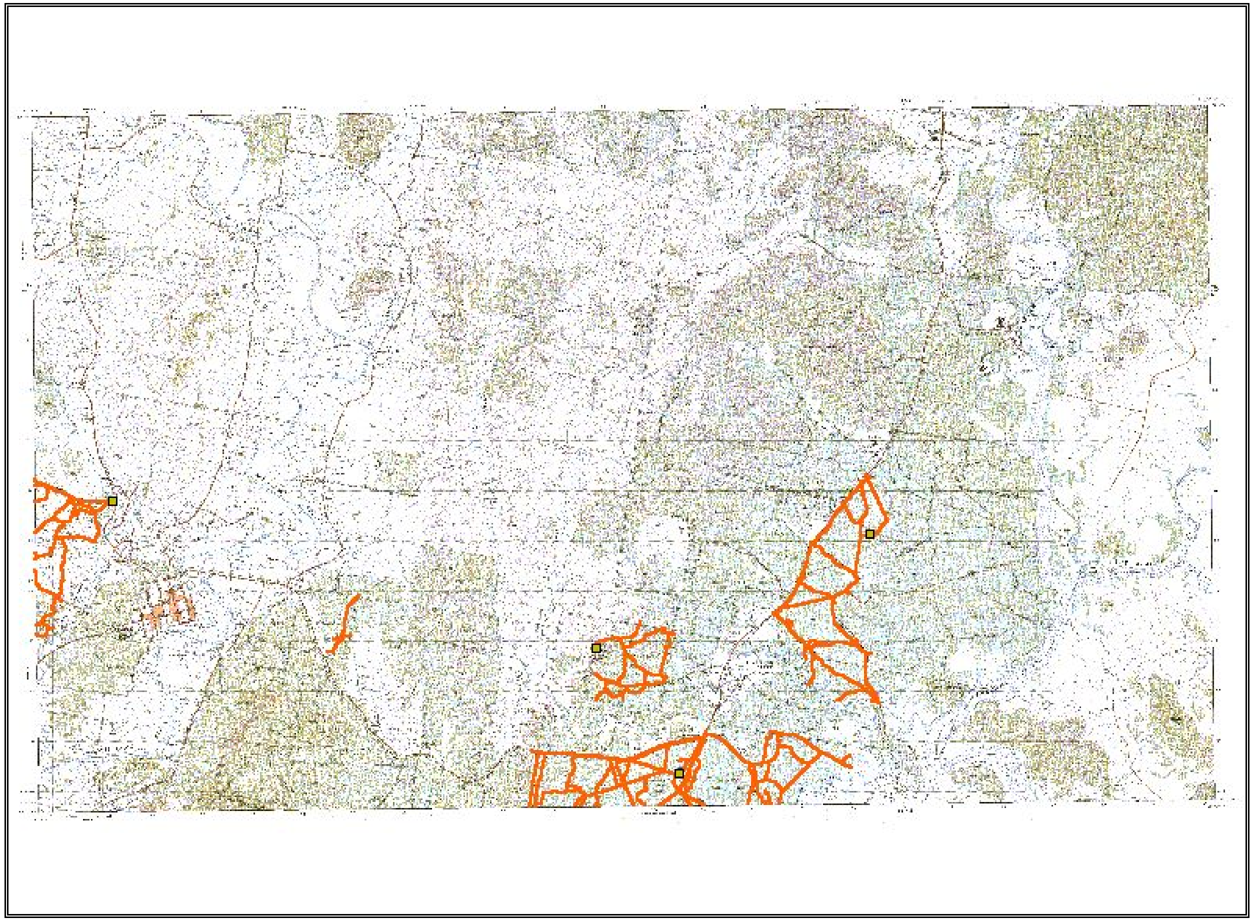
NSW Forests Data integrated with Swansea 1:25000 Topographic Map

Appendix K-68



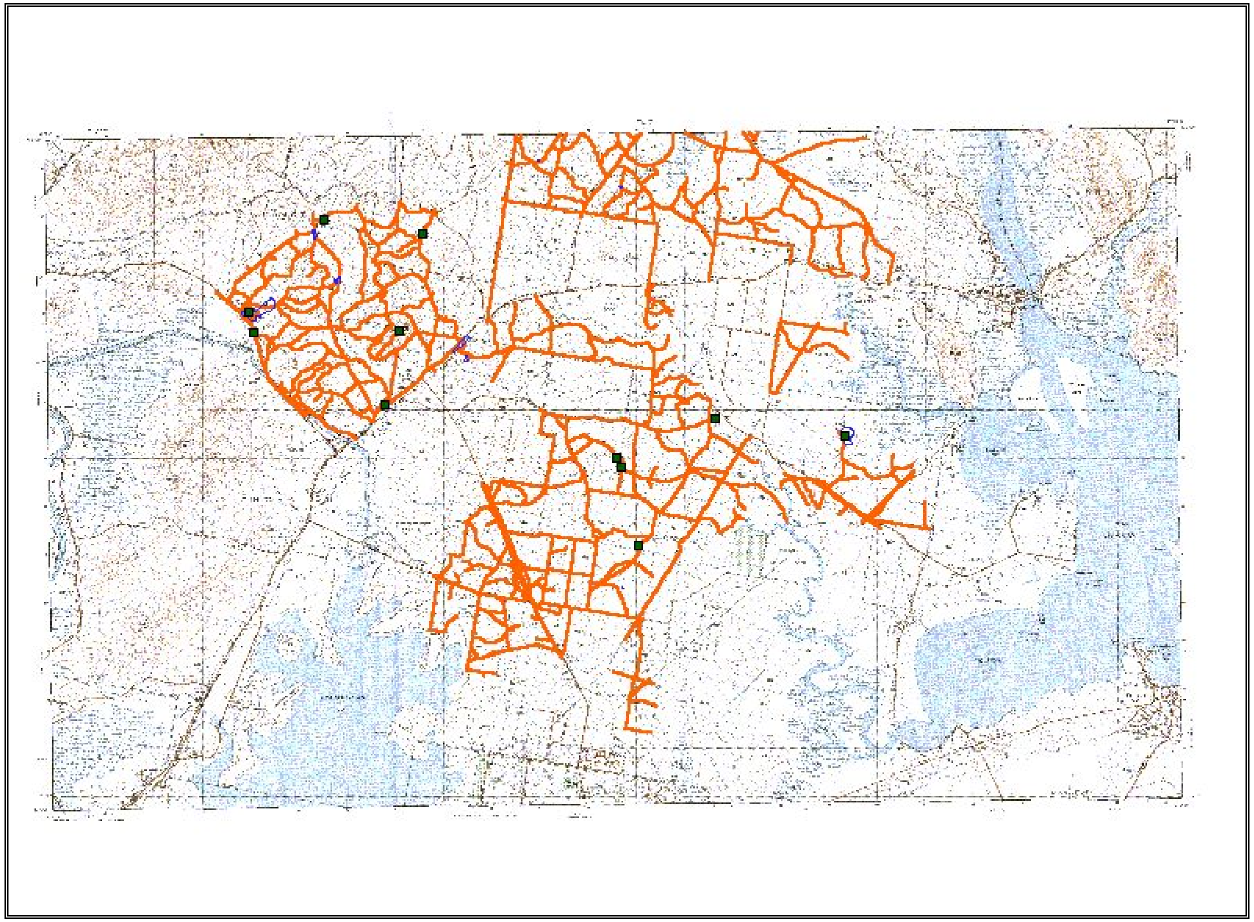
Inset of NSW Forests Data integrated with Swansea 1:25000 Topographic Map

Appendix K-69: Clarence Town (9232-1n)



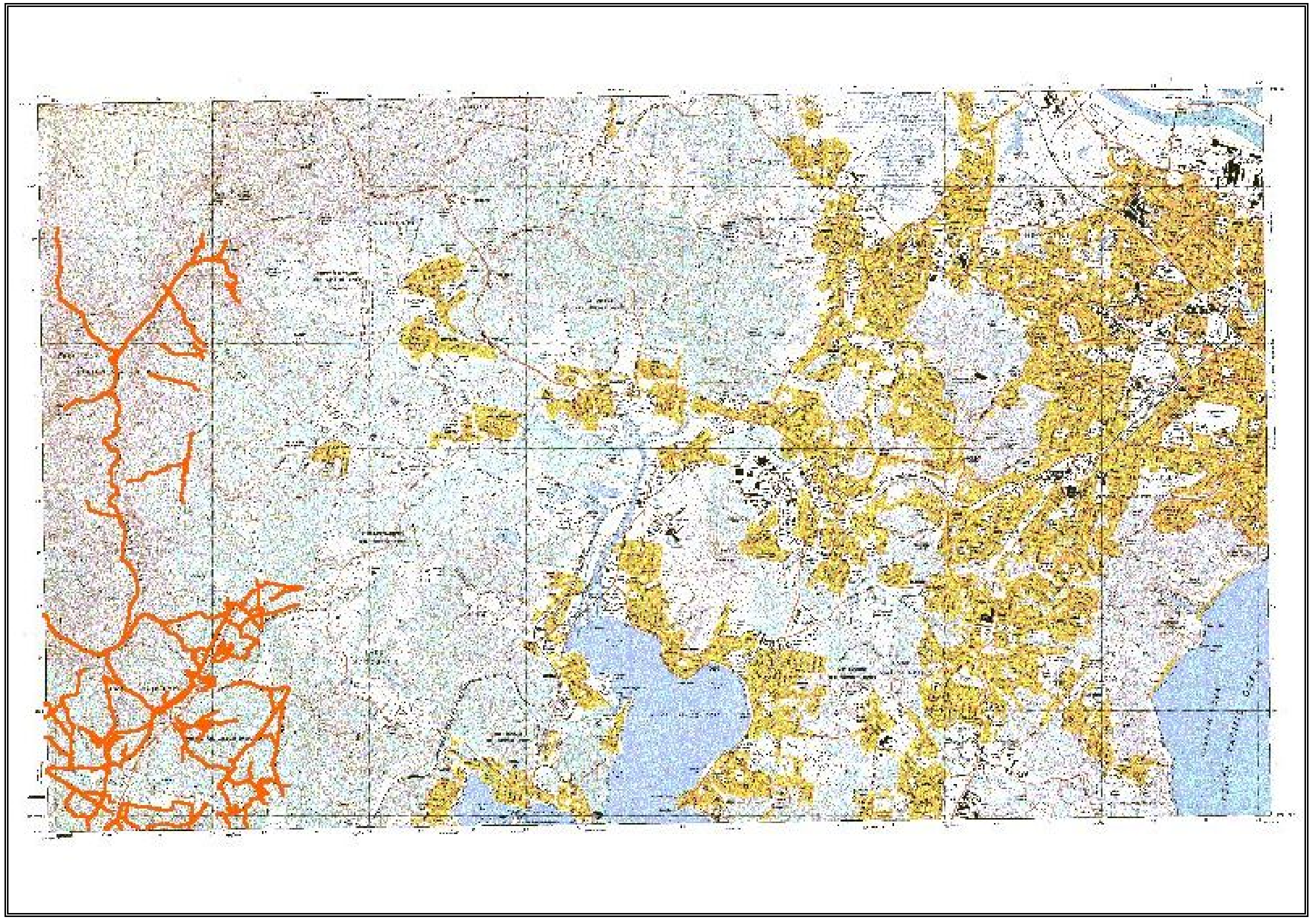
NSW Forests Data integrated with Clarence Town 1:25000 Topographic Map

Appendix K-70: Karuah (9232-1s)



NSW Forests Data integrated with Karuah 1:25000 Topographic Map

Appendix K-71: Walsend (9232-3s)

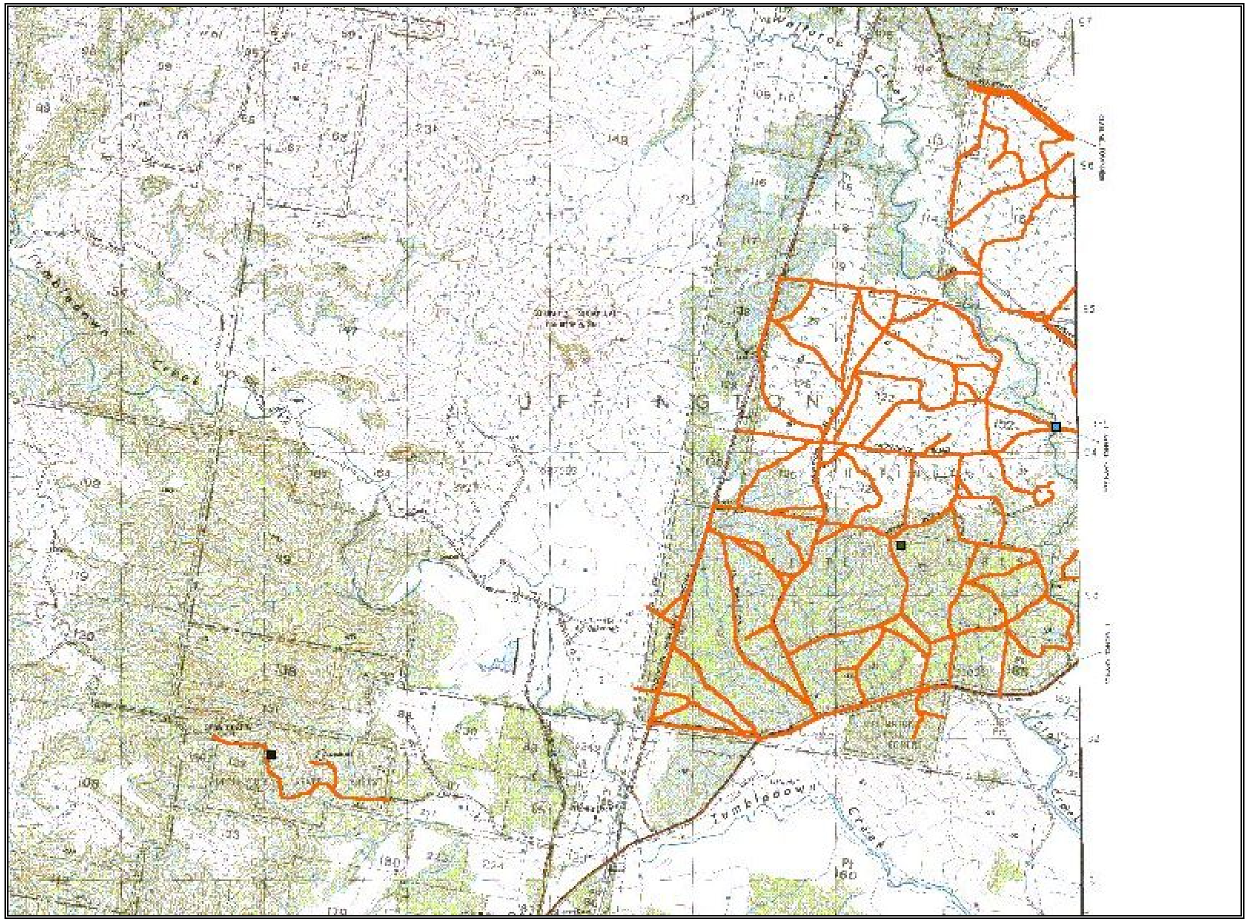


NSW Forests Data integrated with Wallsend 1:25000 Topographic Map

Appendix K-72: Paterson (9232-4n)

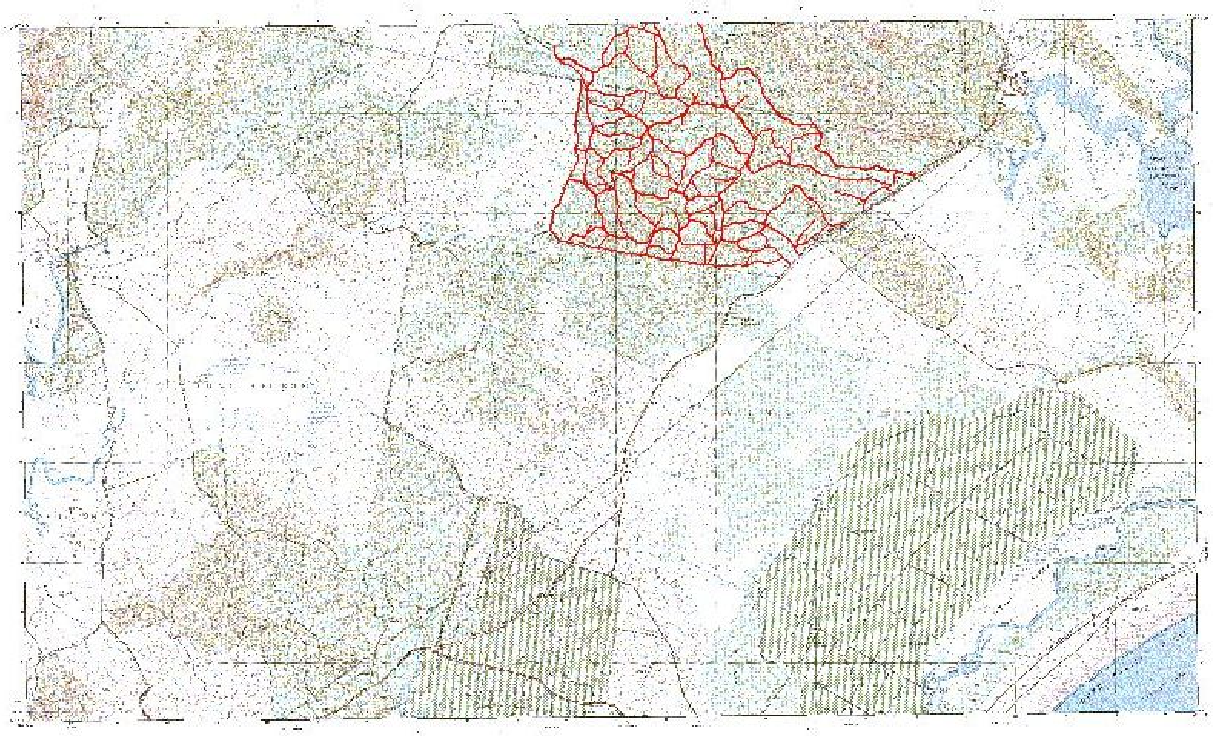
NSW Forests Data integrated with Paterson 1:25000 Topographic Map

Appendix K-73



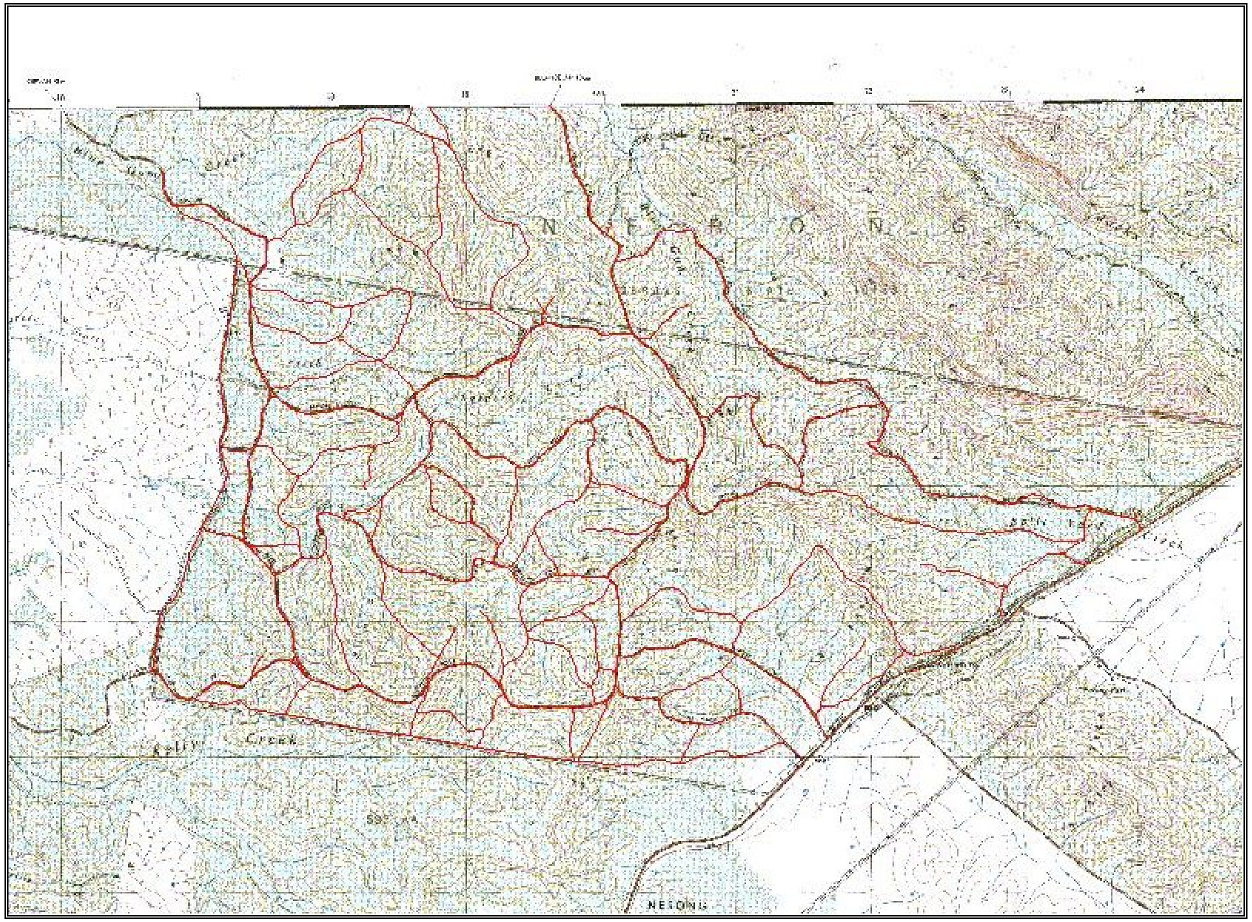
Inset of NSW Forests Data integrated with Paterson 1:25000 Topographic Map

Appendix K-74: The Branch (9332-4n)



NSW Forests Data integrated with The Branch 1:25000 Topographic Map

Appendix K-75



Inset of NSW Forests Data integrated with The Branch 1:25000 Topographic Map