Uses of Aerial Photography at Port Stephens Council

Including Nelson Bay Road Improvements

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Don Begg has been at Port Stephens Council for 19 years after completing his training at Newcastle City Council from 1972 –1981. He commenced at Port Stephens as Registered Surveyor having gained his Registration in March of 1981 after graduation from University of NSW in 1977. His role when first employed at Council was to undertake the survey work related to the Salamander Residential Development Project by Port Stephens Council.

In the early 1990's, Don supervised the survey work required for the investigations into future strategies for the upgrading of Nelson Bay Road from Stockton to Nelson Bay. He has co-ordinated the acquisition of digital data by photogrammetry using a combination of Council staff and external specialist consultants. The acquisition of aerial photos for the road improvement project has lead to the use of aerial photography for many other applications at Council.

Don's position at Council now includes management of the GIS section as well as the traditional survey component of his work.

ABSTRACT

Port Stephens Council commissioned its first major aerial photography data capture exercise in 1992. This was prompted by the need for up-to-date topographic detail of approximately 30km of Nelson Bay Road, extending from Stockton on the LGA border with Newcastle, to Nelson Bay.

In order to best utilise the initial costs to bring the aircraft into the area, it was decided to fly runs over the complete Port Stephens LGA at a scale of 1:16,000 in addition to the 1:5,000 and 1:8,000 runs which would be used to produce digital mapping of specific sections of the road corridor.

Funding for improvements to the State roads within the LGA was to be provided by the RTA, however the planning and design work was undertaken by Council staff. It was about this time that an injection of funds was hoped to be forthcoming from the "3x3" fuel levy, so Council had to undertake long term investigation and design in order to demonstrate the need for, and benefits from, improvements to both Nelson Bay Road and another major State funded road, Cabbage Tree Road, which links the Sydney Freeway to Newcastle Airport. This airport, attached to the Williamtown R.A.A.F. Base, was also ear-marked for expansion as a Regional facility with the potential to generate increased traffic volumes.

Apart from the Nelson Bay Road improvement project, many other benefits have been derived from the photography. Another full LGA coverage at 1:16,000 was completed in October 1999, and it is hoped to obtain future runs in order to build a picture of changes and development within the Port Stephens LGA over time.

Since the first uses for the photography as a design aid for road improvements, it has been used by a number of Council Departments in areas such as Holiday Park management and up-grading, flood and drainage studies, Plans of Management for Reserves under Council care and control, and to provide evidence in Land and Environment Court proceedings.

1. INTRODUCTION

This paper is substantially non-technical in nature. The use of consultants to capture the photography and produce digital data from the photos meant that Council staff only required knowledge of the principles of photogrammetry in order to appreciate the capabilities and limitations of the technology. Council survey staff were utilised to provide control points where conventional ground survey techniques were appropriate and consultant surveyors were contracted by Council to provide GPS co-ordinates for control which was remote from established survey marks.

The digital data provided by the consultants needed to be compatible with Survey and Design software so that additional survey data, such as drain invert levels, not available by photogrammetry could be integrated with the digitally mapped data. Since starting the design work, Council has migrated from the **Genacivil** design package to **CivilCad** however the data was able to be utilised in either package. There have also been considerable time delays between capture of the original digital data and the commencement of design of some sections. It has been possible to undertake additional detail survey, using total stations, over areas where changes have occurred since the original photography, and replace the old data with the updated information. In general, the source of the data is transparent to the Civil design software being used.

It is hoped that the applications of aerial photography and some of the issues encountered as outlined in this paper will demonstrate the benefits which can be derived from aerial photos for those involved in surveying and other land management related disciplines.

2. THE INITIAL PHOTOGRAPHY

In addition to the full shire 1:16,000 photography, it was decided to fly the full lengths of Nelson Bay Road and Cabbage Tree Road, as these were the two State roads which would be likely to be funded for major improvements. These were photographed at 1:5,000 as this was the recommended scale from which accuracies in the order of +/- 0.15m in horizontal and +/- 0.12m vertical would be possible.

At this time, Council was considering options for an alternate main road link to Fingal Bay which would by-pass the central commercial and tourist areas of Nelson Bay and Shoal Bay. By the time the photography was commissioned, the preferred route had been identified so 1:8,000 and 1:5,000 photography for this route was acquired at the same time. This was known as the Fingal Bay Tourist Road.

2.1 Photo-Control

All photography undertaken at this time was done with 60% forward overlap so that digital mapping could be produced at some later date. In order to ensure maximum accuracy of digital mapping for the road design work, photo control targets were placed prior to the photography being taken. This required approximately 4 points per photo

frame and their positions were selected by a joint effort between Council survey staff and GeoSpectrum, the aerial photography consultants. In some instances, existing features such as road line-marking or corners of concrete slabs were selected and required no additional targeting. In other situations, where there would be no suitably-located, well defined existing features evident in the photo, special targets were placed in locations as directed by the consultants. These targets were made from black plastic sheeting approximately 1.2 metres square on which a white cross about 0.2 metres wide was painted. A survey peg was place under the centre of the target so that if the target was removed before Council staff could co-ordinate it, the peg may be left un-disturbed.

The selection of suitable positions for control points depended on several factors. These factors included :-

- clear definition of the point in the photography
- positioning such that it would be towards the outer edge of the corridor to be mapped. This is for a similar reason that survey work should be from the whole to the part.
- accessibility for placement of target and / or co-ordination of the point.

It was not necessary that the same point be used for both vertical and horizontal control. In some instances, for example, a power pole was used as the horizontal control and the adjacent edge of bitumen was used for vertical control.

The co-ordination of targets was undertaken as soon as possible after the photography was flown, in case the target was destroyed. Co-ordination of existing features to be used for control was undertaken on a project basis, as and when sections of road were to be digitally mapped.

3. SECTIONS DIGITALLY MAPPED SO FAR

To date, the total length of Nelson Bay Road from the southern boundary of the Port Stephens LGA through to Anna Bay has been digitally mapped, although design and up-grade works have not proceeded sequentially along the road. Decisions as to which section will be addressed next have been guided by factors such as availability of funding, condition of existing carriageway and accident statistics on various sections.

The plan in Figure 1 shows the segment locations and those which have been substantially upgraded using the digital mapping data.

Following is a brief description of some sections of the work done so far and some of the issues encountered during design and construction phases.

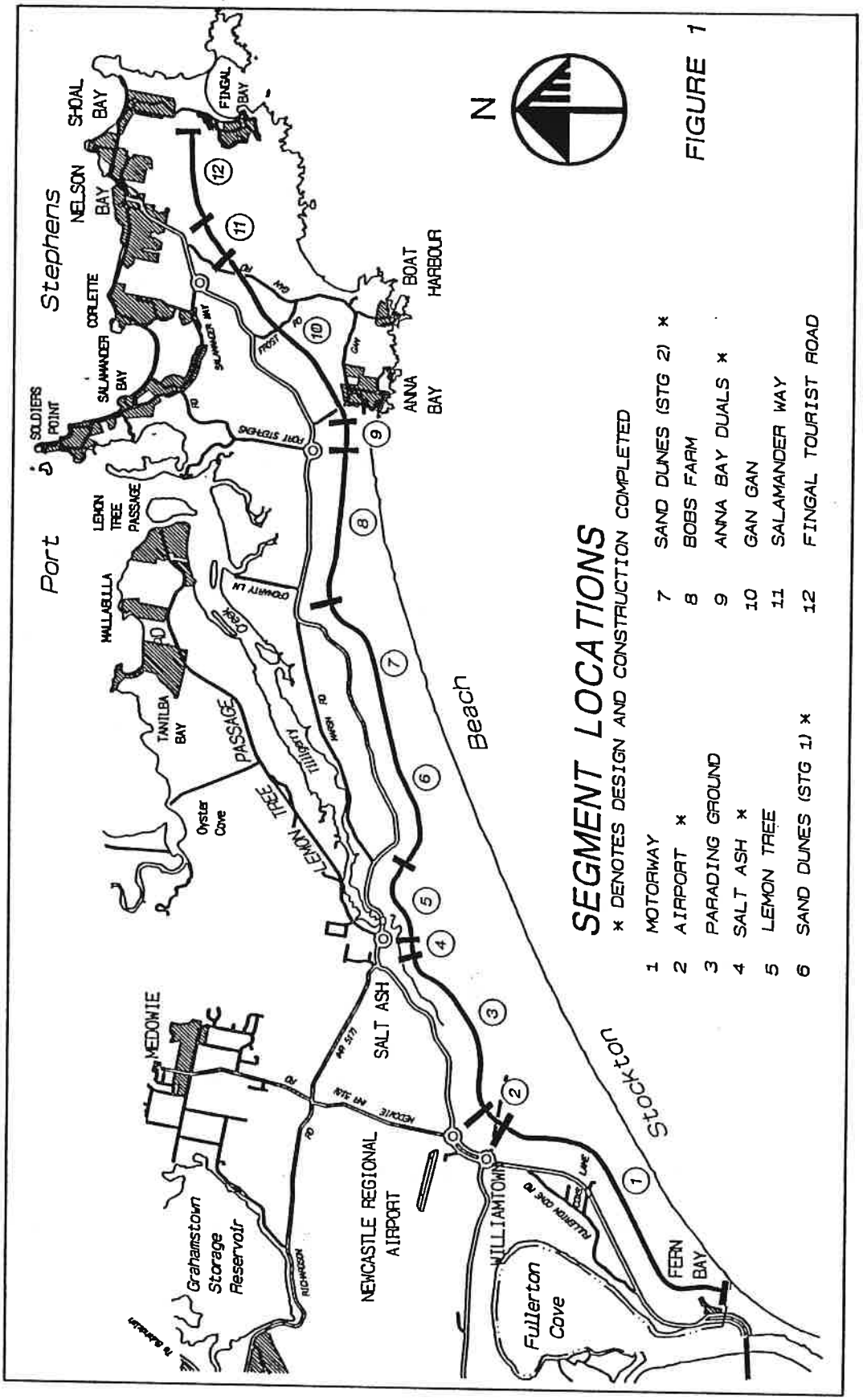
Port Stephens
SHOAL BAY
NELSON BAY
CORLETTE
SALAMANDER BAY
SOLDIERS POINT
LEMON TREE PASSAGE
TANILBA BAY
Oyster Cove
MALLABULLA
PASSAGE
LEMON TREE
Tilligerry
MEDOWIE
Grahamstown Storage Reservoir
SALT ASH
NEWCASTLE REGIONAL AIRPORT
WILLIAMTOWN
Fullerton Cove
FERN BAY
Stockton Beach
FINGAL BAY
BOAT HARBOUR
ANNA BAY
PORT STEPHENS
SALAMANDER WAY
N
SEGMENT LOCATIONS
* DENOTES DESIGN AND CONSTRUCTION COMPLETED
1 MOTORWAY
2 AIRPORT *
3 PARADING GROUND
4 SALT ASH *
5 LEMON TREE
6 SAND DUNES (STG 1) *
7 SAND DUNES (STG 2) *
8 BOBS FARM
9 ANNA BAY DUALS *
10 GAN GAN
11 SALAMANDER WAY
12 FINGAL TOURIST ROAD

FIGURE 1

3.1 The "Parading Ground" segment

This segment was named as per notation on the Williamtown 1:25,000 series topographic map. Prior to commissioning of the aerial photography, some ground detail work had already been undertaken along this section which extends from the intersection with Medowie Road (near the Williamtown RAAF base) to Salt Ash.

The corridor mapped was one of the widest done to date due to the possibility of a major deviation under consideration. As with much of Nelson Bay Road, considerable development had occurred along the frontage of this main road, either restricting the options for widening and re-alignment or requiring costly acquisition and disruption to residents.

An option considered for this, and other sections, has been to relocate the carriageway away from existing development and then deny access to properties across the new road boundary. This would hopefully avoid some of the traffic issues which arise when you provide for separated dual carriageways through developed areas.

Being the first section to be digitally mapped, there were many practical lessons learned. Port Stephens LGA has a very good coverage of established Survey Co-ordination Permanent Marks, especially along the Nelson Bay Road corridor. Council design office staff had already developed a "survey accurate" digital cadastre for this road corridor in anticipation of the need to be able to fairly accurately relate topographic data to property boundaries. Deposited Plans covering the full length of Nelson Bay Road were obtained and connections to established PM's shown on those DP's were used as a basis for this digital cadastre. Additional field connections were made where connections between boundary and ISG were either non-existent or exceeded intervals of approximately 1km. At the time that this digital cadastre was being developed, the DCDB was probably still only "on the drawing-board" at the LIC.

It seemed a logical progression from the use of SCIMS data to control horizontal co-ordinates that it be used for vertical control as well. Levelled Survey Control marks were available at either end of the short length Nelson Bay Road between the roundabouts at Cabbage Tree Road and Medowie Road intersections and they were adopted to establish co-ordinates for the photo-control points in this vicinity.

Being the first digital data received and being a little sceptical of the vertical accuracy claimed possible (+/- 10 cm on a well defined surface), some comparisons were done between the digital data provided and ground levels observed during earlier survey work undertaken by Council. The differences seemed to confirm that the expected accuracies were not being achieved. To cut a long story short, after much soul searching to find out why, it was discovered that the published level on one particular Survey Control point had been revised by about 6 cm since original ground survey was completed by Council surveyors. In effect, the photogrammetry consultants had been supplied with control point data which contained a vertical misclose which was reflected in the derived topographic data. Hence it is important to ensure that control

point data is as accurate as possible in order to achieve the level of accuracies possible from this technology.

Another lesson learned was the importance of verifying data, in particular where reconstruction work is to tie into existing road levels. When working with contract construction firms, any perceived inaccuracies in design levels can lead to claims for additional payments.

3.2 Salt Ash

Another State road, Richardson Road, intersects with Nelson Bay Road at Salt Ash. Richardson Road is a major link from the Pacific Highway at Raymond Terrace to Nelson Bay Road.

This particular intersection had been identified for a major up-grade for many years, as evidenced by allowances for re-routing of Richardson Road and significant re-alignment of the eastern boundary of Nelson Bay Road in a subdivision plan dated 1970.

3.3 "Sand Dunes" - Stages 1 and 2

These two stages, designed and constructed over approximately 2 years, totalled about 5 km in length. Due to a number of factors, these stages presented issues not encountered with earlier sections.

This section of the Nelson Bay Road was constructed in about 1950 as an alternative to Marsh Road which follows the edge of Tilligerry Creek and suffers from inundation during king tides. The new section is constructed partly through vacant Crown Land and also has some private development gaining access across the road boundary. There were significant environmental issues encountered in this section due to the heavily timbered nature of the land. The original concept design was based on the notion of a completely new 60 metre wide alignment to ultimately accommodate dual carriageway in both directions. In the short term, to get maximum value for money, it was planned to construct only 2 of the ultimate 4 lanes and utilise the existing 2 lanes to achieve dual carriageway in both directions for half the cost. Ultimately, the new construction was to be duplicated and the old 2 lane carriageway would no longer be used.

Stage 1 of the Sand Dunes section was designed to incorporate an existing major transmission line easement so clearing of trees was not a major issue. Stage 2 however was following a proposed transmission line easement which was unused at that time. This section was also to the south of the current road reserve and almost exclusively over vacant crown land.

From a photogrammetry point of view, the major problem encountered was the difficulty in obtaining vertical accuracy through the tree canopy and ground cover of low ferns. This was initially not considered to be of major concern given the sandy nature of the soil and the ease with which it could be moved around if "true" ground heights were found to be slightly lower or higher than those provided by

photogrammetry. In hindsight, it would have been advisable to "ground-truth" the construction zone following initial tree clearing. Over some 3 km of stage 2, even a small constant error in ground levels resulted in a significant volume of excess soil being left over with no convenient means of disposal. Some minor re-grading of design levels "on-the-fly" overcame this problem. Another related problem caused by a slight inaccuracy in existing surface levels was the effect on the horizontal position of the top of batter in sections of significant cut. The proposed new road boundaries had been gazetted over the Crown Land and it was desirable that the final constructed batters be contained within the road reserve. Even relatively minor differences between interpolated existing surface and actual ground level can cause a lateral movement in the line where the batter slope intersects the natural surface.

Other Significant Issues

Other significant issues faced during this segment of design and construction were not related to the use of photogrammetry, but may be of interest to others involved in similar projects.

Preservation of Wildlife
As with many new road construction projects involving major tree and ground-cover clearing, the effects on native flora and fauna was the subject of careful consideration. For much of this section of Nelson Bay Road, the new road corridor cuts through bushland which provided habitat for a number of animals. Several options were considered for the provision of a safe means for these animals to move from one side of the new dual carriageway to the other. The option chosen was a fauna underpass, constructed at a natural low point in the road, along with climbing poles and timber fencing to encourage animals to use it. To my knowledge, no study has been made to assess the success or otherwise of this feature.

Aboriginal Middens
Being situated quite close to the coastline in an area that would have provided a suitable living environment for early aboriginal groups, the existence of middens was the subject of investigation prior to construction. A number of sites were identified, investigated and the appropriate action taken in consultation with the local Aboriginal Council.

Provision of U-Turn Bays
The second stage of the Sand Dunes project created a dual carriageway some 4 km in length with considerable separation between northbound and southbound lanes in some places. The Port Stephens Winery has recently been developed as a Tourist activity in conjunction with the commercial vines. As a result, provision had to be made so that this business was not disadvantaged by loss of trade due to southbound traffic being unable to gain convenient access to the Winery. In addition some residential accesses front this section of road so provision had to be made to reduce the need to travel in the "wrong" direction for vehicles leaving or entering affected properties. This created the need for numerous and large signs to ensure that drivers were made aware that they were, in effect, entering a one way traffic situation when leaving affected properties or completing a U-turn.

3.4 Bobs Farm (To deviate or not to deviate, that is the question!)

This latest section is the longest section addressed so far. It extends for approximately 7 km from the end of the Sand Dunes (stage 2) to the intersection with Port Stephens Drive at Anna Bay.

This section had been identified for widening by the RTA since about 1958, and some acquisition to create a 40 metre reserve had already been completed. Current Design Standards and traffic volumes, however, indicated that problems would be experienced if these standards were to be applied within the existing corridor. Considerable development along the road frontage had been approved and, due to the low, flat nature of the land, significant drainage difficulties were already apparent. Further construction of impervious carriageway was going to exacerbate the problem and drainage easements through adjoining private property would be required.

The option of utilising an existing major Transmission line easement to create a deviation to the east of the existing road was put forward as a possible alternative. This had the major advantages of construction without the need to accommodate daily commuter traffic and would eliminate the need for significant acquisition of private land, some of which would affect properties previously affected by acquisition in the earlier scheme in 1958. The original photography intended for road design work was confined to the existing road corridor on the earlier assumption that the existing carriageway would be up-graded. It was here that Council was able to benefit from the 1:16,000 shire-wide photography.

Although the same level of accuracy obtained from the 1:5,000 photography was not possible from the 1:16,000, this smaller photography was done with 60% overlap. In addition, sufficient ground points could be identified in the photos to provide adequate control. The typical point accuracy available from the 1:16,000 photos was +/- 0.5m horizontal and +/- 0.4m vertical. This, however, was adequate for the undeveloped sandy ground over which additional digital topographic data was required to provide base information for concept consideration. This data could be seamlessly integrated with the earlier data derived from the 1:5,000 photography. The horizontal accuracy was quite adequate for determining the extent of private and Crown land through which a proposed deviation would pass and for design templates to be applied to assist in preliminary cost estimates.

After lengthy consideration by Council and the RTA of the deviation concept as opposed to duplication of the existing 2 lane carriageway, the latter route was put forward as the preferred option. To say that this decision was unpopular with the locals would be an understatement.

Whilst the number of environmental factors, such as the existence of squirrel-glider den trees and Aboriginal middens identified within the existing road reserve, was probably greater than that encountered in Stage 2 of the Sand Dunes dual carriageway, it was the effect on humans that appears to have stirred the locals. The concept plans for the existing corridor provided for a number of different approaches to providing for "U-turns" to account for the separated carriageways. Feelings of some of the locals were

running so high that at one point, Council surveyors were ordered to stay away from the 7 km length completely. Even if survey was requested for reasons un-related to the road up-grade project, it was a "no-go zone" because the phone would run hot as soon as the surveyors were spotted. This highlights the problems which may be encountered with residential development fronting arterial roads which later require substantial widening or up-grading to cope with increased traffic volumes.

At the time of preparation of this paper, no start has been made on detailed design or construction for this stage. The writer has not been involved in the discussions or consideration of the two alternative routes, however it would appear that the long term suitability of major road construction on the coastal sand dune is a significant factor which is tending to sway the RTA towards the existing corridor.

4. OTHER USES FOR PHOTOGRAPHY

4.1 Plans of Management of Council Reserves

Council is required to prepare Plans of Management for all reserves under its control. These plans have to identify current and proposed uses for various sections of each Reserve. Some reserve holdings are made up of several parcels and these separate parcel boundaries have to be identified in addition to the surround boundary.

The Plans of Management are put on public display and submissions and comments are invited prior to adoption of the Plan. The photography has proven very useful in the preparation of documentation for these Plans. The general public can usually relate better to photographs than survey-type plans, so the aerial photos have been incorporated into the Plans of Management.

At the original scale of 1:16,000, most of the reserves appear as a very small area, covering perhaps a few centimetres in each direction, and very little ground detail would be visible at that scale. Scanning and enlarging does not produce a very good result as the image becomes very "grainy" as it is enlarged. A better result however is achieved if the consultant uses the original film and provides Council with an enlargement of the area in question. The enlargement can then be scanned to produce quite a good image which Council can print using its design-jet or colour laser-jet plotters to any desired size.

For the purposes of inclusion in the Plan of Management, it has been found that very basic imaging software can be used to enhance the image to produce satisfactory results without the need to utilise any rectification software. Whilst the scale varies slightly over the extent of the image, basic line-work and text can be added to the image quite easily to indicate the relationship between ground detail and property boundaries.

4.2 Salt Ash Flood and Drainage Study

For many years, debate has simmered regarding how floodwater from major events has made its way from the Hunter River, at Raymond Terrace, overland to Salt Ash and into

Tilligerry Creek or Fullerton Cove. This generally low lying area has a network of drains constructed over the years in an attempt to drain some areas.

Recently, a study was approved for partial funding by the Department of Land and Water Conservation to resolve this question and help formulate ways of overcoming it or avoiding further development which would add to existing problems.

Aerial photography (1:10,000 scale) and digital mapping was undertaken over the area bounded by the Pacific Highway, Richardson Road, Nelson Bay Road, Cabbage Tree Road and Masonite Road.

Whilst the full study is yet to be completed, initial examination of the digital contour maps gives a very clear indication of the overland route which floodwater would take and what level of water would be required for it to flow from Raymond Terrace to Williamtown.

To give a "ball-park" figure, this photography and mapping exercise cost approximately $40,000.

4.3 Supporting Evidence for Land and Environment Court

Recently, the Planning section from Council was able to use the 2 series of 16,000 photography to identify non-approved improvements made on a semi-rural parcel.

The enlargement and addition of the improvements to this particular property could be very clearly identified between the 1992 and 1999 series of photos, and the approximate sizes of the improvements could be easily determined.

In another case, Council was able to assist the EPA with investigations into an illegal waste dump site. The combination of the 1992 1:5,000 and 1:16,000 photos provided graphic evidence of the location of the site in relation to surrounding environmentally sensitive features.

4.4 Identification of Bush Fire Hazards and Fire Trails

As is the case with many rural Local Government Areas, Port Stephens Council has the local Rural Fire Service under its "umbrella". The photos have proven very useful to this organisation in the identification of fire hazard areas and fire trails available to use in the event of a bushfire.

5. CONCLUSION

Aerial photography can provide a very useful and cost effective resource for those involved in Land Planning and Management as well as traditional Engineering applications. The well-known saying "a picture is worth a thousand words" is worth remembering when preparing reports and public exhibition material which includes maps or plans which will be viewed by non-technical people.