Bureau of Transport Economics

# WORKING PAPER 48

# FLOOD DAMAGE IN TAMWORTH

## COSTS OF THE NOVEMBER 2000 FLOOD

ISSN 1440–9707

ISBN 0 642 73203 5



This publication is available free of charge from the Bureau of Transport Economics, GPO Box 501, Canberra, ACT 2601, by downloading it from our website (see below), by phone 02 6274 7210, fax 02 6274 6816 or e-mail *bte@dotrs.gov.au.*

**http://www.bte.gov.au**

*Disclaimers*

The BTE seeks to publish its work to the highest professional standards. However, it cannot accept responsibility for any consequences arising from the use of information herein. Readers should rely on their own skill and judgement in applying any information or analysis to particular issues or circumstances.

Cover photo of the Tamworth flood by courtesy of the Northern Daily Leader.

Printed by the Department of Transport and Regional Services.

# FOREWORD

Report 103 *Economic Costs of Natural Disasters in Australia*, which was released in March 2001, was the first BTE publication in the area of natural disasters. Floods in Tamworth in November 2000 provided an opportunity for the BTE to follow on from its initial work and to gain some experience in estimating the costs of a natural disaster.

The BTE is currently engaged in a study on the costs and benefits of flood mitigation. This work involves several case studies of which the Tamworth case study is the first to be completed.

David Ingle Smith and Andrew Gissing were engaged as consultants to undertake the field work for the BTE and were assisted by Neil Gentle from the BTE. The report on the field work prepared by Mr Smith and Mr Gissing formed the basis for much of the BTE paper.

The BTE sympathises with all those affected by the November 2000 flood and is grateful to those who willingly provided information to the study team. Thanks are also due to the Tamworth City Council, the State Emergency Service and the Bush Fire Brigade who all provided valuable assistance during the field work.

Neil Gentle was responsible for extracting cost estimates from the data and for the compilation of the paper. Sharyn Kierce and Lara Smigielski provided valuable comments on drafts of the paper. The work was carried out under the general supervision of Joe Motha, Deputy Executive Director.

Tony Slatyer
Executive Director

Bureau of Transport Economics
Canberra
September 2001

# CONTENTS

## TABLES

## FIGURES

# EXECUTIVE SUMMARY

Tamworth, especially the industrial area of Taminda, experiences frequent flooding. The most recent flood in November 2000 provided an opportunity to estimate the savings in costs that would have occurred in Taminda if there had been a levee to protect the area. As part of a wider study by the BTE to investigate the benefits of flood mitigation, the effectiveness of the central business district (CBD) levee in preventing flood damage was also made part of the study. The study therefore had two objectives:

- Estimate the economic costs resulting from the November 2000 floods at Taminda.
- Estimate the costs avoided in Tamworth by the CBD levee during the November 2000 flood.

## TAMINDA SURVEY

The economic costs of the flood at Taminda were estimated from data obtained from a survey of business in the flood-affected area. Based on the survey data, the following results were obtained:

- The flood in November 2000 was about 0.4 metres less in depth than the 1984 flood. The 2000 flood is thought to be about a 10-year average return interval (ARI).
- Direct damage costs were about $144 000 to buildings and contents and $32 000 to roads.
- In preparing for the flood, labour costs amounted to about $25 000. Damage avoided by the preparation effort was estimated to be approximately $781 000.
- Clean-up and restoration after the flood cost about $56 000 in labour and materials.
- Cost of business disruption to the local community totalled $214 000 in lost value added. Taminda businesses lost an estimated $59 000 in forgone profit.
- The State Emergency Service (SES) and the Bush Fire Brigade incurred costs of about $20 000 and $1 440 respectively.

- Total economic costs to the Tamworth community were estimated at \$494 000. Because business losses in Tamworth can be offset by gains elsewhere, the national losses were less—estimated at \$280 000.

Most respondents to the survey received warning of the flood from several sources, but mostly from radio, neighbours and the SES. Their assessment of the warnings was mixed, with some regarding the warnings as good and others regarding them as totally inadequate. Accurate predictions of flood heights and times are difficult in Taminda. However, confusion arose due to some businesses receiving a late warning that significantly overstated the height actually reached.

The flood illustrated the substantial amount that can be saved if timely warnings are given and acted upon. Businesses with prior flood experience generally had effective flood action plans. It was fortunate that the 2000 flood occurred during business hours, allowing even those without flood action plans to prepare. Scope exists to encourage other businesses in Taminda to develop flood action plans and these would be of great benefit during future floods, especially if they are larger and occur at less convenient times.

Few respondents were skilled in the use of sandbags or aware of their limitations.

Payment of increased rates to fund a levee to protect Taminda was not popular with many survey respondents. Several of the larger businesses were more positive in their response to the proposition, depending on the increases likely to be imposed.

The relatively minor nature of the November 2000 flood means that extrapolation of the estimated costs to larger floods requires caution. However, the results are consistent with earlier estimates by PPK (1993) which could therefore form the basis for cost estimation of larger floods.

## CBD SURVEY

The flood of November 2000 was relatively small. It would not have inundated even the lowest lying buildings in the CBD had no levee been in place.

The opportunity was taken to trial a low-cost method of loss estimation that could possibly be used in future studies of this kind.

The method was based on a fast field survey of commercial and industrial enterprises in the CBD and is referred to as a reconnaissance method. The survey covered all businesses in the CBD in the area identified by PPK (1993) as being flooded in the probable maximum flood (PMF). Information recorded for each enterprise was:

- location;
- an estimate of the size;
  - small (less than 190 m$^2$);

  - medium (more than 190 $m^2$ and less than 650 $m^2$);
  - large (more than 650 $m^2$ and usually estimated by pacing out the dimensions);
- type of business;
- value category;
  - measured on a scale of 1 (low value) to 5 (high value); and
- estimate of floor height above ground level.

Of the 387 premises below the PMF level, 314 were below the 100-year ARI flood level. A total of 88 per cent of the properties surveyed were classified as either value class 2 or 3 and 87 per cent of the properties were in the small size range. The number of properties in the survey below the 100-year ARI flood level is consistent with the number reported by PPK (1993). However, there is a marked difference in the number of properties at risk from the PMF. The PPK number is much higher (587) and is thought to be due to the different methods used. It is considered that the survey approach used in this study is superior.

The stage-damage curves used for estimating direct damage are based on a combination of size and value class of the business and are those used in a number of earlier ANUFLOOD surveys. The total *potential* direct damage from a 100-year ARI flood estimated using these stage-damage curves was \$5.36 million. Using a damage reduction factor of 0.6 gives an estimate of *actual* direct damage of \$3.2 million.

The BTE compared the above results with those obtained using the Rapid Appraisal Method (RAM), developed for the Victorian Department of Natural Resources and Environment and those obtained by PPK(1993). The RAM gives an estimate of actual direct damage of \$5.7 million in 2000 prices. The larger damage costs are due to larger unit area damage costs used in the RAM compared with those implied in the stage-damage used in the current analysis. The PPK (1993) results were much higher still at \$33 million for actual direct damage costs in 2000 prices. The higher results derived by PPK are due to higher unit area damage costs than in the stage-damage curves used in this current analysis and possibly deeper over-floor flood heights. However, there is insufficient detail in the PPK report to be certain.

Comparison of the three approaches highlights the paucity of good quality information on stage-damage curves for commercial and industrial premises. Further research on commercial and industrial stage-damage curves is required if consistent and reliable damage estimates are to be achieved.

Overall, the reconnaissance method provides a low-cost approach to assess whether previous studies of industrial and commercial flood losses still represent current conditions.

# CHAPTER 1 INTRODUCTION

Floods have been a regular occurrence in the city of Tamworth. About 40 floods have occurred since the commencement of records in 1925. The largest floods since 1925 occurred in 1955 and 1962, reaching 7.16 metres and 6.86 metres on the Tamworth flood gauge respectively (PPK 1993, p. 3). Significant flooding occurred in 1984, and less extensively in November 2000. Part of Taminda, the industrial area of Tamworth, was inundated in 2000. Taminda has no structural protection—a conceptual design for a levee has been completed with detailed design work expected to commence in late 2001. The central business district (CBD) is protected by a recently upgraded levee and suffered no inundation.

The November 2000 flood provided an opportunity to estimate the savings in costs that would have occurred in Taminda if there had been a levee to protect the area. The flood also provided an opportunity to explore methods of estimating damage costs avoided by the existence of a levee—as was the case for the Tamworth CBD. Therefore, the study had two objectives:

- Estimate the economic costs resulting from the November 2000 floods at Taminda.
- Estimate the costs avoided in Tamworth by the CBD levee bank during the November 2000 flood.

Businesses in the Taminda area had several hours warning of the impending flood. There have been few studies of floods in predominantly industrial areas that allow estimation of the savings that can be made by good use of the time available from when a warning is given until premises are flooded. Because Taminda is almost entirely industrial, the study provided a rare opportunity to examine the effect of floods on industrial enterprises and the effectiveness of flood preparation.

The Taminda study was relatively straightforward, as the techniques have been previously used many times. Estimating the effect of a levee after its construction is not straightforward. The task is to judge what might have happened if the levee had not been there. Although estimating *potential* direct damage is a matter of using standard stage-damage curves, estimating the likely *actual* damage is much more speculative. Far more difficult is the estimation of the indirect costs associated with disaster response by the State Emergency Service (SES) and volunteers and the effects of business disruption.

The study of the Tamworth CBD is therefore as much a means of testing the usefulness of the adopted method as it is of estimating the savings due to the levee bank.

## PREVIOUS STUDIES OF TAMWORTH

### Smith and Greenaway (1984)

Smith and Greenaway (1984) studied the 1984 flood in Taminda and estimated that the total damage sustained to the flood-affected premises was $1.44 million in 1984 prices ($2.91 million in December 2000 prices) (Smith & Greenaway 1984, p. 1). The report by Smith and Greenaway (1984, pp. 35–36) included a database of the information collected during the 1984 study. The data were also keyed to maps that allowed the location of the affected properties to be identified. This information made it possible to compare over-floor flood levels of the 1984 and 2000 floods and changes in potential damage.

Because the 1984 flood occurred in the early hours of the morning during a long weekend, only some of the affected businesses were able to prepare. Smith and Greenaway were therefore able to compare damages for those who were prepared and those who were not. The November 2000 flood peaked towards the middle of the day, giving all businesses opportunity to save much stock and equipment before the flood entered their premises.

### PPK (1993) study

In 1993, the Tamworth City Council commissioned PPK Consultants Pty Ltd to develop a Floodplain Management Study (PPK 1993). The study made recommendations on flood mitigation measures for those parts of Tamworth subject to flooding. Among the recommendations were:

- construction of a levee to protect Taminda; and
- an upgrade of the CBD levee.

At the time of the PPK (1993) report, the CBD was partially protected by an existing levee that was constructed in the 1930s. It had been raised several times during the 1970s. An audit of the levee in 1992 cast doubts on the structural integrity of the levee (PPK 1993, p. 34). At that time the levee was assessed as providing protection for a flood between 3 and 5 per cent annual exceedance probability (AEP)[1]. PPK recommended that the levee be upgraded to protect the CBD against a 1 per cent AEP flood. The upgrading was completed in 1999.

---

1 Annual exceedance probability (AEP) is the likelihood of occurrence of a flood of a given size or larger in any one year, usually expressed as a percentage. A 5 per cent AEP flood means that there is a 5 per cent risk or a probability of 0.05 of a flood of that size, or larger, occurring in a given year.

PPK concluded that the construction of a levee to protect Taminda against a 1 per cent AEP was justified on economic grounds. PPK (1993, p. 66) suggested that some form of user pays funding for the levee would be appropriate. No levee has yet been constructed, although a conceptual design has been completed.

A levee from Matthews Street to Thibault Street (frequently referred to as the Goonoo Goonoo levee) was under construction at the time of the field work for this study (May 2001). The levee is designed to protect properties along the western fringe of Goonoo Goonoo Creek floodplain. The area is affected by affluxes due to the raised CBD levee. Although not directly related to the present study, it is mentioned because several business people interviewed in Taminda were critical of the levee, claiming that it increased flood heights in Taminda. However, modelling by Lyall and Macoun (PPK 1993, Appendix B, p. 18) concluded that the Goonoo Goonoo Creek levee would have a negligible effect on downstream flood levels.

## ISSUES INVESTIGATED

Apart from estimating damage costs in Taminda, the opportunity was taken to investigate the preparations made for the flood in Taminda. The Smith and Greenaway (1984) study aggregated preparation time and clean-up time. These two times were left disaggregated in the present study. Questions were also asked about the source of warnings and their effectiveness.

The suggestion in the PPK (1993) report that the funding of the Taminda levee should include at least some element of user pays was followed up. The possibility of funding the levee through a rate increase was included in the survey to gauge the reaction to this suggestion. Respondents were also asked about their attitude to the construction of the Taminda levee.

## METHOD

The study had two distinct components—the Taminda investigation and the CBD investigation.

### Taminda investigation

The primary source of information was a questionnaire that was administered by interviewing business people in their offices in Taminda. The questionnaire was designed as an aid to discussion and a vehicle for reporting responses. The questionnaire allowed fast collection of information and did not require respondents to spend a lot of time searching through records. The survey was conducted sufficiently close to the time of the flood for memories to be still reliable and far enough removed in time for damage estimates to have been estimated with reasonable accuracy.

The survey form, which is at appendix I, sought information on:

- the site;
- flood mitigation measures;
- flood warnings;
- direct damages;
- damage reduction as a result of mitigation measures;
- indirect losses;
- other adverse effects;
- insurance; and
- other information on the enterprise and the Taminda levee.

In addition to the survey, information on infrastructure costs was obtained from the Tamworth City Council. Information on the response effort was obtained from the SES and the local fire brigade.

**CBD investigation**

There was no actual flood damage to properties in the CBD, due mainly to the low level of the flood and the existence of a levee protecting the area. Because there was no damage to measure, an approximate approach was adopted for estimating the potential damage to commercial enterprises in the CBD if there were no levee and if there had been a 100-year ARI flood[2]. The method involves allocating each enterprise to a size and value class. Each combination of size and value class has an approximate stage-damage curve that can be used to estimate potential damage (Smith 1994; BTE 2001, pp. 67–68). The results obtained in this way were compared with results obtained by the Rapid Appraisal Method (RAM) developed for the Victorian Department of Natural Resources (VDNRE 2000).

2 Annual recurrence interval (ARI) is a statistical estimate of the average period in years between the occurrence of a flood of given size or larger. For example, floods with a discharge as large, or larger, than the 100-year ARI flood will occur, on average, once every 100 years.

# CHAPTER 2 TAMINDA INVESTIGATIONS

Taminda is floodprone and has experienced floods on a number of occasions since development began, with major floods occurring in 1955, 1962 and 1984. Details of the depth of inundation for earlier floods are not known, but a study of damage was undertaken following the floods of January 1984 (Smith & Greenaway 1984). It is thought that the flood of 1984 corresponded approximately to a 20-year ARI flood and the flood of 1955, which was more severe, corresponded to a 75-year ARI flood. It is difficult to give a precise recurrence interval for the flood of November 2000, but it would likely be close to 10-year ARI. It is clear that it was not a rare event.

## FLOOD LEVELS

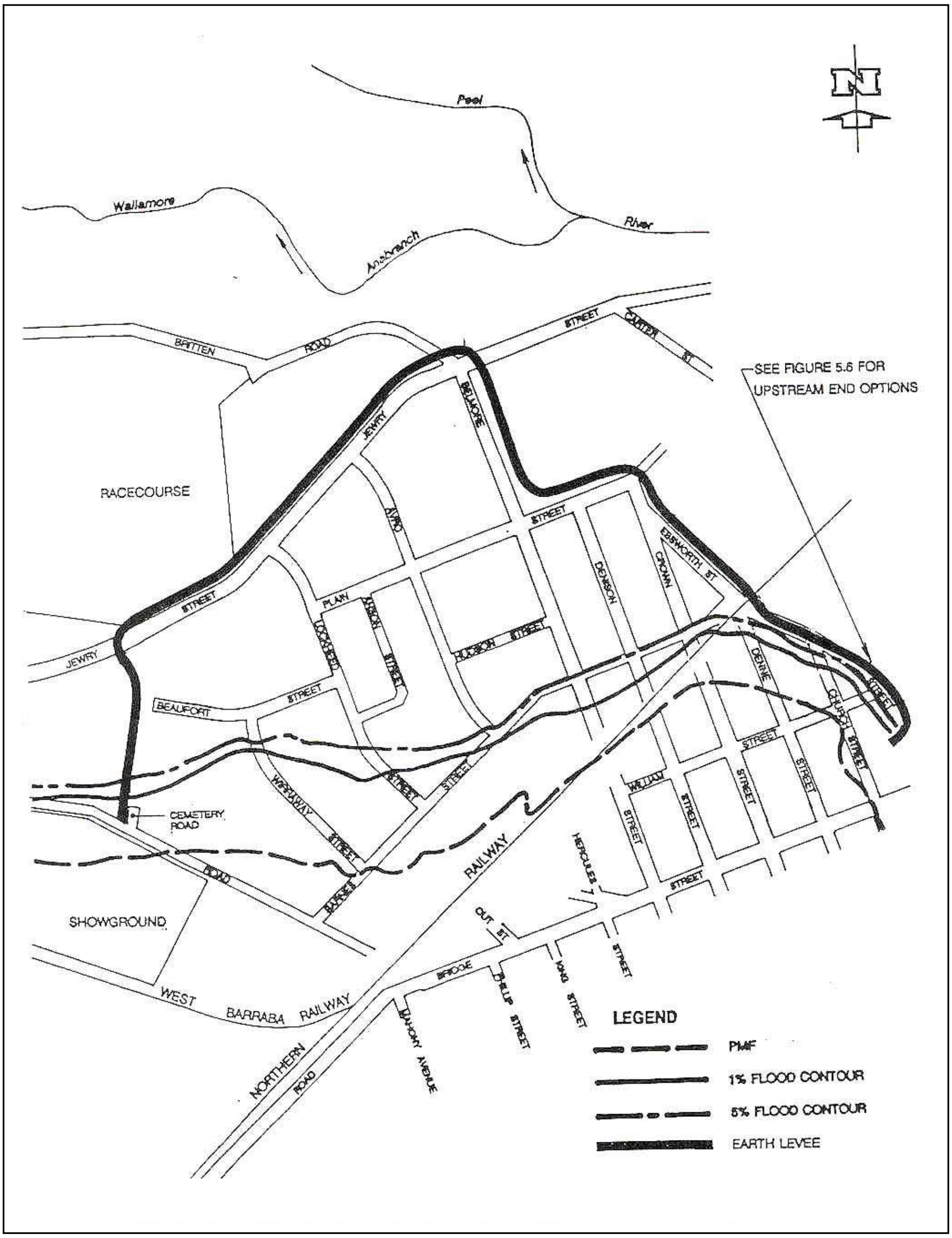
The most reliable data on the extent of earlier floods are from the flood depths that exceeded the floor level of the older buildings. This, however, raises difficulties as many of the buildings have their floor levels raised above that of the surrounding ground level. Discussions with older residents make it clear that this form of construction was a response to the known flood liability of the site. In more recent years, Tamworth City Council has imposed floor level restrictions on new constructions.

The data collected for the November 2000 flood indicated that the over-floor level was approximately 0.4 metres lower than for the 1984 flood. It is possible that there were minor variations in the differences in depth across Taminda. The modelling undertaken by PPK (1993) indicates that the difference in flood level between the 20-year ARI and 100-year ARI floods is about 0.5m. The difference in height between the 20-year ARI flood and the probable maximum flood (PMF) is some 4.6m.

The topography of Taminda is such that there is relatively little increase in the lateral extent of floodwaters for floods above the level of 20-year ARI. This is illustrated in figure 2.1.

Clearly, the impact of deeper inundation within the affected area will have marked effects on flood losses. This is due to the difficulty of raising items to a level to escape flood damage and the problem that roads become impassable so

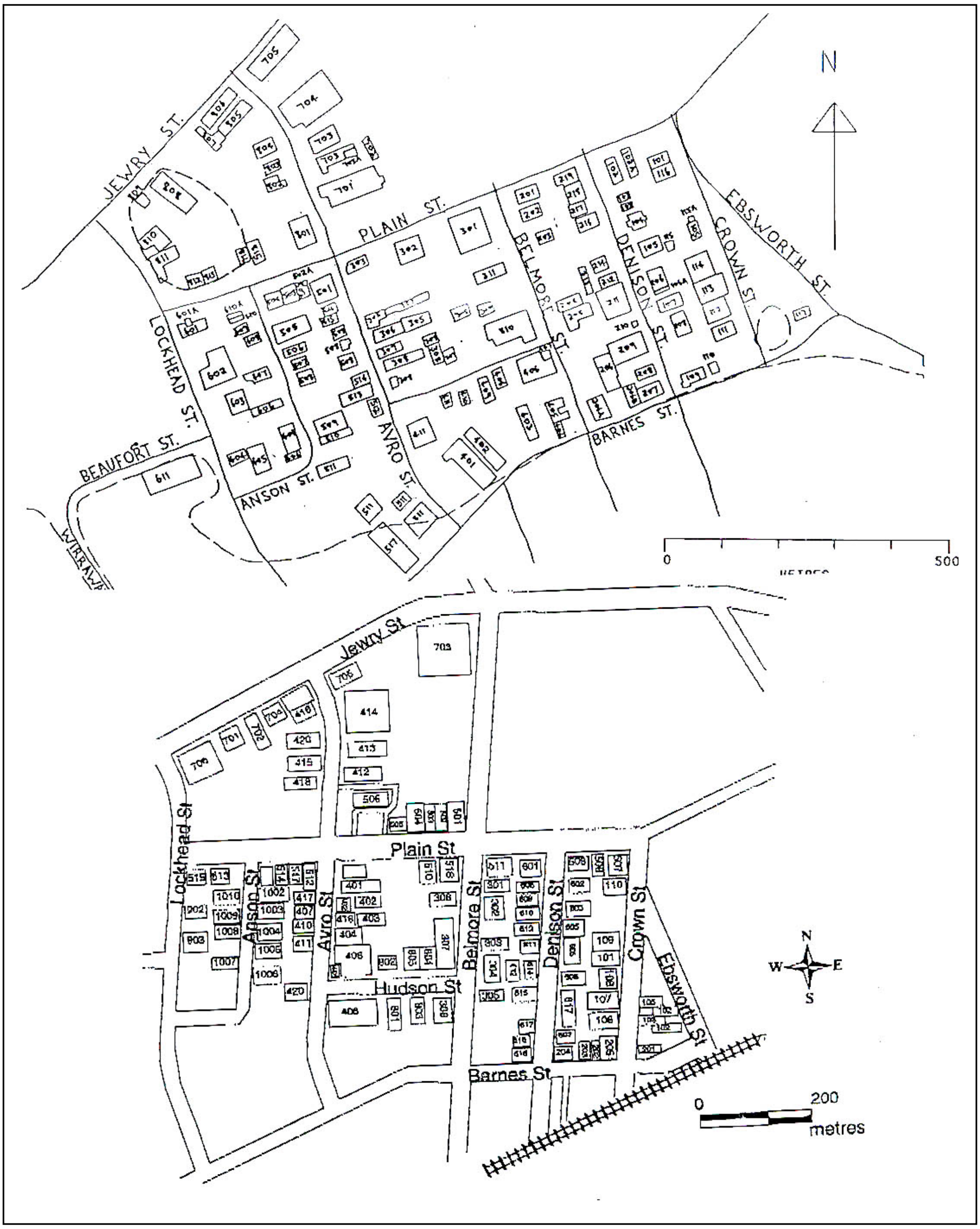
FIGURE 2.1 THE LIMITS OF THE FLOODS IN THE TAMINDA INDUSTRIAL ESTATE AND THE SITE OF THE PROPOSED LEVEE




*Source* PPK (1993, figure 5.5, volume 1)

that stock and equipment cannot easily be moved to flood-free sites. Further, a flood peak that arrived at night, during a weekend, or a public holiday, would likely be more damaging than a flood in daylight hours during the working week.

FIGURE 2.2 LOCATION MAP AND CODE NUMBER OF BUILDINGS SURVEYED IN 1984 (TOP) AND 2001 (BOTTOM)




*Source* Smith & Gissing (2001a, figure 2)

The over-floor flood depths recorded in the survey (appendix II) apply to the main covered area of the buildings concerned. In a few cases, the height of floor areas for individual buildings varies. For instance, there is sometimes additional elevation due to loading bays for trucks. In other cases, equipment and stock were located in open areas at ground level, especially for some establishments that deal in heavy steel items or timber products. This is not thought to be a major problem in interpreting the data, as the over-floor depths apply to the main working and/or storage areas.

## THE QUESTIONNAIRE

The questionnaire (appendix I) was administered in face-to-face contact with the respondents. Every attempt was made to obtain specific answers suitable for use in the BTE study and in a form that could be portrayed on a spreadsheet. Where the respondents did not know the answer, or were not prepared to divulge the information, the appropriate cell on the spreadsheet has been left blank.

The location of the enterprises included in the surveys, together with the code numbers listed on the spreadsheet, are given in figure 2.2.

With only minor exceptions, questionnaires were completed for all those buildings considered appropriate for inclusion in the survey. All respondents were prepared, with minor exceptions, to willingly supply the information requested.

Questionnaires were completed for the majority of buildings that experienced over-floor flooding in the 1984 flood and for all new buildings located in the area flooded in November 2000. A number of buildings in the survey did not experience flood loss in November 2000. These have been included, as they can assist with the evaluation of estimated flood losses for a more severe flood event.

The survey did not extend to the potential limits of a probable maximum flood. This was predominantly because enterprises located above the limits of the 1984 flood (and in some cases just above the limits of the November 2000 flood) were adamant that they were totally flood-free.

The surveys of 1984 and 2001 had comparable distributions of enterprise types (table 2.1). The key feature is that approximately 50 per cent of the enterprises are concerned with retailing or wholesaling of a wide range of goods. Firms engaged in car repairs are included within the retail heading.

## COST ESTIMATES

Disaster costs are usually estimated within three broad categories—direct, indirect and intangible costs (BTE 2001). Intangible costs mostly relate to impacts on residential properties, heritage assets and the environment. As the Taminda flood-affected none of these, intangible costs can be safely ignored.

TABLE 2.1 ASIC CLASSIFICATION OF ENTERPRISES INCLUDED IN THE FLOOD SURVEYS OF 1984 AND 2001

| *ASIC No.* | *Description* | *1984* | *2000* |
|---|---|---|---|
| **Agriculture** | | | |
| 02 | | 0 | 1 |
| **Manufacturing** | | | |
| 21 & 23 | Food & textiles | 2 | 0 |
| 25 | Wood & wood products | 8 | 8 |
| 26 | Paper & printing | 1 | 0 |
| 27 | Chemical products | 3 | 0 |
| 28 | Non-metallic, including glass | 5 | 4 |
| 31 – 34 | Fabricated metal etc. | 17 | 8 |
| **Construction** | | | |
| 41 & 42 | Building & building materials | 4 | 6 |
| **Trading** | | | |
| 47 | Wholesale | 26 | 33 |
| 48 | Retail | 32 | 27 |
| **Transport** | | | |
| 51, 55 & 57 | Transport depots & storage | 10 | 6 |
| **Various services** | | | |
| 63, 71, 84 & 91 | Council services, video hire etc. | 2 | 3 |
| 92 | Cafes | 2 | 3 |
| **Total** | | 112 | 99 |

*Source* Smith & Gissing (2001a, p. 6)

TABLE 2.2 DIRECT DAMAGE COSTS FOR TAMINDA—NOVEMBER 2000

| *Damage category* | *No. of businesses* | *Damage cost ($)* |
|---|---|---|
| Stock | 14 | 80 140 |
| Equipment | 7 | 57 300 |
| Fabric | 9 | 7 020 |
| *Total* | *21*[a] | *144 460* |

a Figures do not add to total because some businesses reported damage in more than one category.

*Source* Survey of businesses in Taminda in April and May 2001.

## Direct costs

The 21 damaged properties in the survey reported a total damage cost of $144 460 (table 2.2). Minor damage, such as water damage to the lower part of office furniture and doors, in some properties had not been repaired at the time of the survey. It is unlikely that these costs would have been included in the reported cost estimates. However, the underestimate in damage costs is not expected to be significant.

Fortunately, the November 2000 flood occurred during normal business hours with sufficient warning time to allow most survey respondents to prepare for the flood. The preparation effort was generally successful and was estimated to have reduced damage by $781 000. That is, the actual damage was about 16 per cent of the estimated potential damage.

The total cost to the nine properties reporting damage to the fabric of the building was not large. Fabric damage was entirely due to damage to driveways and gravel surrounds to buildings.

Direct damage was not large for 20 of the 21 properties—they averaged only $3 070 damage per property. However, one property sustained considerable damage of $80 000, or 55 per cent of the total damage in Taminda.

The direct damage costs are very much less than the $787 900 ($1 640 000 in December 2000 prices) reported by Smith and Greenaway (1984, p. 10) for the 1984 flood. The lower damage costs are primarily a result of the November 2000 flood being smaller than the 1984 flood. A second reason is that the 1984 flood occurred during a long weekend and preparations for the flood were not possible for many of those affected. In contrast, the November 2000 flood occurred during business hours and all of those affected had the opportunity to prepare. The potential for reduction of damage through adequate preparation is large, as illustrated by the data collected by Smith and Greenaway (1984) and for this study.

### *Roads and other Council assets*[3]

Tamworth City Council made available copies of all correspondence related to applications for flood assistance. This provides damage estimates from the November 2000 event for roads, bridges, river works etc. A major component of these costs is for labour, which is included in all figures given below.

The bulk of these costs is repaid to the Council from State and Commonwealth funds. As always, there is much discussion between the three tiers of government as to exactly what should be included. This is because the Natural Disaster Relief Arrangements (NDRA) are limited to restoring assets to their pre-flood condition.

The allocation of costs to Taminda is as finally agreed between the three tiers of government. Minor items are still to be agreed, but for Taminda any further changes will be minimal and can be ignored for the purposes of this report.

3 This section is almost entirely drawn from the report of the Taminda survey by Smith and Gissing (2001a).

The total cost for the whole area administered by the Tamworth City Council is close to $2 million. Most of this is repaid to the Council from NDRA funds. Of the total approved for the Tamworth City Council, only $31 781 is specifically related to Taminda. All are for emergency road closures and repairs to road surfaces and road shoulders. Five specific locations within Taminda are mentioned.

**Indirect costs**

Following the recommendations in BTE (2001), indirect costs include

- costs of preparing for the flood;
- clean-up costs; and
- emergency services costs.

Whether the costs of lost trade for local businesses should be included in indirect costs depends on the perspective taken by the analysis. The economic costs of lost trade are included if a local perspective is taken. A national perspective would exclude most instances of lost trade on the grounds that trade lost during a flood would be taken up by another business unaffected by the flood, or deferred in time. An estimate of the costs of lost trade is included in the following analysis.

***Costs of preparation***

Preparation for the November 2000 flood involved lifting floodprone stock above the expected flood height and, in at least one case, the removal of stock to a flood-free location by truck. Respondents reported the effort involved in reducing flood damage in terms of person-hours of work. In-house labour was used exclusively for preparation. The value of the preparation effort was based on average weekly ordinary time earnings (AWOTE) for November 2000 (ABS 2001a). The Australian Standard Industrial Classification (ASIC) was used to estimate a weighted average AWOTE for the businesses responding to the survey. The weekly rate, estimated by this procedure, was $718.80.

The total person-hours reported by the 73 establishments that prepared for the flood was 1 400, giving a total preparation cost of $25 150. The average cost per square metre was 49 cents.

***Costs of clean-up and restoration***

Clean-up and restoration costs include the costs of materials and additional labour, as well as the cost of in-house labour. Even if a property was not inundated, respondents reported that the time to restore stock to shelves took much longer than to lift it prior to the flood. This is to be expected because restoration of stock that was removed under emergency conditions involved a degree of sorting and restacking not required when the stock was lifted or removed.

The 65 properties reporting both a preparation time and a clean-up and restoration time reported a total of 2 921 hours of in-house labour for clean-up and restoration at a cost of $52 490. These same properties took 1 267 person-hours in preparation. That is, clean-up and restoration required 2.3 times the in-house labour required for preparation. A further three properties reported a clean-up and restoration time, but no preparation time.

In addition, businesses reporting times for clean-up and restoration spent $2 030 in cleaning materials. Although almost without exception clean-up was undertaken with in-house labour, a total of $1 250 was spent in the hiring of additional labour to assist the in-house staff. The total clean-up and restoration cost was $56 200 and averaged $1.20 per square metre.

***Lost trade***

The average time during which it was not possible to open for business was 1.9 days for the 80 businesses reporting lost trade. Most businesses (77.5 per cent) reported two days or less trading time lost. The maximum trading time lost was seven days (one business only).

The economic effect of the lost trade depends on where the boundaries of the analysis are drawn. If a national perspective is taken, the economic effect of the lost trade would be small (BTE 2001, p. 77). However, if the analysis is confined to the Taminda area, the economic effect would be approximately equal to the value added[4] that was lost during the time of business interruption.

Survey respondents were asked if the trade lost was subsequently made up. The answers were mixed. Some said they normally worked close to full capacity, so it was not possible to make up any lost trade. Others said that their competitors and some customers were similarly disrupted and so the opportunity to make up the loss existed.

Service providers had the greatest difficulty in making up lost trade. For example, an ice cream distributor commented that ice cream sales were mostly impulse purchases, and once lost due to an inability to supply the product, the sale subsequently could not be regained. It was also evident that some lost services could not be attributed totally to the flood. For example, a car washing business operator commented that he lost business whenever it rained. His business was disrupted, but it would have been disrupted by the rain irrespective of the occurrence of a flood.

---

4 Value added, in general terms, represents gross output less intermediate inputs.

TABLE 2.3 RATIO OF VALUE ADDED TO SALES FOR SELECTED INDUSTRIES

| *Industry* | *Value added/sales (%)* |
|---|---|
| Textile, clothing, footwear and leather manufacturing | 33.6 |
| Wood and paper product manufacturing | 35.1 |
| Printing, publishing and recorded media | 40.4 |
| Petroleum, coal and chemical manufacturing | 30.7 |
| Non-metallic mineral product manufacturing | 30.3 |
| Metal product manufacturing | 41.5 |
| General construction | 17.4 |
| Construction trade services | 41.5 |
| Wholesale trade | 16.3 |
| Retail trade | 17.9 |
| Road transport | 40.6 |
| Other transport and storage | 39.3 |
| Accommodation, cafes & restaurants | 46.3 |
| Property and business services | 52.7 |
| Private community services | 87.0 |

*Source* ABS (2001b)

The following results are based on the assumption that all trading time lost during the flood led to a loss of value added. However, it is clear that this will be an overestimate of the economic effect.

Lost value added was estimated from annual turnover data using information on value added and sales contained in ABS (2001b) (table 2.3). The turnover for each business reporting lost trade was multiplied by the relevant ratio of value added to sales to give an estimate of the lost value added for the disrupted business. The estimated loss of value added obtained in this way was $214 300. As noted above, this estimate overstates the value added that was lost due to the Taminda flood.

The financial loss to flood-affected businesses is measured by the loss in profit. Profit lost on the days during which trading was not possible was estimated using data on operating profit before tax found in ABS (2001b). The estimated lost profit was $58 700, which is significantly less than the economic loss.

### *Emergency services costs*[5]

#### *Costs to SES*

The costs to the Tamworth–Parry [Shire] SES unit resulting from the flood of November 2000 were kindly supplied by Bob Allen, Executive Officer of the Namoi Division of the NSW State Emergency Service.

5 This section is almost entirely drawn from the report of the Taminda survey by Smith and Gissing (2001a).

The total man-hours for the period 16–23 November were 1 020. The opportunity cost of this labour using AWOTE of $718.80 is $18 330.

Direct costs for payment of fuel, sand, sandbags, other consumables plus phone/fax, totalled $8 600.

There is no formal breakdown of the costs for Taminda, as the Tamworth/Parry Unit covers a larger geographical area than Taminda. However, it is thought that 75 per cent of the overall costs could be allocated to Taminda, where the sandbagging operations were predominantly used. The total cost is therefore $20 200 ($13 750 for labour and $6 450 for materials).

For a larger flood, it is likely that a larger proportion of the SES assistance, and thereby costs, would be directed elsewhere in the wider Tamworth/Parry area. In part, this is because the November flood caused relatively little inundation of residential buildings.

*Bush Fire Brigade*

Like the SES, the Bush Fire Brigade is a volunteer organisation. Its headquarters share the same buildings and storage areas as the SES at the edge of the floodprone area of Taminda. Its main contribution to the flood response in November 2000 was to make its three units available during the immediate clean-up phase. This was a task that it shared with the Tamworth Fire Service—the full-time fire service.

Three mobile Bush Fire Brigade pump units with a total crew of ten persons worked for a full day immediately after the floods to assist with the clean-up of industrial enterprises in Taminda. The estimated opportunity cost of the labour is $1 440.

The service was much appreciated by firms that had experienced over-floor flooding. For instance, at Campbell's (a large wholesale grocery depot and store) the smaller mechanised pumping units were able to motor up and down the aisles and use adapted high pressure hoses to clean out the river sediment that is a feature of all floods of this kind.

*Other facets of emergency management*

The city fire brigade and police are important and additional elements of emergency services active during a flood. These are essentially professional organisations and no estimate is given of the costs of their involvement. The relevant cost would be the marginal costs incurred because of the flood (BTE 2001, p. 86).

## Total costs of the November 2000 flood

The total estimated cost of the Taminda flood was $493 500. The largest component of the estimated cost is business disruption. This cost, as explained earlier, is believed to overstate the economic effect of the flood on the local community. The estimate of $493 500 is therefore an upper estimate (table 2.4).

If a national perspective is taken, the total estimated cost falls to about $280 000. This will understate the total economic costs due to the observation made earlier that some lost trade cannot be made up, no matter where the boundaries to the analysis are drawn.

## ADDITIONAL OBSERVATIONS FROM THE SURVEY[6]

During the course of the interviews, respondents provided information and views on a number of aspects of flooding that could not be adequately expressed in spreadsheet format. A summary of these comments is given below.

### Flood warnings

The response of flood victims to the quality of flood warnings is always mixed. Some regard the warnings as good, while others consider them to be totally inadequate. Often, the contrasting responses are from neighbouring premises! For those who are critical, the response can sometimes be interpreted as a form of 'blame transference'. The Taminda interviews included both forms of response.

TABLE 2.4 SUMMARY OF TAMINDA FLOOD COSTS

| *Cost category* | *Cost* |
|---|---|
| Direct costs | |
| Buildings & contents | $144 460 |
| Council assets | $31 781 |
| *Sub-total* | *$176 241* |
| Indirect costs | |
| Preparation | $25 152 |
| Clean-up | $56 205 |
| SES | $20 197 |
| Bush fire brigade | $1 438 |
| Business disruption | $214 279 |
| *Sub-total* | *$317 270* |
| **Total** | **$493 511** |

*Note* Figures may not sum to total due to rounding

*Source* BTE analysis

6 This section is almost entirely drawn from the report by Smith and Gissing (2001a) on the Taminda survey.

Because the Timbumburi Creek is a relatively small headwater catchment, it is difficult to provide warnings that are precise in regard to the time and height of the flood peak. Further, the location at the junction of the Peel River will cause the magnitude of floods to vary depending on the time and amount of rainfall in the two catchments.

For the flood of November 2000, there appeared to have been some confusion due to some premises receiving a late warning that significantly overstated the actual height reached.

For warnings to be effective, it is widely accepted that recipients should receive the information from more than one source. The best warnings are those that are delivered specifically to each potential victim.

For the November 2000 flood, most survey respondents received warnings from a combination of sources. Those most frequently mentioned were radio, neighbours and the SES. Many respondents reported that the decline in local radio services had resulted in warnings that were much less specific than in earlier years.

Many respondents reported that they preferred to receive warnings personally, either orally from a member of the SES or by phone. The possibility of phone contact with a nominated person for each of the premises at risk in Taminda was much discussed, including with the SES. The SES indicated that this is very difficult to arrange, as individual firms do not keep the list of phone contacts updated between floods. The use of a cascading system (where information is transmitted to individuals in a sequential and organised manner) or more recent forms of automatic dialling and warnings could be further investigated.

An efficient warning system, comprising both an accurate forecast and its dissemination, is one key to mitigating the effects of floods.

It should be noted that the PPK (1993) report includes a proposal for the installation of an ALERT warning system. This has not come to fruition but would have the potential to improve the warnings available to Taminda.

Although some respondents were critical of the forecasts provided by the SES, the general view applauded the activities of such a volunteer organisation.

**Flood warning action plans**

An essential component for successful damage reduction is for each enterprise to have an effective flood reduction action plan. Ideally, this would commence with information on the correlation of flood level (as given in the forecast) with the appropriate floor level for each enterprise. It would then list activities to be undertaken to reduce damages. These would include such measures as lifting or removing stock and equipment to flood-free locations, the use of sandbags etc.

A few of the enterprises interviewed had such plans, although it was unusual for respondents to be aware of floor height in relation to flood stage. Those that had plans, not surprisingly, were enterprises that had experienced over-floor flooding and where senior staff members had been present at the time of the earlier inundation. Many of those with flood experience had marked the level of earlier floods on walls and the like—for example—the level of the 1955, 1962 or 1984 floods. This reinforces the usefulness of warnings that relate forecast flood levels to those of earlier major floods.

Individual owners had plans to remove stock to flood-free locations by truck, to lift stock and equipment and, in one case, the owner had a store of filled sandbags.

If a flood action plan were available for each flood-prone enterprise, there would be potential for considerable savings from flood damage reduction measures. This is illustrated in the study of the January 1984 flood in Smith and Greenaway (1984). The first stage is a flood audit that informs owners of flood depth in relation to gauge forecasts and this is followed by the preparation of a flood action plan. Action plans are unique to each establishment and the managers and staff should play a role in designing them. It is, however, possible to provide broad guidelines of what could be done.

**Sandbagging**

Sandbags can be used to block entrances to buildings and have the potential to reduce losses from shallow flooding. For the November 2000 flood, the SES provided a supply of filled sandbags from their headquarters located at the edge of the flood-prone area of Taminda. The normal procedure was for individual enterprises to collect the filled sandbags by truck. Alternatively, if the SES were so requested, it was possible for them to deliver sandbags.

However, this excellent scheme raised some problems.

A number of enterprises that used sandbags reported that they would not use them again. The reason was that the sandbag protection leaked. The problem here is that for effective use, skills are needed in stacking the sandbags, which are best used in conjunction with plastic sheeting. Few of the users were aware of how to use sandbags effectively, despite earlier efforts by the SES to arrange meetings on their use.

A limited number of respondents stated that they were unaware of the SES scheme to provide sandbags.

It is important that the limitations of the use of sandbags, including the limits to the height at which they are effective for commercial and industrial premises, are understood. Their use is often more effective for residential brick buildings with limited entry points for floodwaters and which are otherwise impermeable.

### Clean-up and the fire services

Many of the respondents who experienced over-floor flooding were extremely grateful for the services provided by the City Fire Brigade and the Bush Fire Brigade (a voluntary organisation) during the clean-up phase. This involved the use of high-pressure hoses to wash off sediment when the floodwaters had receded.

Again, a minority complained that they did not know of this service.

### Levee construction

A conceptual design and cost of a levee to protect Taminda to the level of the 100-year ARI flood are presented in PPK (1993). The location is shown in figure 2.1. The cost of the levee, in 1993 prices, was approximately $2.2 million and had a benefit-cost ratio of 1.13. The conceptual design has been revised and detailed designing is expected to commence in late 2001.

But how should the Taminda levee be funded? Such schemes are usually funded by partnerships between Commonwealth, State and Local Governments and at national and state levels they are assessed on a priority basis. The problem with the Taminda levee is that protection is entirely for the industrial and commercial sectors and it tends, therefore, to have a relatively low priority ranking. It is worth noting that, in NSW, the Department of Land and Water Conservation (DLWC) and floodplain management authorities have recently agreed on a points system to assess priorities.

An alternative to assist with local funding for the Taminda levee is for the local government costs to be recouped (in part or in full) from the beneficiaries, that is, the enterprises in Taminda.

The opinion of many of the respondents was that they are not interested in contributing to such a scheme. They stated, often forcibly and quite correctly, that they have contributed through their rates to other expensive structural measures in Tamworth. Therefore, they felt that the Taminda levee should be funded by the Council from rates. Some—mostly larger—businesses, expressed the view that they would be prepared to contribute to the cost of a Taminda levee, but it depended on what the contribution would be. It is likely that larger enterprises would be more prepared to make such contributions.

### Levee and afflux—flood perception

It is a common perception, at Tamworth and elsewhere, that major levees cause flood levels to increase in height elsewhere on the floodplain. This effect is technically known as 'afflux'. Indeed, such effects do occur, but in most cases the increases in flood level are small. The PPK report (1993, p. 65) considers the afflux effects for the proposed Taminda levee. The maximum effect would be at Bridge Street, with an estimated rise of between 2 and 4 centimetres and insignificant effects further upstream (that is, in the area of the Tamworth CBD). The downstream effects are also thought to be small, only affecting low-lying agricultural land.

A related effect, frequently mentioned during the course of the 2001 survey, occurs due to the construction of mounds (or pads) that are commonly used in the construction of buildings in Taminda. Some of these are associated with buildings constructed 20 to 30 years ago; others were built on mounds to comply with the more recent building regulations imposed by Tamworth City Council for new constructions in floodprone areas.

Perception of these mounds mentioned during the 2001 survey was of two kinds: afflux and changes to the velocity of flow of the floodwaters. Such comments were usually associated with the effects of the construction of the mound of a relatively new large hardware store. This is certainly of a much larger size than earlier mounds. The BTE understands that the Council conducted hydraulic analyses prior to the construction of the store.

The flood levels used in the study were based on those provided by survey respondents. However, local perception is that velocities for the November 2000 event were larger than those experienced from earlier floods and that the major effects were around the junction of Ebsworth and Plain Street. Certainly, erosion of gravel driveways and the like in that area was severe.

It is emphasised that these comments do not represent a detailed study, but could form the basis for investigation prior to the approval of similar large mounds in Taminda.

### Property values

The questionnaire was not designed to deal with any adverse effects of flooding on property values. It was noticeable, however, that most of the empty buildings were in the more flood-prone parts of Taminda. Also, comments from older residents made it clear that it was difficult to sell or lease buildings in such areas, often regardless of whether the main floor level was raised.

Should a levee be constructed, some increase in property values in Taminda can be expected. This is noted, but without detailed analysis, in the PPK report (1993, pp. 65–66).

## ESTIMATING LOSSES FOR MAJOR FLOODS

The floods of November 2000 were relatively minor, and were probably around 10-year ARI. Floodwaters exceeded floor level for only 25 enterprises, and for about half of these, the depth was 0.1 metres or less; only three experienced over-floor depths of 0.5 metres or more.

For such shallow over-floor flooding it is relatively easy to undertake measures to reduce damage—in many cases little more than lifting tools that were on the floor. It is possible to use the data obtained for many of the enterprises at risk to estimate the losses that would accompany more severe inundation. Campbell's, a wholesale food store, is used as an example to illustrate a possible methodology.

**Campbell's risk of flood damage**

The depth of over-floor flooding in November 2000 was 0.25 metres throughout the whole store. This building was predominantly constructed after the 1984 event, but the depth of the flood of January 1984 would have been 0.65 metres. A 100-year ARI event would result in over-floor inundation of 1.15 metres and a PMF with a depth of 4.85 metres.

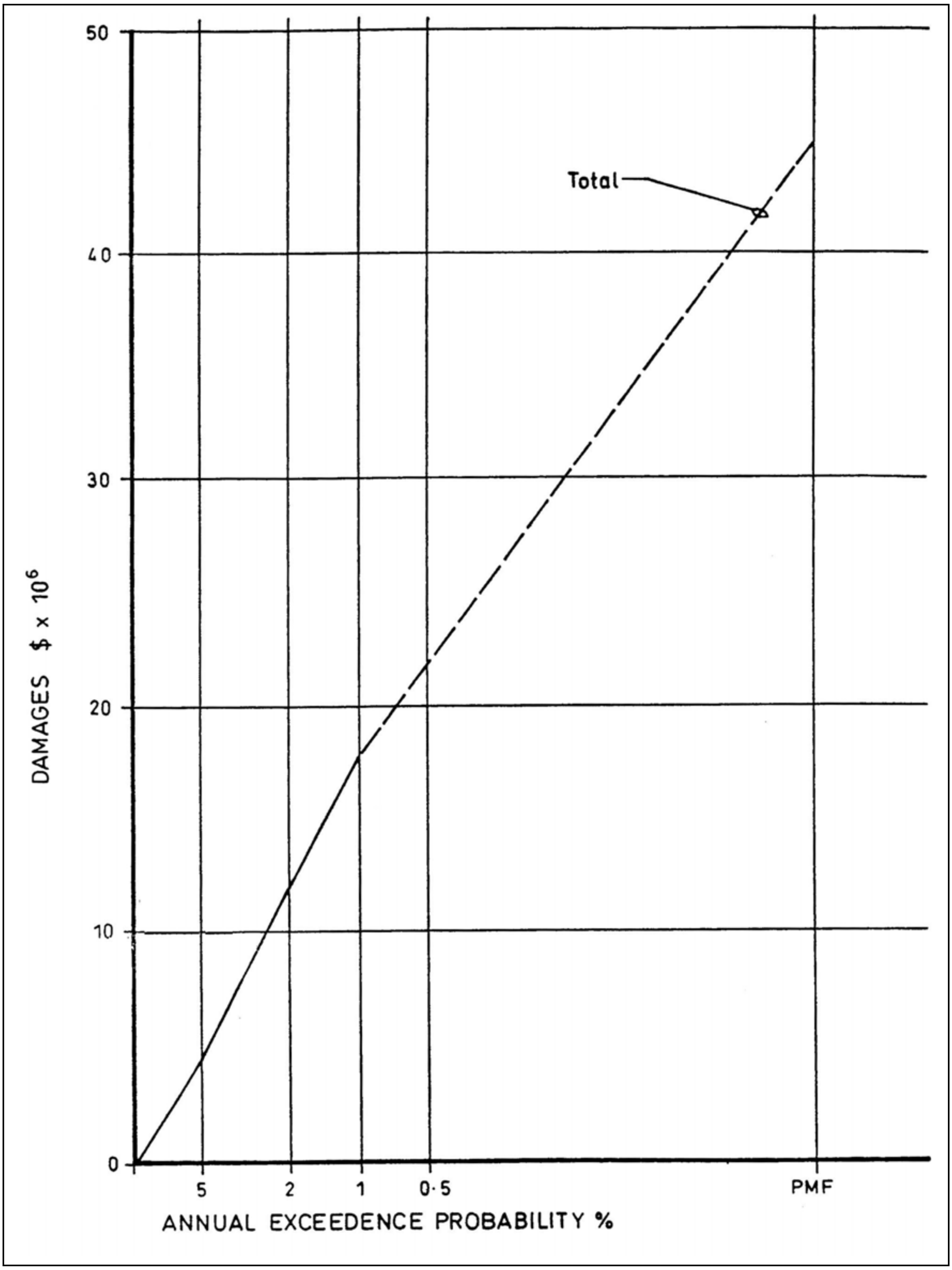
The total value of stock and equipment (predominantly forklifts) is reliably estimated to be $2.15 million.

Earlier studies in Australia confirm that an over-floor flood of 0.75 metres would cause a loss of some 50 per cent of stock and equipment, even after reasonable loss reduction measures had been undertaken. A flood of 1.5 to 2.0 metres or more would, without doubt, result in a total loss of all stock and equipment.

This approach, with care, could be applied to many of the other enterprises included in the survey. It might be necessary to consider the height of stock and equipment in a manner different from that of Campbell's, where stock is on racks and has a reasonably uniform distribution of value with height over the floor. Measures taken to reduce losses, except for normal road vehicles, are dominated by the lifting of stock and equipment—rarely are such items removed from the site to flood-free locations. There is a stage where lifting ceases to be effective or practicable and this also applies to equipment. In many cases (such as Campbell's) major items of equipment are forklifts, which play a key role in lifting stock. Once flood levels reach around 0.75 metres, forklift motors become useless due to water action. It is unlikely that the forklifts (as opposed to road vehicles) could then be removed from the site and they would also become a near total loss. At lower over-floor depths, fork lifts have difficulty maintaining traction, thus reducing their ability to assist in lifting stock above anticipated flood levels.

Care must be taken not to extrapolate the result to damages that could be expected from deeper floods. A cursory glance at the data shows that several enterprises have values of stock and equipment that exceed $500 per m$^2$.

FIGURE 2.3 ESTIMATED DAMAGE FOR TAMINDA AS A FUNCTION OF FLOOD SEVERITY




*Source* PPK (1993, volume 2, figure 6.2)

## CONCLUSIONS OF TAMINDA SURVEY

The survey conducted in Taminda provided information based on interviews undertaken with staff of flood-prone commercial establishments.

The major shortcoming is that the flood of November 2000, on which the survey is based, was a relatively minor event. Because of this, care should be taken if the November 2000 losses are extrapolated to those that could be expected from a more severe flood event. The previous section provides guidance on how the data could be used to estimate flood losses for more severe flooding.

The study by PPK (1993) contains estimates of losses for floods of differing severity in Taminda. The results are reproduced in figure 2.3. Analysis to convert the results in appendix II to assess losses from more severe floods was not attempted. However, a visual comparison suggests that the PPK damage estimates are reasonable—more detailed analysis would require updating the loss data for the effects of inflation and allowing for new buildings in Taminda. Similarly, updated damage estimates for other areas in NSW could be obtained from earlier detailed floodplain management studies.

# CHAPTER 3 CBD INVESTIGATIONS[7]

The flood of November 2000 was below 20-year ARI—it was likely to be closer to 10-year ARI. It is clear from the Tamworth City Council Floodplain Management Study (PPK 1993) that such a flood event would fail to inundate even the most low-lying buildings in the area of the CBD, with or without a levee. This is illustrated in figure 3.1.

The proposed approach was modified to undertake a reconnaissance survey of all buildings within the Tamworth CBD area subject to the Probable Maximum Flood (PMF). The aim was to trial a methodology that could perhaps be used in future studies of this kind. At the same time, the survey provided a chance to review the PPK (1993) study, and to consider the effectiveness of the Rapid Assessment Method of calculating damage.

The method and results of this reconnaissance survey are outlined below. This is followed by a discussion of how to assess the savings to areas of commercial activity that are protected by levees.

## TAMWORTH CBD AND LEVEE PROTECTION

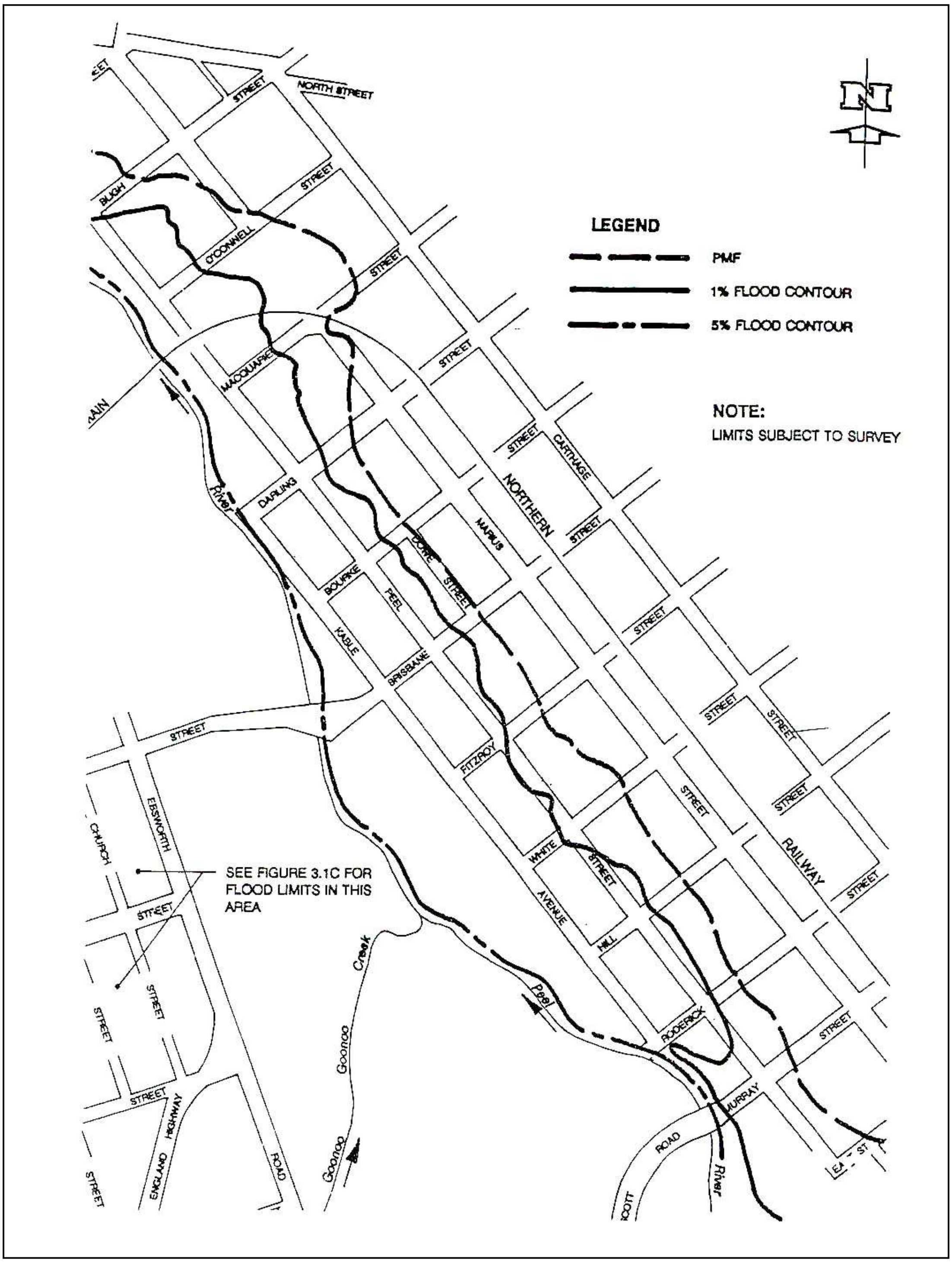
The flood hydrology of the Peel River and the effects of flooding on the Tamworth CBD are described in PPK (1993). At the time of that study, levee protection was in place for the CBD, but the study considered the levee as being unsatisfactory in regard to its level of protection and limitations of construction. This view was based on an audit of all major levees undertaken by the NSW Government following the Nyngan flood of April 1990. The proposal, in 1993, was that the Tamworth CBD levee should be increased in height and construction defects rectified.

Tamworth City Council accepted this aspect of the study and the reconstructed levee was completed in the late 1990s. The level of protection for the CBD is the 100-year ARI flood plus 1.0 metre of freeboard.

FIGURE 3.1 TAMWORTH CBD FLOOD LIMITS

---

[7] This section on the CBD investigations is a reproduction, with minor amendments, of the report by Smith and Gissing (2001b).




*Source* PPK (1993, figure 3.1a, Volume 1)

## The PPK study

The PPK study (1993, Appendix C, Volume 2) included a benefit-cost study of the proposals for the CBD levee. Appendix C (p. 13) states '… the survey carried out covered only the properties affected by the 1% AEP event. The number of additional properties likely to be damaged during the PMF was estimated from contour mapping and aerial photography'. Also '… the commercial properties in the CBD … were not surveyed for floor level. It was necessary to estimate floor levels from contour mapping, existing survey and a site assessment of the height of floor above natural surface.'

The number of properties is given in table 3.1.

Direct flood damages were estimated as follows:

1. A flood category (low, medium or high) was ascribed to each building.
2. The flood area of each building (details of the method are not given) and depth of over-floor flooding.
3. The damage functions used were based on $140/m$^2$ for low value, $360/m$^2$ for medium and $550/m$^2$ for high.
4. The damage functions are for an over-floor depth of 2.0 metres, with zero damage for inundation at floor level and 70 per cent of the damages taken to occur at an inundation level of 1.2 metres.
5. The values calculated using step 4 were for potential direct damage. This was adjusted to actual damage by assuming that actual damage was some 24 per cent of potential damage for shallow inundation, increasing linearly to 65 per cent for 2 metres of water over floor level.
6. A clean-up cost of $2 000 was assumed for each property inundated.

The problem of indirect loss damage was discussed. For the purposes of calculating the overall loss, indirect losses were taken as 15 per cent of actual direct loss.

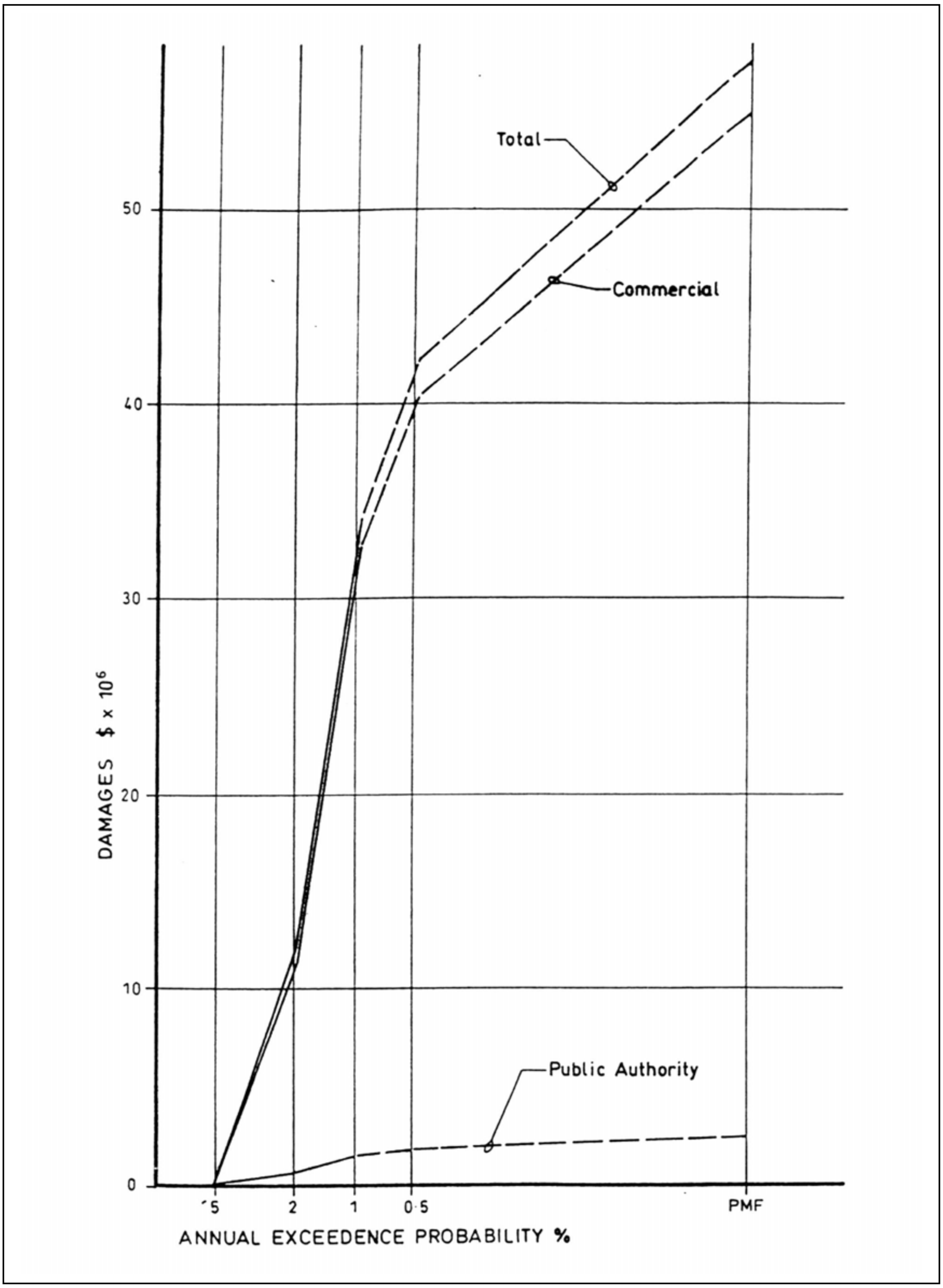
The results for commercial damage to the area protected by the CBD levee are also given in table 3.1.

The methods used are similar to those employed for many other benefit-cost analyses undertaken for floodplain management studies in New South Wales. The overall approach follows that outlined in the original ANUFLOOD Manual (Taylor, et al. 1983) with modifications based on the results of the detailed study of Nyngan (Water Studies, 1990) and by updating the earlier ANUFLOOD stage-damage curves.

**The use of the 1993 study to assess damages averted by the levee**

The PPK (1993) study includes a figure that relates damages (estimated using the procedure outlined above) to flood probability. The figure, reproduced here as figure 3.2, can be used as a base from which to assess the losses averted due to the levee for a specific flood.

FIGURE 3.2 TAMWORTH CBD DAMAGES




*Source* PPK (1993, figure 6.1, volume 2)

TABLE 3.1 ESTIMATED ACTUAL COMMERCIAL AND INDUSTRIAL DAMAGES—TAMWORTH CBD

| | *Number of properties* | | *Damage ($ million)[a]* | | |
|---|---|---|---|---|---|
| *Flood event (AEP %)* | *Flood affected* | *Damaged* | *Direct* | *Indirect* | *Total* |
| 5 | 13 | 11 | 0.326 | 0.071 | 0.397 |
| 2 | 383 | 308 | 9.420 | 2.029 | 11.449 |
| 1 | 394 | 394 | 27.805 | 4.959 | 32.764 |
| PMF | 587 | 580 | 47.297 | 8.254 | 55.551 |

a 1993 dollars

*Source* PPK (1993, Table 4.1, Appendix C, Volume 2)

The results could be modified to allow for inflation and, if required, further modified to incorporate any changes to the costing procedure. For example, the indirect (trading) losses could be deducted. A further modification would be to assess if there had been any major changes (increases or decreases) in the number of buildings protected.

The PPK study does not attempt to cost additional losses in detail—for example, those incurred by the emergency services. These are thought to be small in comparison with the direct losses sustained by the inundated commercial enterprises.

It should be noted that a feature of most Australian commercial (and residential) flood loss assessments is that they provide loss estimates in terms of *actual* damage. The more usual procedure used in many overseas administrations is to provide the damages averted in terms of potential loss—clearly a much larger value.

All recent (say post-1985) levee construction in New South Wales has been based on benefit-cost studies comparable to that used for the Tamworth CBD. Thus, assessing the savings for specific floods could be estimated using the studies that were initially provided to justify the levee construction—or in the case of Tamworth—its reconstruction. The cost of the upgrading, both in level of protection and in the quality of construction, of the Tamworth CBD levee in the late 1990s was much reduced because a levee already existed.

## BACKGROUND TO THE 2001 STUDY

The merit of the 2001 survey was that the field time to provide the basis for assessment was the equivalent of two person-days, with about three person-days for analysis. The style of the reconnaissance survey was possible because a suitable detailed hydrological survey in map form was available from the PPK (1993) report (figure 3.1).

**Methodology for the 2001 study**

The field survey included recording information for all the individual commercial and industrial premises in the CBD. In detail, the survey included the area from Roderick Street in the east to Darling Street in the west and was to the level of the PMF as given in the PPK study.

The information recorded for each enterprise was:

- Location—street (and number where available);
- an estimate of size of the enterprise;
- type of enterprise (later classified according to ASIC);
- an estimate of the value category of the enterprise; and
- an estimate of the height of floor level above ground level.

Additional information on these data is given below.

***Location—Street and Number***

Street numbers are only infrequently available for most enterprises in the CBD. Location could, however, be determined with reasonable accuracy in relation to the street intersections that were also noted in the survey. This enabled the position of individual enterprises to be determined with reasonable accuracy from the large-scale (1:4000) maps made available by Tamworth City Council. Individual enterprises could also be located on the detailed flood maps available in the PPK Report.

***Size***

Earlier background studies associated with ANUFLOOD established a methodology for dealing with size of commercial enterprises. Buildings were classified into three categories.

- Small (size 1) corresponds approximately to the average shop with a floor area less than about 190m$^2$.
- Medium (size 2) represents a floor area between approximately 190m$^2$ and 650m$^2$. This corresponds to the size of a small supermarket.
- Large (size 3) is for enterprises in excess of 650m$^2$. In these cases, the floor area is estimated in square metres, usually by pacing out the dimensions of the building.

Problems do occasionally occur—for instance, when unroofed areas are a part of the enterprise. However, the procedure to estimate size is thought to represent a useful balance between the considerable effort required to assess accurately the floor area of every enterprise and the accuracy of the damage assessment. It is however, important that the floor area of large category enterprises is determined with reasonable accuracy. This is because such 'superstores' can contribute a very large proportion of the flood damage.

### *Type of enterprise*

These were noted as a brief (usually one or two word) description such as 'supermarket', 'bank', 'hairdresser women' etc. After the field survey was complete, these were converted to ASIC code numbers. These code numbers provide a profile of the commercial and industrial composition of the area concerned.

The ASIC is an internationally-based code to describe (among other things) building use by the use of four numbers. The numbers given in this report are based on the ASIC given in ABS (1983). It provides a simple way of describing the use of commercial and industrial buildings.

### *Value Class*

This was assessed on a scale from 1 (low value) to 5 (high value). The value is a subjective estimate of the likely loss that would be sustained if the building were inundated by floodwaters. The alternative is for value class to be determined on the basis of the ASIC code number. However, even a brief field inspection allows for variations within a single value class. For example, a dress shop can have a few high value items or consist of hundreds of garments on racks. Field assessment permits such differences within a single ASIC class code to be better defined.

The stage-damage curves used for flood loss assessment are based on a combination of size and value class.

### *Floor Elevation*

As surveyed floor heights are rarely available for commercial and industrial buildings, the standard procedure is to assess floor height from available contour information. This was the case for the Tamworth CBD, where the ground height maps were of high quality with detailed contours. In Tamworth, most commercial enterprises are of 'slab on ground' construction and it can be assumed that floor heights correspond to ground level. However, there are always exceptions where, for various reasons, floor level is significantly above ground level. These are relatively few in Tamworth, but where the floor level was 'raised', it was noted on the survey forms. Floor level was estimated by eye to the nearest 0.25 metres.

In other Australian locations, especially where there is a long history of flooding, it is more common for floor levels to be raised. This is sometimes due to council building regulations that recognise flood risk or because the owners are aware of the risk. This is illustrated by the buildings in Taminda.

TABLE 3.2 CLASSIFICATION OF TAMWORTH CBD COMMERCIAL AND INDUSTRIAL ENTERPRISES BY SIZE

| *Size* | *Total* | *Below 100-year ARI flood* |
|---|---|---|
| Small (size 1) | 338 | 273 |
| Medium (size 2) | 43 | 38 |
| Large (size 3) | 6 | 3 |
| *Totals* | *387* | *314* |

*Source* Smith & Gissing (2001b, table 2)

## RESULTS OF THE BUILDING SURVEY FOR TAMWORTH CBD

The results of the survey are outlined below. The use of the results for flood loss estimation is discussed in a later section.

### Number of buildings

The topography of the CBD is that of a relatively flat floodplain backed by a sharp break of slope. It was therefore, relatively easy to define the line of the PMF during the course of the survey. The exact position of the 100-year ARI flood line was less obvious, but errors in allocating premises liable to 100-year ARI flooding are thought to be small.

The total number of commercial and industrial enterprises in the survey area to the level of the PMF was 387. There were no residential buildings. The 387 included 29 premises that were empty at the time of the survey. All enterprises in shopping arcades were included individually in the survey.

Of the 387 premises, 314 were below the level of the 100-year ARI flood.

### Size of premises

The size category was noted for each enterprise listed in the survey. The results are given in table 3.2.

### ASIC classification

A summary of the results based on the ASIC code is given in table 3.3, restricted to the first or second digit of the code. This form of presentation provides a simple description of the overall pattern of commercial activity in the CBD.

Approximately half of the enterprises were engaged in wholesale or retail trading (including all forms of vehicle sales, spare parts etc). A further 20 per cent provided services ranging from cafes to government agencies dealing with the public. Manufacturing (broadly equivalent to ‘industrial’) is limited to only eight establishments.

TABLE 3.3 USE OF PREMISES IN THE CBD (BASED ON THE ASIC CODE)

| *ASIC code* | *Industry* | *Number* | *Percentage of total* |
|---|---|---|---|
| 2 | Manufacturing | 5 | 1.3 |
| 3 | Manufacturing | 3 | 0.8 |
| 47 | Wholesale Trade | 16 | 4.1 |
| 48 | Retail | 171 | 44.2 |
| 52 | Services | 3 | 0.8 |
| 6 | Finance & Offices | 85 | 22.0 |
| | Services & Public Admin. | 10 | 2.6 |
| 9 | Entertainment | 5 | 1.3 |
| | Pubs, Cafes, etc. | 40 | 10.3 |
| | Personal Services | 20 | 5.1 |
| | Empty | 29 | 7.5 |
| *Totals* | | *387* | *100.0* |

*Source* Smith & Gissing (2001b, p. 8)

TABLE 3.4 CLASSIFICATION OF THE TAMWORTH CBD COMMERCIAL AND INDUSTRIAL PREMISES BY VALUE CLASS

| *Value Class* | *Number* | *Percentage* |
|---|---|---|
| 1 (low) | 3 | 0.8 |
| 2 | 231 | 59.6 |
| 3 | 111 | 28.7 |
| 4 | 13 | 3.4 |
| 5 (high) | 0 | 0 |
| Empty | 29 | 7.5 |

*Source* Smith & Gissing (2001b, p. 9)

Such a profile of activities is to be expected for an active regional centre.

### Value class

The value classes assessed in the field are given in table 3.4.

The mean weighted value class for those of size 1 (small) was 2.4, excluding the empty premises.

## COMPARISONS WITH THE PPK SURVEY

### Number of properties

The PPK survey estimated that there are 587 properties at risk from the PMF and 394 at risk from the 100-year ARI event (table 3.1). The corresponding numbers for the 2001 survey are 387 and 313.

The number of properties at risk from the 100-year ARI event are similar between the two surveys, given slight variations in the boundaries used for the CBD and changes of ownership etc. However, there is a much wider discrepancy for the number at risk from the PMF.

This difference is thought to result from the methods used in the PPK damage survey. Field inspection of properties was used only to the level of the 100-year ARI event. For those located between the 100-year ARI and the PMF, the numbers were taken from the 1 to 4000 cadastral maps made available by Tamworth City Council. Such maps show property blocks, but not buildings. The over-estimation of buildings using property maps is a common fault in earlier damage studies. This also applies to the use of air photos to assess the number of commercial enterprises. In this case, large numbers of individual trading entities are housed under one roof 'footprint', as is the case for the arcades in the Tamworth CBD.

It is considered that the methods and number used in the 2001 survey are superior to those employed in the 1993 study.

**Size**

The PPK study states that damage estimates were based on floor area. However, no detail is given as to how these were ascertained.

**Value class**

Three value classes were used.

## DAMAGE ESTIMATION

There are essentially two approaches to the estimation of flood damage. These are:

- computer-based analysis; and
- reconnaissance methods.

*Computer-based analysis* considers each building in relation to floor height for a range of flood depths. Direct losses are estimated using stage-damage curves appropriate to each building class (floor area and value class). These losses are then adjusted in relation to available warning time and prior flood experience to estimate actual loss. The resulting estimates for actual direct damage are then modified to allow for additional indirect losses.

In Australia, the first application of computer-based assessment used the ANUFLOOD program developed in the early 1980s. Subsequently, others have used similar methods. That employed by PPK in their 1993 study is termed URBLOSS.

*Reconnaissance methods* are similar in style to those described as computer-based, but are much less demanding in time, and therefore, cost. A case can be made for the use of reconnaissance methods in order to obtain a list of priorities for additional mitigation measures. Those areas with a high priority could then be subject to the more detailed computer-based methods.

Such techniques could, perhaps, also be of use to obtain a rapid appraisal of the losses sustained from an actual flood or, as in the case for the Tamworth CBD, an estimate of the damages avoided due to mitigation methods.

The first detailed study of a Rapid Appraisal Method (RAM) was published in May 2000 (VDNRE, 2000). This was designed to provide '…a methodology for the rapid and consistent evaluation of floodplain management measures in a benefit cost analysis framework' (VDNRE 2000, p. 1).

The study reported here for Tamworth represents a slightly different approach to a reconnaissance flood survey.

Whichever approach is taken, it is clear that there is a need for more attention to the stage-damage curves that are used for commercial and industrial buildings. Very few studies undertake the work necessary to establish such damage functions and most rely on modifying very much earlier accounts from the ANUFLOOD studies.

Neither approach will produce satisfactory results in the absence of detailed hydrological studies on magnitude, frequency and extent of flooding.

## DAMAGES BASED ON THE 2001 SURVEY

The damage estimates given here are restricted to those for a 100-year ARI event and are used to illustrate the method. Losses for floods of other recurrence intervals could be obtained using a similar approach. The method, as applied, did not involve the use of computer programs designed to evaluate damage. It is, therefore, a simple application of a reconnaissance or rapid assessment technique.

### Flood depth

Visual inspection of the map, reproduced here as figure 3.1, and the 1:4000 topographic map of the CBD indicated that the average depth of over-floor flooding for a 100-year ARI flood throughout the CBD would be approximately 0.5 metres. Allowance was made for the small number of buildings that had raised floor levels.

### Stage-damage curves

The curves used were those from earlier ANUFLOOD surveys as given in Smith (1994). The stage-damage curves are for small, medium and large size enterprises adjusted to allow for the five value classes used in the field survey. They are reproduced in table 3.5.

### Value classes

For the small (size 1) enterprises the value class was taken as 2.4, which is the weighted mean for all small premises.

For medium (size 2) enterprises, the distribution of value classes is shown in table 3.6.

There were three large (size 3) enterprises. All were value class 3 and the appropriate damage in $/m² was interpolated from table 3.5.

TABLE 3.5 POTENTIAL DIRECT STAGE-DAMAGE CURVES FOR COMMERCIAL PROPERTIES

| | *Value class*[a] | | | | |
|---|---|---|---|---|---|
| *Over-floor depth (m)* | *1* | *2* | *3* | *4* | *5* |
| **Floor area < 186m²** | | | *($)* | | |
| 0.00 | 0 | 0 | 0 | 0 | 0 |
| 0.25 | 1 755 | 3 510 | 7 020 | 14 040 | 28 080 |
| 0.75 | 4 388 | 8 775 | 17 550 | 35 100 | 70 200 |
| 1.25 | 6 581 | 13 162 | 26 325 | 52 650 | 105 300 |
| 1.75 | 7 313 | 14 625 | 29 250 | 58 500 | 117 000 |
| 2.00 | 7 750 | 15 502 | 31 005 | 62 010 | 124 020 |
| **Floor area 186m² to 650m²** | | | *($)* | | |
| 0.00 | 0 | 0 | 0 | 0 | 0 |
| 0.25 | 5 558 | 11 115 | 22 230 | 44 460 | 88 920 |
| 0.75 | 13 455 | 26 910 | 53 820 | 107 640 | 215 280 |
| 1.25 | 20 475 | 40 950 | 81 900 | 463 800 | 327 600 |
| 1.75 | 22 668 | 45 338 | 90 675 | 181 350 | 362 700 |
| 2.00 | 24 131 | 47 263 | 96 525 | 193 050 | 386 100 |
| **Floor area > 650m²** | | | *($/m²)* | | |
| 0.00 | 0 | 0 | 0 | 0 | 0 |
| 0.25 | 3 | 6 | 13 | 25 | 50 |
| 0.75 | 16 | 32 | 65 | 126 | 253 |
| 1.25 | 33 | 66 | 133 | 265 | 530 |
| 1.75 | 54 | 109 | 218 | 435 | 870 |
| 2.00 | 65 | 130 | 260 | 520 | 1 040 |

*Notes* The dollar values are in 1993 values. They were increased by 20 per cent to allow for inflation for use in the damage assessment in table 3.6.

a Value class relates to the enterprise's susceptibility to flood damage with 1 = very low and 5 = very high.

*Source* Smith (1994), BTE (2001, p. 67)

TABLE 3.6 ESTIMATE OF CBD POTENTIAL DIRECT DAMAGE USING ANUFLOOD STAGE-DAMAGE CURVES

| | | *Average damage*[a] | *Total damage* | |
|---|---|---|---|---|
| *Value class* | *No. buildings* | *($/building)* | *($'000 1993)* | *($'000 2000)*[b] |
| **Size 1** | | | | |
| 2.4 | 273 | 10 200 | 2 784.6 | 3 341.5 |
| **Size 2** | | | | |
| 1 | 1 | 10 000 | 10.0 | 12.0 |
| 2 | 23 | 20 000 | 460.0 | 552.0 |
| 3 | 12 | 40 000 | 480.0 | 576.0 |
| 4 | 2 | 80 000 | 160.0 | 192.0 |
| *Sub-total* | *38* | | *1110.0* | *1332.0* |
| | *Square metres* | *($/m$^2$)* | | |
| **Size 3** | | | | |
| 3 | 11 500 | 50 | 575.0 | 690.0 |
| **Total** | | | **4 469.6** | **5 363.5** |

a Damage figures interpolated from table 3.5 for over floor depth of 0.5 metres.

b Updated to 2000 prices using a factor of 1.2.

*Source* Smith & Gissing (2001b, p. 12)

### Damage estimates for the 100-year ARI flood

The flood depth for all properties at Tamworth was taken as 0.5 metres, which represents the average depth for all buildings subjected to the 100-year ARI event. The damage costs were interpolated from table 3.5 and updated for inflation.

As stressed throughout this report, there is a pressing need for updated stage-damage information for the commercial sector. The updated ANUFLOOD values are used to illustrate the method. The same values, with differing assumptions regarding updating, are used in the PPK study and in the RAM method, which are described below.

### Actual direct damage

The potential value needs to be adjusted to give an estimate of actual direct damage. The estimate of actual value allows for flood warning time and prior flood experience of those at risk. The longer the warning time and the more the experience, the smaller will be the actual direct damage.

An appropriate ratio of actual to potential damage for Tamworth (without the levee) would be 0.6. The concept was outlined earlier. Details are given in VDNRE (2000) and follow initial work in this area described in Smith and Handmer (1986).

This estimate of the ratio is for a situation without a levee in place. With levee protection, the effects of prior flood experience would, over-time, be reduced. This is a critical factor in evaluating the losses that are averted once levee protection is in place. In assessing the damages averted by such structural measures, there is a case for providing a value for damages averted that only allows a small value for prior flood experience. This problem applies whatever method of damage assessment is employed. The ratio of 0.6 used above would be inappropriate where the effects of flood experience has become minor; a more suitable value might be 0.8.

A ratio of 0.6 gives an actual direct damage total for a 100-year ARI event for the CBD as $3.2 million in 2000 prices.

## DAMAGES BASED ON THE RAPID APPRAISAL METHOD (RAM)

The 2001 survey of Tamworth also provided the opportunity to compare the method established in BTE (2001) with the RAM method as presented in VDNRE (2000).

The RAM field survey for commercial and industrial flood damage is restricted to counting the number of small to medium size non-residential buildings in the flood-prone area. For larger buildings (area greater than 1000m$^2$) the floor area is estimated and they are allocated to one of three value classes.

A damage value of $22 500 is allocated to all smaller non-residential buildings. This is an estimate of potential direct damage that does not include clean-up costs.

Losses to larger non-residential buildings are based on ANUFLOOD damage data but increased by 60 per cent, of which about half is to allow for the effects of inflation on the latest published ANUFLOOD values (Smith, 1994). Indeed, the VDNRE (2000, p. 19) states that '… where the analyst can readily compute the damages, it is suggested that ANUFLOOD be used but that changes be increased for a further 60 per cent'. Alternatively, the RAM recommends that the following damage values are used—a low value class of $45/m$^2$, medium at $80/m$^2$ and a high value estimate of $200/m$^2$.

In applying the RAM to the Tamworth survey data, it is assumed that all size 1 enterprises correspond to the less than 1000m$^2$ class. The size 2 and size 3 buildings losses are based on the $/m$^2$ values for the appropriate class described above.

The RAM assumes that an over-floor flood depth of 0.3 metres applies to all locations.

The potential direct damages, using the RAM, for the Tamworth CBD are outlined in table 3.7.

TABLE 3.7 ESTIMATE OF CBD POTENTIAL DIRECT DAMAGE USING THE RAM

| *Size category* | *No. of buildings* | *Total area ($m^2$)* | *Damage ($)* | *Total damage[a] ($'000)* |
|---|---|---|---|---|
| 1 | 273 | | 22 500 | 6 142.5 |
| | | | *($/$m^2$)* | |
| 2[b] | 24 | 24 000 | 45 | 1 080.0 |
| | 12 | 12 000 | 80 | 960.0 |
| | 2 | 2 000 | 200 | 400.0 |
| *Sub-total* | 38 | 38 000 | | 2 440.0 |
| 3 | 3 | 11 500[c] | 80 | 920.0 |
| **Total** | **314** | | | **9 502.5** |

a 2000 prices

b All size 2 properties are assumed to have a floor area of 1000 $m^2$.

c Total floor area from table 3.6.

*Source* Smith & Gissing (2001b, p. 13-14)

The RAM (VDNRE 2000, p. 20) then modifies the potential direct damage to allow for the effects of warning time and prior flood experience. The appropriate ratio of actual to potential damages for Tamworth is estimated to be 0.6 as above, giving an actual direct damage loss of $5.7 million.

### Discussion of RAM

The RAM certainly provides a quick method of assessment. The basic shortcoming is that only a single flood depth is used to estimate loss. The depth of over-floor inundation selected for the method is 0.3 metres. This may be appropriate for rapid assessment in much of Victoria, but is not a suitable method for locations that have a high flood range. For instance, the height range for the Hawkesbury-Nepean region from bank-full to the 100-year ARI flood is well in excess of 10 metres.

The VDNRE report compares the results of the RAM to more detailed flood damage surveys that have been undertaken in Victoria. However, none of the examples involve the flooding of a relatively large number of commercial or industrial buildings. The RAM also applies to agricultural flood losses and the comparison to actual examples of this kind seems acceptable, albeit the depth of inundation in much of Victoria is relatively small.

The VDNRE report again highlights the paucity of good quality information on stage-damage curves for commercial and industrial premises. Although it uses modified ANUFLOOD data, these data were collected many years ago, and at the time the ANUFLOOD manual recommended that new stage-damage curves should be obtained for differing locations.

## DAMAGES ESTIMATED IN THE PPK SURVEY

The results of the 1993 PPK damage survey for the commercial and industrial sectors of the CBD are given in table 3.1.

The direct damage for a 100-year event is estimated to be $27.8 million. This estimate is for actual direct damage at 1993 values.

If the estimate is updated for inflation, the value is closer to $33 million. This is very different from the value obtained in the 2001 survey reported here. The difference is mainly due to the values ascribed to the unit area damage. At a height of 1.2 metres, the PPK value class damages are approximately $100, $250 and $400/m$^2$ (at 1993 values).

## OTHER BENEFITS AND COSTS

A levee also reduces the costs of infrastructure repair (e.g. roads, culverts etc) and enables provision of emergency services. Where levees have been in place for some years, it is not possible to provide reliable estimates of such savings—as is the case for the Tamworth CBD.

There are, however, additional costs that arise from levee protection. Of these, the major one is the maintenance of the structures—necessary even in flood-free years. The PPK report (1993, p. 39) estimates the annual costs to be $160 000 in 1993 prices. Throughout Australia, the maintenance costs for structural flood mitigation works are the responsibility of local government. If such structures were damaged by flood action, the repair costs would be met under the NDRA.

An additional complication is that the presence of a levee can sometimes cause local drainage and stormwater to back-up behind the protective structure. This is the case with the Tamworth CBD levee. The flood of November 2000 did not cause over-floor inundation of buildings, but it did require the use of temporary pumps to discharge the water into the main river. The pumps were supplied by the Tamworth City Council and the City and Bush Fire Brigades. It was not possible to obtain the costs of providing the pumps.

Levee provision can lead to other costs that are even more difficult to assess. There are costs due to an increase in potential damage that would result from floods that exceed the design limit of the levee or that cause levee failure at heights below the design limit. This potential is enhanced both by new developments in the 'protected zone' and by the loss of flood experience that causes increases in the ratio of actual to potential damage.

Finally, there is the problem of enhancement of land values once levee protection is provided. It is difficult to find studies that provide information and guidance on this type of benefit. It is mentioned in the PPK study (1993, p. 38) but without any firm statement about what such benefits might be.

## ESTIMATION OF DAMAGE—SUMMARY

The discussion of the three approaches is limited to potential and actual direct losses. The question of additional indirect losses is omitted here because of the account given on this topic in BTE (2001). There are also minor differences on whether or not clean-up is included in the various estimates.

### Computer-based damage assessment

This is clearly superior in that each enterprise is considered in detail for over-floor depth. It is recommended for use when a detailed hydrological study is available, as was the case for Tamworth in the 1993 report. Indeed, such methods that can speedily assess damages at a range of heights provide values for average annual damage, and can consider a range of mitigation options appropriate to any urban area with a major flood problem.

The computer-based approach has been employed for a large number of flood-prone towns in New South Wales, which are well over 50 in number.

### The reconnaissance method

The style of field survey adopted in the 2001 survey is considered the best blend of speed and classification of premises by size and value class. Further, this form of survey could be used for later detailed computer assessment (with ANUFLOOD, URBLOSS or other similar methods), or for a quick assessment of damage that employs much less sophistication as regards hydrological information; for instance, for a quick one-off survey to assess damage from a specific flood event.

### Shortcomings.

As stressed above, whichever method is used, there is a need for better information on the stage-damage curves employed to assess commercial and industrial losses. Ideally, these would be specific for each local area. In practice, they are likely to be based on more general stage-damage curves.

Middlesex University (in the UK) has worked in this field for many years and produced stage-damage curves for differing uses (for which the ASIC code could act as a guide). However, these published tables from Middlesex University have their limitations, mainly due to variation of losses within classes. Caution should be used in transferring the Middlesex University data to Australian conditions. The UK commercial and industrial stage-damage curves were first described in Penning-Rowsell and Chatterton (1977), and later updated in Parker et al (1987) and in FLAIR (1990). Recent background to the inadequacies of residential, commercial and industrial stage-damage curves in Australia is given in Blong (2001).

The recommendation is that further research be undertaken to provide updated stage-damage curves for commercial and industrial enterprises. The aim would be to provide a set of curves that could be used (perhaps with local modification) throughout Australia. If this is undertaken, the combination of size and value class used in the Tamworth survey of 2001, and basic to the ANUFLOOD approach, could form a valuable framework.

In short, the major deficiency is that the stage-damage curves for the various cells in table 3.5 require further work.

## CONCLUSIONS OF CBD SURVEY

The original aim of the Tamworth CBD study was to assess the losses averted by the levee for the flood of November 2000. It transpired that the magnitude of that flood would not have caused damage in the protected area, even without a levee in place.

The proposed approach was changed to undertake a reconnaissance survey of the commercial area to illustrate the potential of quick field surveys that could be used to assess losses from recent floods. This was undertaken and the results compared with those that would be obtained by applying the Rapid Appraisal Method (RAM) outlined in the VDNRE study (VDNRE 2000). A number of shortcomings of the RAM approach were described.

Comparisons of the work undertaken in 2001, RAM and the initial study by PPK for Tamworth (PPK, 1993) all highlight the need for improved—and ideally, widely applicable—stage-damage information for differing types of commercial and industrial enterprises.

In NSW, the assessment of the savings from specific floods due to damage reduction by structural works is best undertaken by using the floodplain management studies that exist for the majority of major flood-prone communities in that State. However, the large difference between the 2001 survey and the PPK results suggests some caution is required.

For other States, the available data are often much less precise and a modified form of reconnaissance survey used in Tamworth could perhaps be employed. However, for comparability, improved stage-damage curves would be required.

The question of additional losses due to indirect effects remains a difficult problem, but guidelines for their estimation are given in BTE (2001). This applies especially to commercial and industrial losses. There is much more damage data for residential losses, although a more consistent approach to these between different studies would be of value in obtaining comparable assessments for different localities.

# CHAPTER 4 CONCLUSIONS

An upper estimate of the damage costs of the flood in Taminda in November 2000 is $493 500 if a local perspective is taken. From a national perspective, the damage cost is estimated to be at least $280 000. The Taminda flood was small (about a 10-year ARI event). Damage would increase substantially for deeper floods.

Businesses made good use of the warning time available to them. Shifting of stock and equipment above expected flood levels resulted in an estimated reduction in direct losses of $781 000 (84 per cent).

The CBD survey illustrated the potential use of the reconnaissance method to obtain fast estimates of flood damage. The survey highlighted the need for improved and widely applicable stage-damage curves for commercial and industrial enterprises.

The CBD survey results were consistent with results obtained using the RAM, which is not surprising since both methods are based on ANUFLOOD stage-damage curves. There were significant differences between the results of the survey with those obtained by PPK. The PPK results implied higher costs per square metre than either the reconnaissance method or the RAM. This could be due to deeper over-floor flooding estimated by PPK. However, there is insufficient detail in the PPK report to be certain on this point.

Unlike the Taminda results, the large difference between the 2001 survey and the PPK results suggests the need for caution if extrapolation of the 2001 survey results to deeper floods using the PPK results is required. Overall, the results suggest that previous floodplain management studies in New South Wales may be a reliable source for fast assessment of flood damage costs in that State. The reconnaissance method provides a low-cost method of assessing whether previous studies are still representative of current conditions. In other States and Territories, the reconnaissance method could provide a low-cost method of quickly assessing flood damage costs to commercial and industrial enterprises. However, any method of damage estimation depends on reliable stage-damage curves.

## REFERENCES


ABS 1983, *Australian Standard Industrial Classification*. Cat No. 1202.0, 2 volumes. Canberra.

ABS 2001a, *Average Weekly Earnings, Australia*, Cat No. 6302.0, Canberra.

ABS 2001b, *Summary of Industry Performance, Small and Medium Businesses*, Cat No. 8142.0.55.002, Canberra.

Blong, R. 2001 (in press), *Estimating flood damage*. In. Smith D.I. & Handmer J.W. (eds). Residential Flood in Australia.

BTE 2001, *Economic Costs of Natural Disasters in Australia*, Report 103, BTE, Canberra.

FLAIR 1990, *Flood Loss Assessment Information Report*, Flood Hazard Research Centre, Middlesex Polytechnic, UK. (378p (by A. N'Jai, S. M. Tapsell, D. Taylor, P.M. Thompson and R. C. Witts)

Parker, D.J., Green C.H.J. and Thompson, P.M. 1987, *Urban Flood Protection Benefits: A Project Appraisal Guide*, Gower Technical Press, Aldershot.

Penning-Rowsell, E. C. and Chatterton, J.B. 1977, *The Benefits of Flood Alleviation: A Manual of Assessment Techniques*. Farnborough: Saxon House.

PPK 1993, *Tamworth City Council: Floodplain Management Plan*, (2 volumes), PPK Consultants Pty. Ltd.

Smith, D.I. 1994, 'Flood damage estimation—A review of urban stage-damage curves and loss functions', *Water South Africa*, vol. 20, no. 3, July, pp. 231-238.

Smith, D.I. & Gissing, A. 2001a, *Damage Survey; Taminda Industrial Estate – April 2001*, CRES ANU, Canberra.

Smith, D.I. & Gissing, A. 2001b, *Damage Survey; Tamworth Central Business District (CBD)*, CRES ANU, Canberra.

Smith, D.I. & Greenaway, M.A. 1984, *Commercial and Industrial Flood Damage: Case Study for the Taminda Estate – Tamworth NSW*, CRES Working Paper 1984/14, CRES, ANU, Canberra.

Smith, D.I. and Handmer, JW (eds) 1986, *Flood Warnings in Australia: Policies, Institutions and Technologies,* CRES, ANU, Canberra.

Taylor, J., Greenaway, M.A. and Smith D.I. 1983, *ANUFLOOD: A Programmer's Guide and User's Manual,* CRES, ANU, Canberra.

VDNRE 2000, *Rapid Appraisal Method (RAM) for Floodplain Management.* Melbourne: Victorian Department of Natural Resources and Environment, Prepared by Read Sturgess and Associates, Melbourne.

Water Studies 1990, *The Costs of Flooding: Nyngan, April 1990,* Water Studies Pty. Ltd. Sydney, NSW Department of Water Resources.

## ABBREVIATIONS

| | |
|---|---|
| ABS | Australian Bureau of Statistics |
| AEP | annual exceedance probability |
| Ann. turn. | average annual turnover |
| ANU | Australian National University |
| ARI | annual recurrence interval |
| ASIC | Australian Standard Industrial Classification |
| AWOTE | average weekly ordinary time earnings |
| BTE | Bureau of Transport Economics |
| CBD | central business district |
| Clean. mat. | clean-up materials |
| Clean/rest | clean-up and restoration |
| CRES | Centre for Resource and Environmental Studies |
| D | days |
| Dam. stock | damaged stock |
| Dam. equip. | damaged equipment |
| Dam. fabric | damaged fabric |
| Days T L | days of trading lost |
| Diff. | difference |
| DLWC | New South Wales Department of Land and Water Conservation |
| F | false |
| m | metre |
| $m^2$ | square metre |
| NDRA | natural disaster relief arrangements |
| n/g | not gathered |
| PMF | probable maximum flood |
| Prep. | preparation |
| RAM | rapid appraisal method |
| S & E | stock and equipment |
| SES | State Emergency Service |
| St. No. | street number |
| T | true |
| VDNRE | Victorian Department of Natural Resources and Environment |
| WOF | water over floor |

# APPENDIX I QUESTIONNAIRE USED IN THE 2001 SURVEY

No.…….

**TAMWORTH COMMERCIAL DAMAGE QUESTIONNAIRE**

**SITE INFORMATION**

1. **Address, name and position of respondent**

2. **Estimate of floor area ($m^2$)**

   **If multiple buildings list separately**

3. **Building Use**

   **Description**

   **ASIC Code**

4. **Length of Occupation this Site**

   **Comments re previous flood experience (if possible dates and over-floor depth**

**FLOOD MITIGATION MEASURES**

5. **Building design** (to avoid shallow over-floor flooding)

6. **Temporary measures** (sandbagging, temp. flood-proofing)

7. **Pre-Flood Action Plan** (If YES, brief description)

## FLOOD WARNINGS

8. **How received?**

9. **Situation for flood of November 2000**

10. **How useful** (Comments re possible improvements)

## DIRECT DAMAGES

11. **Losses to stock, raw materials** (Best estimate in dollars)

12. **Losses to equipment** (If possible separate out, ie vehicles, computers, machinery etc)

13. **Losses to building fabric** (if possible from invoices for cost of repair)

## DAMAGE REDUCTION

14. **Estimates of damage avoided by all reduction measures** (breakdown by type if possible, ie vehicles, stock, machinery etc)

15. **Cost of these measures** (Especially no. of person hours)

16. **Clean-up costs**

17. No. person hours/days, who were they

18. Were commercial clean-up staff used (If so cost)

19. Estimate costs of clean-up material

**20. <u>Trading time lost</u>** (Likely in working days)

**21. <u>Trading partially affected</u>** (This will require discussion, eg not all stock available)

**22. <u>Perception of trade lost to competitors</u>** (either short-term or long-term)

## OTHER ADVERSE EFFECTS

(Some headings listed, there may be other comments)

**23. <u>Outage time</u>** (electricity, water, phones, road access)

**24. <u>Other comments</u>**

## INSURANCE

**25. <u>Were any losses covered by insurance</u>** (If YES, try and get amount received)

(is insurance for all branches of the firm or for this site only)

**26. <u>Cover only for direct losses of contents/stock</u>**

**27. <u>Cover includes building fabric</u>**

**28. <u>Cover includes clean-up</u>**

**29. <u>Cover includes business interruption</u>** (if so try for details of length etc)

**30. <u>Has insurance been specifically refused because of flood risk</u>**

**31. <u>Has premium been increased because of flood risk</u>**

## ADDITIONAL INFORMATION

**32. <u>Estimate of weekly or annual turnover</u>**

**33. <u>Assistance with damage reduction or clean-up from SES/Council</u>**
(If so details)

**34. <u>How could losses be better reduced for future events of similar magnitude</u>**

**35. <u>Comments on problems of a floodprone location</u>**
(Has the enterprise considered moving because of floods)

**36. <u>Would the enterprise be prepared to contribute to the costs of a levee</u>**, likely via rates increase?

## COMMENTS NOT COVERED BY ANY OF THE ABOVE QUESTIONS

## APPENDIX II DATA FROM THE TAMINDA SURVEY

Data collected during the survey were stored in a spreadsheet. The data are reproduced in table II.1.

**Guide to individual questions.**

A guide to the columns, numbered 1 to 28, on the spreadsheet is given below. Figure 2.2 shows the approximate location, with the code numbers used in the spreadsheet, for the surveys of 1984 and 2001.

**2 to 5. Site, code number and location.**

The name of the enterprise was recorded in the spreadsheet in column 1, but is not reproduced in table II.1. The 2001 survey code number is recorded in column 2 and the 1984 survey code number in column 3. The road name and street number are given in columns 4 and 5 respectively. As is commonly the case with commercial and industrial enterprises, street numbers are rarely used and are only listed where the number was prominently displayed.

**6. ASIC number.**

This is a four-figure code taken from the Australian Standard Industrial Classification (ABS 1983). It corresponds to an internationally agreed code and provides a convenient description of the use of all enterprises.

The use (using the first two code numbers) for the 1984 and 2001 surveys are given in table 2.1.

**7. Size in square metres.**

This is for the covered area of the building. Minor problems occur when outside, on-ground areas are used for storage of timber or bulky, weatherproof items such as steel or gravel.

**8 and 9. Over-floor flood depth**

Depths of water over-floor (WOF) for the 2000 flood (8) and the 1984 flood (9) in metres. The floor level used was that for the main area of the enterprise.

**10. Difference in over-floor depth 1984 less 2000**

In cases where the 2000 depth was given as greater than 1984 the values are negative, eg –0.1 etc. Where the building is new, (that is, it was not included in the 1984 survey) column 10 is left blank.

**11. Preparation time**

Time taken to prepare for flood reduction measures, most frequently lifting stock and equipment. This is given in person-hours, with a working day taken to be eight hours.

**12. Clean-up and restoration time**

Time for clean-up and to replace stock and equipment after the flood has receded, in person hours. In most cases the staff involved in the clean-up were the normal staff of the enterprise, occasionally with the addition of extra staff, see 13 below. In no case were specialist commercial clean-up firms used.

**13. Extra clean-up staff**

This is the cost, in dollars, of hiring additional staff, either trades persons or casual assistance.

**14. Cost of clean-up materials.**

Direct cost of cleaning materials, in dollars.

**15. Damage to stock.**

Damage to stock, in dollars.

**16. Damage to equipment.**

Damage to equipment, in dollars.

**17. Damage to building fabric.**

This includes the costs of repairing driveways and gravel surrounds, in dollars. For the flood of November 2000 damage to actual building fabric was insignificant.

**18. Days lost to trading.**

Days lost to trading.

**19. Savings to stock and equipment.**

Savings to stock and equipment, in dollars, from damage reduction measures. There is a query with savings to vehicles. In most cases these were not included in the savings. This was because the respondents considered such savings as self-evident. However, the specialist vehicles, such as fork-lifts, were included.

**20. Estimate of total value of stock.**

This was the respondents estimate of the total value of stock on site. In most cases these estimates are thought to be reasonably accurate.

**NOTE**: in those cases where respondents could only estimate stock plus equipment as a single value, the combined total is given in Column 22.

**21. Estimate of total value of equipment**

In most cases these were given in terms of replacement cost, ie new for old, rather than as an estimate of average remaining value. There was considerable uncertainty with some respondents but it is thought that the higher values are likely to be reasonable good quality estimates.

**NOTE**: in those cases where respondents could only estimate stock plus equipment as a single value, the combined total is given in Column 22.

**22. Total stock and equipment**

In the majority of cases the combined value of stock and equipment is the sum of columns 20 and 21, it is in dollars. Where respondents could not list stock and equipment separately the total is given in column 22, with columns 20 and 21 left blank.

**23. Average annual turn-over.**

Turn-over given in dollars. In some cases this was reported as weekly or monthly but for consistency has been reported in annual terms. Experience with similar surveys is that most respondents are willing to give this value but are reluctant to divulge additional information on trading finance. A few of the larger, chain enterprises have a company policy not to divulge turn-over and in a few cases, the respondent did not know the value.

**24. Insurance cover**

'True' (T) indicates that such cover is available, 'false' (F) that it is not. The form of cover can vary however. In all cases where cover is given as 'true', direct flood losses to stock and equipment are included. Small businesses do not have any flood cover. The situation with business interruption is less certain and such cover is likely only available to larger enterprises that are part of a chain. In some cases respondents (who did not suffer loss in November 2000) did not know the situation regarding insurance cover. Where they were a small local firm these are listed as having no cover, ie 'false'. In a small number of cases the situation was unclear and these have been left blank on the spreadsheet.

**25, 26, & 27. Outage time.**

Outage time, in days, for phone, electricity and water respectively. Except for phones, outage time was minimal. The situation with phones was complex, and a number of respondents experienced short outage time immediately after the flood. Mobile phone networks did not operate successfully during the flood – this is thought to be due to over-loading of the system.

**28. Years that the enterprise has been on the site.**

In many cases staff had been there for the same number of years as the enterprise. This is significant in assessing prior flood experience and its role in flood damage reduction.

TABLE II.1 DATA COLLECTED DURING THE TAMINDA SURVEY

| 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *2000 No* | *1984 No* | *Street* | *St No* | *ASIC* | *Size* | *WOF* | *84 WOF* | *Diff* | *Prep* | *Clean/Rest* | *Cleanup Staff $* | *Clean Mat $* | *Dam Stock $* | *Dam Equip $* | *Dam Fabric $* |
| 101 | 105 | Crown | | 3487 | 350 | 0.1 | 0.2 | 0.1 | 12 | 18 | 0 | 80 | 0 | 0 | 0 |
| 102 | | Crown | 2 | 4736 | 247 | 0 | | | 6 | 7.5 | 0 | 0 | 0 | 0 | 0 |
| 103 | | Crown | | 2850 | 337.5 | 0 | | | 0.33 | 0.5 | 0 | 0 | 0 | 0 | 0 |
| 104 | | Crown | | 4864 | 337.5 | 0 | | | 3 | 3 | 0 | 0 | 0 | 0 | 0 |
| 105 | | Crown | | 4861 | 337.5 | 0 | | | 6 | 6 | 0 | 0 | 0 | 0 | 0 |
| 106 | 111 | Crown | | 4728 | 1050 | 0.2 | 0.8 | 0.6 | 30 | 35 | 0 | 500 | 2 000 | 2 500 | 0 |
| 107 | | Crown | | 4745 | 660 | 0.2 | | | 15 | 80 | 0 | 200 | 0 | 0 | 0 |
| 108 | 113 | Crown | 21 | 4731 | 554 | 0.75 | 0.55 | -0.2 | 16 | 40 | 0 | 0 | 1 200 | 300 | 0 |
| 109 | 114 | Crown | | 5713 | 810 | 0 | 0.03 | 0.03 | 16 | 60 | 0 | 0 | 0 | 0 | 50 |
| 110 | 116 | Crown | | 4751 | 700 | 0 | 0.2 | 0.2 | 3 | 0.5 | 0 | 0 | 0 | 0 | 150 |
| 201 | | Barnes | | 4853 | 323 | 0 | | | 20 | 22 | 0 | 0 | 0 | 0 | 0 |
| 202 | | Barnes | | 0206 | 100 | 0 | | | | | 0 | 0 | 0 | 0 | 0 |
| 203 | 110 | Barnes | 9 | 4243 | 141.8 | 0 | 0.08 | 0.08 | 3 | 3 | 0 | 0 | 0 | 0 | 0 |
| 204 | 109 | Barnes | | 4732 | 588 | 0 | 0.01 | 0.01 | 6 | 7 | 0 | 0 | 0 | 0 | 0 |
| 205 | | Barnes | | 0000 | 286 | | | | | | | | | | |
| 206 | | Barnes | 53 | 4728 | 207 | 0 | | | 6 | 6 | | 0 | 0 | 0 | 0 |
| 301 | 202 | Belmore | 4 | 4861 | 319 | 0.33 | 0.8 | 0.475 | 10 | 32 | 0 | 0 | 0 | 0 | 0 |
| 302 | 203 | Belmore | | 4728 | 1680 | 0.2 | 0.6 | 0.4 | 60 | 120 | 500 | 0 | 0 | 0 | 0 |
| 303 | 204 | Belmore | 18 | 4735 | 420 | 0 | 0.06 | 0.06 | 18 | 9 | 0 | 0 | 0 | 0 | 0 |
| 304 | 205 | Belmore | | 4795 | 1250 | 0 | 0 | 0 | 21 | 40 | 0 | 0 | 0 | 0 | 0 |
| 305 | | Belmore | | 4861 | 392 | 0 | | | 16 | 16 | 0 | 0 | 0 | 0 | 0 |
| 306 | 311 | Belmore | 23 | 4731 | 608 | 0.3 | 0.75 | 0.45 | 9 | 112 | 500 | 150 | 1 000 | 0 | 1 500 |
| 307 | 310 | Belmore | | 4745 | 689 | 0 | 0.25 | 0.25 | 8 | 8 | 0 | 0 | 0 | 0 | 0 |

*Source* Smith & Gissing (2001a)

TABLE II.1 DATA COLLECTED DURING THE TAMINDA SURVEY (CONTINUED)

| 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *2000 No* | *1984 No* | *Street* | *St No* | *ASIC* | *Size* | *WOF* | *84 WOF* | *Diff* | *Prep* | *Clean/Rest* | *Cleanup Staff $* | *Clean Mat $* | *Dam Stock $* | *Dam Equip $* | *Dam Fabric $* |
| 308 | | Belmore | | 4861 | 1424 | | | | | | | | | | |
| 401 | | Avro | 24 | 2531 | 580 | 0 | | | 3 | 7 | 0 | 0 | 0 | 0 | 0 |
| 402 | 305 | Avro | 28 | 4242 | 319 | 0 | 0 | 0 | 0.33 | 0.66 | 0 | 0 | 0 | 0 | 70 |
| 403 | 305 | Avro | 28 | 2535 | 798 | 0 | 0 | 0 | 42 | 42 | 0 | 0 | 0 | 0 | 0 |
| 404 | 307 | Avro | 30 | 4861 | 1050 | 0 | 0.1 | 0.1 | 24 | | 0 | 0 | 0 | 0 | 0 |
| 405 | 308 | Avro | 36 | 6336 | 154 | 0 | 0.17 | 0.17 | 5 | 5 | 0 | 0 | 0 | 0 | 0 |
| 406 | 411 | Avro | | 5713 | 2778 | 0 | 0.35 | 0.35 | 100 | 140 | 0 | 0 | 0 | 0 | 0 |
| 407 | 515 | Avro | 29 | 3474 | 420 | 0 | 0.08 | 0.08 | 2 | 2 | 0 | 0 | 0 | 0 | 0 |
| 408 | 514 | Avro | 35 | 3162 | 900 | 0.01 | 0.22 | 0.21 | | | | | | | |
| 409 | 513 | Avro | | 3143 | 700 | 0.4 | 0.6 | 0.2 | 20 | | | | 3 200 | 0 | 0 |
| 410 | 508 | Avro | 31 | 2538 | 608 | 0 | 0.34 | 0.34 | 16 | 16 | 0 | 0 | 0 | 0 | 0 |
| 411 | 507 | Avro | | 4731 | 200 | 0.1 | 0.23 | 0.13 | | 8 | | | | | |
| 412 | 701 | Avro | 12 | 4112 | 2500 | 0.1 | 0.2 | 0.1 | 6 | 6 | | | 2 000 | 15 000 | 0 |
| 413 | 702 | Avro | 14 | 4728 | 1200 | 0.05 | 0.52 | 0.47 | 14 | 35 | | | 0 | 0 | 0 |
| 414 | | Avro | | 4769 | 4380 | 0.25 | | | 44 | 352 | | 500 | 60 000 | 20 000 | 0 |
| 415 | 803 | Avro | | 4861 | 292 | 0 | 0.15 | 0.15 | 4 | 4 | 0 | 0 | 0 | 0 | 0 |
| 416 | 806 | Avro | | 4735 | 450 | 0 | 0.03 | 0.03 | | | 0 | 0 | 0 | 0 | 0 |
| 417 | | Avro | | 5713 | 300 | 0 | | | | | 0 | 0 | 0 | 0 | 0 |
| 418 | 802 | Avro | | 4848 | 450 | 0 | 0.27 | 0.27 | 12 | 48 | 0 | 0 | 0 | 0 | 0 |
| 419 | | Avro | | 6389 | 450 | 0 | | | | | | | | | |
| 420 | 512 | Avro | | 0000 | 310 | | 0.55 | 0.55 | | | | | | | |
| 501 | | Plain | | 4728 | 752 | 0 | | | 24 | 24 | 0 | 0 | 0 | 0 | 0 |
| 502 | | Plain | | 5713 | 836 | 0 | | | 6 | | 0 | 0 | 0 | 0 | 0 |

*Source* Smith & Gissing (2001a)

TABLE II.1 DATA COLLECTED DURING THE TAMINDA SURVEY (CONTINUED)

| 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *2000 No* | *1984 No* | *Street* | *St No* | *ASIC* | *Size* | *WOF* | *84 WOF* | *Diff* | *Prep* | *Clean/Rest* | *Cleanup Staff $* | *Clean Mat $* | *Dam Stock $* | *Dam Equip $* | *Dam Fabric $* |
| 503 | | Plain | | 4728 | 836 | 0 | | | 40 | 40 | 0 | 0 | 0 | 0 | 0 |
| 504 | | Plain | | 4735 | 980 | 0 | | | 36 | | 0 | 0 | 0 | 0 | 0 |
| 505 | | Plain | | 9231 | 200 | 0 | | | | | 0 | 0 | 0 | 0 | 0 |
| 506 | | Plain | | 3162 | 2000 | 0.15 | | | 12 | 24 | 0 | 0 | 0 | 0 | 0 |
| 507 | 101 | Plain | | 4751 | 1320 | 0.01 | 0.08 | 0.07 | 15 | 20 | | | 2 000 | 15 000 | 0 |
| 508 | 102 | Plain | | 4862 | 525 | 0.1 | 0.9 | 0.8 | 10 | 48 | | | 0 | 0 | 1 000 |
| 509 | 102 | Plain | | 2882 | 450 | 0.5 | 0.9 | 0.4 | 6 | 20 | 0 | 0 | 2 000 | 0 | 0 |
| 510 | 301 | Plain | 60 | 4861 | 650 | 0.25 | 0.6 | 0.35 | 15 | | | | 200 | 3 000 | 0 |
| 511 | | Plain | | 2535 | 450 | 0.01 | | | | | 0 | 0 | 0 | 0 | 0 |
| 512 | 501 | Plain | | 4769 | 799 | 0.6 | 0.16 | -0.44 | 48 | 384 | 0 | 100 | 500 | 0 | 1 900 |
| 513 | 503 | Plain | 82 | 4856 | 400 | 0 | 0 | 0 | 6 | | 0 | 0 | 0 | 0 | 0 |
| 514 | 504 | Plain | | 2541 | 300 | 0 | 0 | 0 | 20 | 20 | 0 | 0 | 0 | 0 | 0 |
| 515 | 601 | Plain | | 9231 | 70 | 0 | 0 | 0 | 18 | | 0 | 0 | 0 | 0 | 0 |
| 516 | 502 | Plain | | 9231 | 50 | 0 | 0 | 0 | 8 | | 0 | 0 | 0 | 0 | 0 |
| 517 | 502 | Plain | | 4882 | 400 | 0 | 0 | 0 | | | 0 | 0 | 0 | 0 | 0 |
| 518 | 301 | Plain | | 4861 | 1035 | 0.75 | 0.6 | -0.15 | 50 | 560 | | 500 | 1 000 | 1 500 | 0 |
| 601 | 219 | Denison | | 2535 | | 0 | 0.25 | 0.25 | 3 | 3 | 0 | 0 | 0 | 0 | 750 |
| 602 | 103 | Denison | | 4884 | 128 | 0 | 0.3 | 0.3 | 160 | 64 | 0 | 0 | 0 | 0 | 0 |
| 603 | 104 | Denison | | 4742 | 378 | 0.3 | 0.75 | 0.45 | 2 | 128 | 250 | 0 | 1 000 | 0 | 0 |
| 604 | 105 | Denison | | 3143 | 800 | 0.2 | 0.2 | 0 | 4 | 4 | | | 0 | 0 | 1 000 |
| 605 | 106 | Denison | | 3142 | 500 | 0 | 0.06 | 0.06 | 30 | 2 | 0 | 0 | 0 | 0 | 0 |
| 606 | | Denison | | 2541 | 525 | 0 | | | 6 | 12 | 0 | 0 | 0 | 0 | 0 |
| 607 | | Denison | | 4113 | 202 | 0 | | | 32 | 8 | 0 | 0 | 3 840 | 0 | 0 |

*Source* Smith & Gissing (2001a)

TABLE II.1 DATA COLLECTED DURING THE TAMINDA SURVEY (CONTINUED)

| 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *2000 No* | *1984 No* | *Street* | *St No* | *ASIC* | *Size* | *WOF* | *84 WOF* | *Diff* | *Prep* | *Clean/Rest* | *Cleanup Staff $* | *Clean Mat $* | *Dam Stock $* | *Dam Equip $* | *Dam Fabric $* |
| 608 | 218 | Denison | | 4861 | 375 | 0.01 | 0.35 | 0.34 | 12 | 12 | 0 | 0 | 0 | 0 | 0 |
| 609 | | Denison | | 2535 | 420 | 0.01 | | | 48 | 32 | | | 0 | 0 | 600 |
| 610 | 216 | Denison | 9 | 4751 | 608 | 0.1 | 0.37 | 0.27 | 4 | 9 | | 0 | 0 | 0 | 0 |
| 611 | | Denison | 11 | 4735 | 250 | 0 | | | 10 | 8 | 0 | 0 | 0 | 0 | 0 |
| 612 | 213 | Denison | 13 | 4861 | 260 | 0 | 0.3 | 0.3 | 8 | 4 | 0 | 0 | 0 | 0 | 0 |
| 613 | 217 | Dension | | 4861 | 1155 | 0 | 0.33 | 0.33 | 3 | 6 | 0 | 0 | 0 | 0 | 0 |
| 614 | 214 | Dension | | 4861 | 180 | 0 | 0.15 | 0.15 | 3 | 6 | 0 | 0 | 0 | 0 | 0 |
| 615 | 211 | Denison | | 4751 | 1296 | 0 | 0.15 | 0.15 | 16 | 16 | 0 | 0 | 200 | 0 | 0 |
| 616 | | Denison | | 4861 | 735 | 0 | | | | | 0 | 0 | 0 | 0 | 0 |
| 617 | | Denison | | 4732 | 2100 | | | | | | | | | | |
| 618 | | Denison | | 4861 | 280 | | | | | | | | | | |
| 701 | 809 | Jewry | | 5713 | 350 | 0 | 0 | 0 | | | | | | | |
| 702 | 808 | Jewry | | 4742 | 2800 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 703 | | Jewry | | 4853 | 7400 | 0 | | | | | 0 | 0 | 0 | 0 | 0 |
| 704 | 807 | Jewry | | 4735 | 250 | 0 | 0.15 | 0.15 | | 14 | 0 | 0 | 0 | 0 | 0 |
| 705 | | Jewry | | 0000 | 1500 | | | | | | | | | | |
| 706 | 705 | Jewry | | 0000 | 2071 | | 0.74 | 0.74 | | | | | | | |
| 801 | 409 | Hudson | | 6389 | 560 | 0 | 0.3 | 0.3 | 16 | 24 | 0 | 0 | 0 | 0 | 0 |
| 802 | 309 | Hudson | 9 | 4122 | 300 | 0 | 0.15 | 0.15 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 803 | 408 | Hudson | | 4861 | 697 | 0 | 0.3 | 0.3 | 32 | 32 | 0 | 0 | 0 | 0 | 0 |
| 804 | | Hudson | | 0000 | 550 | | | | | | | | | | |
| 805 | | Hudson | | 5713 | 610 | | | | | | | | | | |
| 901 | 601 | Lockhea d | | 2874 | 400 | 0 | 0 | 0 | | | 0 | 0 | 0 | 0 | 0 |

*Source* Smith & Gissing (2001a)

TABLE II.1 DATA COLLECTED DURING THE TAMINDA SURVEY (CONTINUED)

| 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *2000 No* | *1984 No* | *Street* | *St No* | *ASIC* | *Size* | *WOF* | *84 WOF* | *Diff* | *Prep* | *Clean/Rest* | *Cleanup Staff $* | *Clean Mat $* | *Dam Stock $* | *Dam Equip $* | *Dam Fabric $* |
| 902 | 602 | Lockhead | | 4736 | 1500 | 0 | 0.06 | 0.06 | 40 | 48 | 0 | 0 | 0 | 0 | 0 |
| 903 | 603 | Lockhead | | 4279 | 400 | 0 | 0.15 | 0.15 | 24 | 24 | 0 | 0 | 0 | 0 | 0 |
| 1001 | | Anson | | 4861 | 500 | 0 | | | | | 0 | 0 | 0 | 0 | 0 |
| 1002 | 505 | Anson | | 3168 | 600 | 0 | 0 | 0 | 8 | 8 | 0 | 0 | 0 | 0 | 0 |
| 1003 | 506 | Anson | | 4861 | 400 | 0 | 0.15 | 0.15 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1004 | 507 | Anson | | 4751 | 400 | 0.1 | 0.23 | 0.13 | | | | | | | |
| 1005 | 508 | Anson | | 4861 | 320 | 0.05 | 0.34 | 0.29 | 20 | 20 | | | 0 | 0 | 0 |
| 1006 | 509 | Anson | | 4861 | | | 0 | 0 | | | | | | | |
| 1007 | 607 | Anson | | 2884 | 246 | 0 | 0.2 | 0.2 | | 2 | 0 | 0 | 0 | 0 | 0 |
| 1008 | 608 | Anson | | 4764 | 220 | 0 | 0.03 | 0.03 | | | 0 | 0 | 0 | 0 | 0 |
| 1009 | 609 | Anson | | 4742 | 240 | 0 | 0.15 | 0.15 | 4 | 4 | 0 | 0 | 0 | 0 | 0 |
| 1010 | 610 | Anson | 1 | 4736 | 400 | 0 | 0.12 | 0.12 | 24 | 24 | 0 | 0 | 0 | 0 | 0 |
| 1011 | 509 | Anson | | 0000 | 921 | | 0 | 0 | | | | | | | |
| 1012 | 510 | Anson | | 0000 | 359 | | 0.15 | 0.15 | | | | | | | |

*Source* Smith & Gissing (2001a)

TABLE II.1 DATA COLLECTED DURING THE TAMINDA SURVEY (CONTINUED)

| 2 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *2000 No* | *Days T L* | *Saved $* | *Stock $* | *Equip $* | *Total S & E $* | *Ann Turn $* | *Insurance* | *Phones D* | *Electricity D* | *Water D* | *Years on Site* |
| 101 | 3 | 10 000 | 2 000 | 100 000 | 102 000 | 312 000 | | 0 | 0 | 0 | 20 |
| 102 | 3 | | 80 000 | 30 000 | 110 000 | 2 500 000 | T | 2 | 2 | 0 | 4 |
| 103 | 3 | | 6 000 | 1 000 | 7 000 | 150 000 | F | 0 | 0 | 0 | 1 |
| 104 | 7 | | | 10 000 | n/g | 78 000 | | 0 | 0 | 0 | 1 |
| 105 | 1 | | 10 000 | 70 000 | 80 000 | 260 000 | F | 0 | 0 | 0 | 2 |
| 106 | 2 | | 150 000 | 250 000 | 400 000 | 1 825 000 | F | 0 | 1 | 0 | 6 |
| 107 | 5 | 20 000 | 180 000 | | n/g | | F | 0 | 0 | 0 | 10 |
| 108 | 2 | 40 000 | 90 000 | 25 000 | 115 000 | 480 000 | F | 0 | 0 | 0 | 6 |
| 109 | 2 | | 300 000 | 300 000 | 600 000 | 1 040 000 | | 0 | 0 | 0 | 1 |
| 110 | 0 | 1 000 | 250 000 | 100 000 | 350 000 | 2 500 000 | F | 0 | 0 | 0 | 2 |
| 201 | 2 | | 350 000 | 55 000 | 405 000 | 1 200 000 | F | 0 | 0 | 0 | 8 |
| 202 | 1 | | | | n/g | | | 0 | 0 | 0 | 3 |
| 203 | 1 | | | | n/g | 240 000 | F | 0 | 0 | 0 | 1 |
| 204 | 1 | | 400 000 | | n/g | | | 0 | 0 | 0 | 20 |
| 205 | | | | | | | | | | | |
| 206 | 1 | | | | 300 000 | 145 000 | | 0 | 0 | 0 | 20 |
| 301 | 3 | 10 000 | 30 000 | 35 000 | 65 000 | 200 000 | F | 2 | 2 | 2 | 15 |
| 302 | 2 | 2 500 | 1 000 000 | 190 000 | 1 190 000 | 4 000 000 | F | 1 | 1 | 0 | 23 |
| 303 | 1 | | 90 000 | 50 000 | 140 000 | 800 000 | F | | | | 5 |
| 304 | 1 | | 3 000 000 | 200 000 | 3 200 000 | 2 000 000 | T | 0 | 0 | 0 | 28 |
| 305 | 2 | | 130 000 | 70 000 | 200 000 | | F | 0 | 0 | 0 | 2 |
| 306 | 3 | 25 000 | 120 000 | 100 000 | 220 000 | | | 1 | 0 | 0 | 15 |
| 307 | 1 | | 100 000 | 15 000 | 115 000 | | | 2 | 0 | 0 | 14 |

*Source* Smith & Gissing (2001a)

TABLE II.1 DATA COLLECTED DURING THE TAMINDA SURVEY (CONTINUED)

| 2 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *2000 No* | *Days T L* | *Saved $* | *Stock $* | *Equip $* | *Total S & E $* | *Ann Turn $* | *Insurance* | *Phones D* | *Electricity D* | *Water D* | *Years on Site* |
| 308 | | | | | | | | | | | |
| 401 | 1 | | 7 600 | 65 000 | 72 600 | 312 000 | F | 1 | 0 | 0 | 2 |
| 402 | 0 | | 15 000 | 5 000 | 20 000 | 1 500 000 | | 2 | 0 | 0 | 5 |
| 403 | 2 | | 50 000 | 200 000 | 250 000 | 1 250 000 | F | 1 | 0 | 0 | 50 |
| 404 | 1 | | 100 000 | 100 000 | 200 000 | 280 000 | F | 0 | 0 | 0 | 15 |
| 405 | 2 | | 5 000 | 150 000 | 155 000 | | F | 2 | 0 | 0 | 5 |
| 406 | 0 | | | | n/g | | F | 0 | 0 | 0 | 30 |
| 407 | 1 | | 2 000 | 6 000 | 8 000 | | F | 0 | 0 | 0 | 6 |
| 408 | | | | 200 000 | n/g | | F | | | | 1 |
| 409 | 4 | 30 000 | | | 70 000 | 800 000 | F | 2 | 0 | 0 | 16 |
| 410 | 2 | | | | n/g | | F | 0 | 0 | 0 | 15 |
| 411 | 1 | | 120 000 | | n/g | | F | 1 | 0 | 0 | 12 |
| 412 | 3 | 100 000 | | | 300 000 | 2 500 000 | F | 0 | 0 | 0 | 20 |
| 413 | 5 | | 250 000 | 250 000 | 500 000 | 2 325 000 | F | 2 | 0 | 0 | 11 |
| 414 | 2 | 150 000 | 1 900 000 | 250 000 | 2 150 000 | 44 200 000 | T | 1 | 0 | 0 | 20 |
| 415 | 2 | | | | 80 000 | 450 000 | F | 0 | 0 | 0 | |
| 416 | 1 | | 230 000 | 10 000 | 240 000 | 2 080 000 | T | | | | |
| 417 | 0 | | | | | | | | | | |
| 418 | 3 | | 70 000 | | n/g | | F | 0 | 0 | 0 | 20 |
| 419 | | | | | | | | | | | |
| 420 | | | | | | | | | | | |
| 501 | | | 400 000 | 200 000 | 600 000 | 4 500 000 | | 2 | 0 | 0 | 12 |
| 502 | | | | | n/g | | | 0 | 0 | 0 | |

*Source* Smith & Gissing (2001a)

TABLE II.1 DATA COLLECTED DURING THE TAMINDA SURVEY (CONTINUED)

| *2* | *18* | *19* | *20* | *21* | *22* | *23* | *24* | *25* | *26* | *27* | *28* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *2000 No* | *Days T L* | *Saved $* | *Stock $* | *Equip $* | *Total S & E $* | *Ann Turn $* | *Insurance* | *Phones D* | *Electricity D* | *Water D* | *Years on Site* |
| 503 | 2 | | 500 000 | 50 000 | 550 000 | 6 000 000 | T | 0 | 0 | 0 | 8 |
| 504 | 2 | | 80 000 | 500 000 | 580 000 | 5 000 000 | F | 2 | 0 | 0 | 9 |
| 505 | 1 | | 17 500 | 10 000 | 27 500 | 988 000 | F | 1 | 0 | 0 | 4 |
| 506 | 2 | 15 000 | 40 000 | 200 000 | 240 000 | 1 000 000 | F | 0 | 0 | 0 | 3 |
| 507 | 5 | 45 000 | 300 000 | | n/g | 2 000 000 | | 1 | 0 | 0 | 20 |
| 508 | 1 | 90 000 | 180 000 | | n/g | 1 200 000 | F | 0 | 0 | 0 | |
| 509 | 3 | 5 000 | 6 000 | 6 000 | 12 000 | | | 0 | 0 | 0 | 29 |
| 510 | 3 | | | | 100 000 | | | 30 | 0 | 0 | 3 |
| 511 | 3 | 5 000 | 75 000 | 75 000 | 150 000 | 400 000 | F | 0 | 0 | 0 | 7 |
| 512 | 3 | 12 500 | 140 000 | 310 000 | 450 000 | 1 095 000 | F | 3 | 0 | 0 | 3 |
| 513 | 1 | | 100 000 | | n/g | | T | 0 | 0 | 0 | 5 |
| 514 | 2 | | | | 100 000 | 800 000 | F | 0 | 0 | 0 | 8 |
| 515 | 0 | | 2 000 | 48 000 | 50 000 | 130 000 | | 0 | 0 | 0 | 3 |
| 516 | 1 | | 2 000 | 7 000 | 9 000 | 104 000 | F | 1 | 0 | 0 | 10 |
| 517 | 2 | | 50 000 | 500 000 | 550 000 | 780 000 | F | 2 | 0 | 0 | 4 |
| 518 | 2 | 200 000 | 400 000 | | n/g | | | 7 | 2 | 0 | 8 |
| 601 | 1 | | 60 000 | 90 000 | 150 000 | 200 000 | T | 0 | 0 | 0 | 5 |
| 602 | 1 | | 35 000 | 30 000 | 65 000 | | F | 0 | 0 | 0 | 4 |
| 603 | 2 | | 120 000 | 50 000 | 170 000 | 960 000 | F | 1 | 0 | 0 | 1 |
| 604 | 2 | | | | 60 000 | 600 000 | F | 0 | 0 | 0 | |
| 605 | 1 | | 100 000 | 300 000 | 400 000 | 1 200 000 | F | 0 | 0 | 0 | 18 |
| 606 | 2 | | 60 000 | 200 000 | 260 000 | 1 000 000 | F | 0 | 0 | 0 | 16 |
| 607 | 5 | | 104 000 | 15 000 | 119 000 | 2 275 000 | F | 1 | 1 | 0 | 2 |

*Source* Smith & Gissing (2001a)

TABLE II.1 DATA COLLECTED DURING THE TAMINDA SURVEY (CONTINUED)

| 2 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *2000 No* | *Days T L* | *Saved $* | *Stock $* | *Equip $* | *Total S & E $* | *Ann Turn $* | *Insurance* | *Phones D* | *Electricity D* | *Water D* | *Years on Site* |
| 608 | 2 | 20 000 | 30 000 | 90 000 | 120 000 | 480 000 | F | 0 | 0 | 0 | 15 |
| 609 | 2 | | 50 000 | 200 000 | 250 000 | 300 000 | F | 0 | 0 | 0 | 13 |
| 610 | 2 | | | | n/g | | | 0 | 0 | 0 | |
| 611 | 2 | | 35 000 | 30 000 | 65 000 | 800 000 | F | 0 | 0 | 0 | 2 |
| 612 | 1 | | 30 000 | 30 000 | 60 000 | 160 000 | F | 0 | 0 | 0 | 10 |
| 613 | 2 | | | | 150 000 | | F | 0 | 0 | 0 | 17 |
| 614 | 2 | | 10 000 | 10 000 | 20 000 | 55 000 | F | 0 | 0 | 0 | 2 |
| 615 | 1 | | 450 000 | 12 500 | 462 500 | 2 500 000 | F | 0 | 0 | 0 | 4 |
| 616 | 1 | | | | | | | 0 | 0 | 0 | 40 |
| 617 | | | | | | | | | | | |
| 618 | | | | | | | | | | | |
| 701 | | | | | n/g | | | | | | |
| 702 | 1 | | | | 1 500 000 | 7 200 000 | | 0 | 0 | 0 | 19 |
| 703 | 1 | | | | n/g | | T | 0 | 0 | 0 | 4 |
| 704 | 1 | | | | n/g | | | 0 | 0 | 0 | 2 |
| 705 | | | | | | | | | | | |
| 706 | | | | | | | | | | | |
| 801 | 3 | | | 15 000 | n/g | 1 680 000 | F | 7 | 0 | 0 | 8 |
| 802 | 1 | | 10 000 | 20 000 | 30 000 | 1 000 000 | F | 0 | 0 | 0 | 5 |
| 803 | 2 | | 12 000 | 80 000 | 92 000 | 600 000 | | 1 | 0 | 0 | 18 |
| 804 | | | | | | | | | | | |
| 805 | | | | | | | | | | | |
| 901 | 1 | | | | 60 000 | | F | 0 | 0 | 0 | |

*Source* Smith & Gissing (2001a)

TABLE II.1 DATA COLLECTED DURING THE TAMINDA SURVEY (CONTINUED)

| *2* | *18* | *19* | *20* | *21* | *22* | *23* | *24* | *25* | *26* | *27* | *28* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *2000 No* | *Days T L* | *Saved $* | *Stock $* | *Equip $* | *Total S & E $* | *Ann Turn $* | *Insurance* | *Phones D* | *Electricity D* | *Water D* | *Years on Site* |
| 902 | 1 | | | | n/g | 600 000 | F | 0 | 0 | 0 | 3 |
| 903 | 0 | | 250 000 | 50 000 | 300 000 | | | | | | 32 |
| 1001 | 1 | | | 65 000 | n/g | 416 000 | F | 0 | 0 | 0 | 3 |
| 1002 | 1 | | | | 80 000 | 120 000 | F | 0 | 0 | 0 | |
| 1003 | 0 | | | | n/g | | | 0 | 0 | 0 | |
| 1004 | | | | | n/g | | | | | | |
| 1005 | 2 | | | | 100 000 | 520 000 | F | | | | 12 |
| 1006 | | | | | n/g | | | | | | |
| 1007 | 0 | | 9 000 | 9 000 | 18 000 | 500 000 | F | | | | 32 |
| 1008 | 1 | | | 12 500 | n/g | | | 0 | 0 | 0 | 20 |
| 1009 | 1 | | | 10 000 | n/g | | F | | | | 6 |
| 1010 | 1 | | | 45 000 | n/g | 400 000 | F | 0 | 0 | 0 | 6 |
| 1011 | | | | | | | | | | | |
| 1012 | | | | | | | | | | | |

*Source* Smith & Gissing (2001a)