Economic Benefits of Land Use Planning in Flood Management

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URS

ECONOMIC BENEFITS OF LAND USE PLANNING IN FLOOD MANAGEMENT

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AAD

Annual Average Damage

AEP

Annual exceedence probability

ARI

Average Return Interval

Floodway Overlay (FO)

The FO is a land classification that applies to mainstream flooding in both urban and rural areas. These areas convey active flood flows or store flood water in a similar way to the UFZ but with a lesser flood risk.

Freeboard

A safety factor used in relation to setting floor levels and levee crest levels. Freeboard provides a safety factor to compensate for uncertainties in the estimation of flood levels across the floodplain, wave action, localised hydraulic behaviour and impacts that are related to specific events, such as levee and embankment settlement and other effects, such as, climate change and 'greenhouse' influences. Freeboard is included in the Nominal Protection Level.

Land subject to inundation overlay (LSIO)

The LSIO is a land classification that applies to mainstream flooding in both rural and urban areas. In general, areas covered by the LSIO have a lower risk of flooding than UFZ or FO areas.

Nominal Protection Level

Depth inundated in the 100-year flood plus a freeboard allowance of 300 mm.

PMF

Possible maximum flood

Risk Frontier

The relationship between depth of flooding and damage.

Urban Floodway Zone (UFZ)

The UFZ is a land classification that applies to mainstream flooding in urban areas where the primary function of the land is to convey active flood flows. It also applies to urban floodway areas where potential flood risk is high due to existing development or pressures for new or more intensive development.

3.1 General

Planning measures are aimed at reducing the damages associated with new developments on the floodplain. These measures generally involve land use controls, such as zoning, and design characteristics for buildings, such as minimum floor heights and water proofing.

Planning measures can reduce the costs of flood risk by excluding some activities from the floodplain and by providing conditions under which particular developments would be allowed at locations with given flood risk. Planning measures are generally not aimed at existing buildings and therefore do not reduce the risks of households or business already located on the floodplain.

Previous work has suggested that land use planning is one of the most cost-effective means of reducing the growth of future flood damage in Australia (Australian Water Resources Council 1992). Water Studies (1995) evaluated the benefits of planning measures throughout Victoria and found that introducing appropriate long-term planning measures could have benefits-cost ratios in the order of 2.0 to 3.8.

3.2 Purpose

The purpose of the project is to develop a robust methodology for assessing the economic benefits and costs of land use planning in flood affected areas in regional Victoria. The project will build on DNRE's flood data mapping project and the Rapid Appraisal Method (RAM) for floodplain management. The specific project objectives are to:

- develop a robust methodology for assessing land use planning;
- to apply this methodology to case study areas in the region of the NCCMA; and
- to assess the benefits and costs of introducing improved flood controls into municipal planning schemes.

3.3 Outline of the Report

Background material, including an outline of the rapid appraisal approach, is presented in Section 4. The Victoria Planning Provisions (VPPs) in relation to flooding and some economic issues arising from those provisions are discussed in Section 5. The nine steps of the methodology are set out in Section 6. The methodology is then applied to two case studies within the North Central Catchment Management Authority. These are the LSIOs (including the UFZs) of the urban area of Echuca, a rural city/large town (Section 7), and the urban area of Rochester, a smaller town (Section 8). Detailed issues involved in applying the methodology are dealt with in Appendices.

At the inception of the study it was anticipated that the rural area of the Lower Loddon would also be used as a case study. Residences and residential extensions in rural areas could be treated in the same way as outlined in Section 6 and analysed in the case studies of Echuca and Rochester. However, for the reasons discussed in Appendix 1, the planning provisions concerning earthworks are extremely complex and outside the realm of a rapid appraisal, such as was performed for this project.

4.1 The Rapid Appraisal Approach

The rapid appraisal approach to the assessment of benefits and costs of natural resource management provides information in a timely and cost-effective way. The key principles of the approach are:

> ***Optimal ignorance*** – knowing what facts are not worth knowing.
>
> ***Appropriate imprecision*** – knowing that precise data are often unnecessary, and in the case of floodplain management may be impossible to obtain.

The rapid appraisal approach emphasises that judgement is unavoidable, by structuring and standardising the form of the analysis and by organising the processes of forming judgements. Economic analysis of planning measures using the approach is not an explicit procedure and will always involve considerable judgement by the assessors. The following are some examples of the way these principles can be applied in the rapid assessment of the benefits and costs of land use planning in flood management.

- Use interviews with key experts who are selected for their specialised knowledge and experience of the floodplain or type of damage under consideration. Floodplain managers, municipal planners, and architects or builders are examples of such experts.
- Avoid strict sampling and survey procedures, and statistical niceties. Usually, rough averages or ‘typical’ examples can be used.
- Make use of information about past events and actual floods when predicting future damages.

As with most aids to practical decision making, the rapid appraisal approach is a mixture of science and judgement. The judgements of technical experts will be particularly important in the development of estimates of flooding depths and the associated average return intervals (ARIs) of the causal floods, building costs, and prediction of development on the floodplain with and without planning measures. Because the 'true' values of these parameters cannot be known, the exercise of judgement on these issues and the use of typical examples is unavoidable, with resultant wide confidence bounds around the results.

4.2 Earlier Work

In a review of floodplain management in Victoria, Water Studies (1995) attempted to evaluate the benefits of planning measures throughout Victoria. The evaluation assumed that the rate of growth in average annual damages (AAD) (see Section 6.1) without planning measures in place would be broadly in line with the projected rate of growth in population and housing in rural Victoria. Based on ABS data, this growth rate was estimated to be 1.5 per cent per annum over the 17-year period to 2011.

Water Studies proposed that:

> *the introduction of appropriate long-term planning measures should be capable of reducing the growth rate to 0.5 % pa.*

If the rate of growth could, in fact, be reduced by 1.0 per cent (from 1.5 per cent to 0.5 per cent) through planning measures, a saving of $100 million over 25 years appeared possible. The present value of these savings at a real discount rate of four per cent was $53 million. The present value of the estimated costs of implementing planning measures was estimated to be about $14 million, producing a benefit:cost ratio of 3.78. If the assumed effectiveness of planning measures was halved (1.5% pa to 1.0% pa), the benefit:cost ratio would be 2.0. Water Studies (p.184) concluded that:

> *in benefit-cost terms, the economics of improved planning measures to reduce the rate of growth in future flood damage are compellingly attractive (emphasis in original).*

The Department of Natural Resources and Environment (2000) in the publication *Rapid Appraisal Method (RAM) for Floodplain Management*, proposed that a methodology similar to that used by Water Studies be used by Catchment Management Authorities (CMAs) when evaluating their proposals for land use planning measures to reduce flood damages.

4.3 Project Approach

Based on an assessment of the Water Studies (1995) approach, and within the principles of rapid appraisal, it was decided that the benefits (and costs) of introducing improved flood provisions into municipal planning schemes should be assessed in terms of reducing the current level of flood risk. The methodology developed is more analytical and quantitative approach than was possible in Water Studies' evaluation.

While the methodology is developed for, and applied to, the existing flood provisions of the Victorian Planning Provisions (VPPs), it has been designed to be sufficiently general so that it could be used to evaluate any future refinements of the VPPs.

It must be emphasised at the outset that while the methodology itself is logical and robust, the results from its application must be regarded cautiously and should be described as indicative. This is because of the considerable uncertainty associated with the data that must be used in the methodology. Such sources of uncertainty are noted throughout this report.

The Flood Provisions of the VPPs are applied through the planning schemes of local government. In relation to flooding, planning schemes involve the promulgation of policy, identification of land affected by flooding, the preparation of a local floodplain development plan, and the methods of operation of the flood provisions. Within a planning scheme, every parcel of land is assigned a *zone* and may also have one or more *overlays*. For example, a property may be in a Residential 1 Zone with a Land Subject to Inundation Overlay (LSIO) over the whole or part of the land. Development on the land, or the part of it subject to the LSIO must comply with the provisions of the LSIO as well as the provisions of the Residential 1 Zone.

The zone or overlay specifies whether a permit is required for a particular use or development, including the construction of buildings, the carrying out of works or subdivision of the land. This section outlines the flood provisions relevant to rural Victoria. This study is confined to mainstream flooding in rural and provincial urban areas. We do not consider land contained within the Special Buildings Overlay, which applies to stormwater flooding in urban areas.

5.1 The Urban Floodway Zone and Overlays

The urban flood zone, and the overlays that show the rural floodway and the land subject to inundation are the areas of interest in relation to planning measures on floodplains outside the Melbourne metropolitan area.

5.1.1 Urban Floodway Zone (UFZ)

This zone applies to mainstream flooding in urban areas where the primary function of the land is to convey active flood flows. It also applies to urban floodway areas where potential flood risk is high due to existing development or pressures for new or more intensive development. The overlays (Floodway Overlay and Land Subject to Inundation Overlay) cover a range of situations in both urban and rural areas where the potential flood risk is less than in the UFZ and where control over development and not land use is sufficient. This is because the UFZ, unlike the overlays, controls land use as well as development, with land use being restricted to low intensity uses such as recreation and agriculture. Development is generally not encouraged in the UFZ but the replacement of existing buildings may be permitted. In all other circumstances, the relevant zoning in conjunction with the flood overlay will control land use. Building activity in the UFZ may also affect and increase the potential damages in adjoining areas due to redistribution of floodwaters.

It is important to recognise that the UFZ affects the pattern of development on the floodplain by prohibiting some activities that would otherwise have profitably located on this part of the floodplain. By doing so, the expected damages due to flooding are reduced. Although the zoning reduces the expected value of flood damage, it would be at the cost of foregoing development that was of greater value than the losses prevented. This can be illustrated by assuming that a given activity is operated to maximise the expected present value of future earnings (Lind 1967). That activity will locate on land in the UFZ only if the present value of expected flood losses is less than the increase in the present value of expected earnings obtained by locating in the UFZ rather than at the next best location outside the UFZ. Therefore, to exclude this activity from the UFZ is to cause a reduction in the present value of its expected earnings that exceeds the present value of expected flood losses.

This reasoning assumes that the individuals making such decisions are aware of the expected value of flood damages on the land occupied by the UFZ (see Step 4 of the methodology). This may not be the case and the declaration of the UFZ may reduce flood damages where property is exposed to the hazards of flooding only because of ignorance. Nevertheless, it is likely that the UFZ would exclude some activities that could profitably locate on that land as well as some for which it would not be profitable. The UFZ is not widely used due to its restrictive nature and, we presume, due to the risk of the above type of cost.

As Lind points out, a further case for flood zoning is where society assumes some responsibility for losses of a catastrophic nature that are socially unacceptable. Floods that kill people, and leave others homeless or without employment usually require considerable assistance from governments. By zoning, society protects individuals from exposure to the possibility of such losses.

In the context of a complete benefit-cost analysis, when the UFZ is used to exclude an activity it will be important to compare the earnings of that activity at the next best site relative to location in the UFZ with the damages it would incur by locating in the UFZ. In the context of a rapid appraisal, however, such information would not usually be available.

5.1.2 The Floodway Overlay (FO)

The FO applies to mainstream flooding in both urban and rural areas. These areas convey active flood flows or store flood water in a similar way to the UFZ but with a lesser flood risk. The FO is suitable for areas where there is less need to control land use, and the focus is more on the control of development. Key considerations are whether the development will obstruct flood flows or increase flood risk.

A permit is required for subdivision on land in the FO and the creation of lots that lie entirely within the FO is discouraged but existing lots may have boundaries realigned.

5.1.3 The Land Subject to Inundation Overlay (LSIO)

The LSIO applies to mainstream flooding in both rural and urban areas. In general, areas covered by the LSIO have a lower risk of flooding than UFZ or FO areas. The LSIO may also be used as an interim measure to identify flood-affected areas where the detailed information required to define the floodway is not available. Generally, the LSIO in Victoria corresponds to the land inundated in a one in 100-year flood and the levels of such a flood plus an allowance for freeboard are used as the Nominal Protection Level (NPL).

Permits are usually required to construct a building or to construct or carry out works, including a fence and road works. A permit is required to subdivide land.

5.2 Guidelines for Development

Guidelines have been developed to reflect current best practice and which are intended to guide councils and floodplain management authorities when deciding on proposals for buildings, works and subdivisions where flooding is an issue. These guidelines for development are set out in the Department of Infrastructure's Victorian Planning Provisions Practice Planning Note *Applying for a Planning Permit under the Flood Provisions – a Guide for Councils, Referral Authorities and Applicants.*

Most buildings and works (including levees) require a permit in the UFZ and the flood overlays, and will have conditions imposed on them to meet the objectives of the flood provisions. Building orientation, floor height and restrictions on fencing types are common examples (see DOI VPP Practice Planning Note *Applying the Flood Provisions in Planning Schemes – a Guide for Councils*).

The guidelines are tailored and developed by councils and authorities for application in specific areas, and would be included in a local planning policy or a local Floodplain Development Plan as appropriate. Amongst other things, the guidelines cover the following issues.

5.2.1 Building floor levels

The council specifies a minimum floor level that includes a freeboard margin of at least 300 mm above the 100-year ARI flood level (this minimum floor level is referred to as the NPL), unless the floodplain management authority consents to a lower level. The regulations do not apply to non-habitable garages, carports or sheds, an unenclosed floor area of a building or an extension to an existing building which is less than 20 sq. metres.

The floodplain management authority must consent to any floor levels below the NPL and advise the applicant of the risks associated with over-floor flooding. The location, floor level and design of any building or extension should consider adequate drainage for the site and any adverse hydraulic effects on neighbouring properties. Commercial buildings are usually required to meet the same floor heights as residential buildings but at times this requirement may be relaxed. A minimum standard for a commercial building set below the NPL is that the minimum floor level should be set at the 100-year ARI flood level with flood proofing provided up to the NPL. Flood markers may be required in commercial buildings to show the height of the 100-year ARI flood and other historic floods.

5.2.2 Flood-proofing

Flood proofing involves a number of measures that can be incorporated into the design, construction and alteration of a building in order to reduce damage caused by contact of flood water with the building structure or its contents. Such measures include: water resistant building materials up to the NPL; electrical fittings and sewer fixtures fixed above the NPL; and window sills set above the NPL. Further measures in commercial buildings are the provision of adequate storage areas and shelving above the NPL for the storage of valuable goods and hazardous materials.

5.2.3 Other matters

Additional requirements may be contained within a local Floodplain Development Plan. Applications for permits in overlays and the UFZ must be consistent with that Plan. In the FO such matters might include:

- the number of dwellings permitted on a lot and the density of dwellings per unit area;
- the depth of the flood waters above which a new dwelling would not be permitted – defined as the depth of the 100-year flood above the natural surface at a proposed house site or the access way to the site;
- whether new commercial and industrial buildings are permitted;
- the alignment of buildings relative to the direction of flood flows;
- restrictions on the protrusion of building pads beyond the building envelope; and
- the floor area of extensions for which minimum floor heights apply.

In the LSIO such matters might include:

- the minimum area of lots in a sub-division and the density of dwellings per unit area;
- the depth of the flood waters above which a new dwelling would not be permitted – defined as the depth of the 100-year flood above the natural surface at a proposed house site or the access way to the site;
- building alignment;
- restrictions on the protrusion of building pads beyond the building envelop; and
- the floor area of extensions for which minimum floor heights apply.

This Section describes the nine steps involved in the rapid appraisal of planning provisions related to mainstream flooding in the urban areas of rural Victoria.

6.1 Average annual damage (AAD)

The future timing of floods cannot be known, except in terms of their probability of occurrence. There are different possible magnitudes of flood events and associated with each is a probability that it may occur or be exceeded. For example, a flood with a probability of 0.1 of occurring or being exceeded in a given year (the annual exceedance probability, or AEP) is said to have a 10-year average recurrence interval (ARI), which is often shortened to a '10-year flood'.

Depending on its size, each flood will cause a different amount of damage – large floods have small AEPs and cause more damage than smaller floods with larger AEPs. The average annual damage (AAD) is the average damage per year from flooding that would occur in a particular year over the long term. The AAD is determined by multiplying the damage caused by each flood by its AEP and adding the probability weighted damage across all floods. On a plot of damages against the associated probabilities, AAD is equal to the area under the curve joining the data points. The AAD provides the basis for comparing the economic effectiveness of different management measures, against floods of all sizes, that is, the ability of the measures to reduce the AAD.

The AAD should theoretically include all damages, from the flood that just causes damage to that caused by the possible maximum flood (PMF). However, flood damage data are usually available for only a few specific events and rarely for floods with probabilities less than 0.01. In practice, therefore, estimating AAD can be problematical and the results are dependent on the different methods that are used (Leigh, Chen, Hunter and Blong 2001).

For the assessment of land use planning measures, for example, a requirement that floors be higher than the water level of the 100-year event, it needs to be recognised that significant damages only occur for flood events with probability less than 0.01. Such rare events do occur and if information to ascertain the resultant damages is available it should be used if a reasonable measure of the reduction in AAD due to the measures is to be obtained.

Methods that might be used for determining AADs in the assessment of land use planning measures are outlined below. In order that comparable results are obtained, a standard approach should be used when information for rare floods ($p < 0.01$) is or is not available.

6.2 Overview of methodology

The core of the methodology is benefit-cost analysis (see Appendix 2) in which the benefits of planning measures are evaluated as the difference between the AADs per building with and without the planning measures for a typical example of relevant types of buildings in various sub-areas in the LSIO. If required, the total net benefits for the LSIO may be estimated by forecasting the number of buildings of each type under each scenario, and aggregating across building types and sub-areas.

The methodology is applied using the following steps.

Step1: Divide the study area into sub-areas according to depth of flooding.

Step 2: Estimate the value of typical examples of the types of buildings in the study area with and without the planning measures.

Step 3: Estimate the value of typical contents in the various types of buildings in the study area.

Step 4: Estimate AAD per building for each type of building in each sub-area of the study area without the planning measures.

Step 5: Estimate AAD per building for each type of building in each sub-area of the study area with the planning measures.

Step 6: Estimate the gross annual benefit of the planning measures for each type of building in each sub-area.

Step 7: Estimate the net benefit of the planning measures for each type of building in each sub-area.

Step 8: (Optional) Predict numbers of each type of building in each sub-area in the future with and without planning measures.

Step 9: (Optional) Estimate net benefits for each sub-area.

Steps 2,4,and 5 are further broken down into logical components.

If forecasting the number of buildings that might be constructed is not regarded as a credible process, particularly in the counterfactual scenario of no planning measures in place, the analysis may stop at Step 7 – the net benefits for each type of building in each sub-area.

6.3 Step1: Divide the study area into sub-areas according to depth of flooding

Assessment of the flood depth and damages produced by a given flood on a house by house basis would produce the most accurate estimate possible of the AAD per house. Such an approach, however, is outside the realm of a rapid appraisal. Larger areas containing many houses must be used if a rapid appraisal is to be feasible. For each of these areas, estimates of depths of flooding for a *representative site* are required.

Sub-areas that are judged to have broadly similar average depths of flooding may need to be defined within the study area, for example, major depressions or large areas of higher ground. This is because a flood of a given ARI will not produce the same depth of flooding and, therefore, the same degree of damage to a given type of building over the whole study area1. Such sub-areas should only be defined if it were judged that they are sufficiently large to cause significant bias in the estimate of damages in the situation where damages were assumed to be proportional to the average depth across the entire floodplain. This is a matter of judgement because the accuracy of the data does not permit such bias to be tested in a statistical sense.

Where the definition of sub-areas is appropriate, it might be expected, at the least, that the UFZ, the FO (if relevant) and the remainder of the LSIO might constitute three distinct sub-areas. It would then need to be decided if the LSIO beyond the UFZ or the FO should be sub-divided.

6.4 Step 2: Estimate the value of typical examples of the types of buildings in the sub-areas.

6.4.1 Step2a: Without planning measures

All buildings of a given type (residential, commercial, industrial) in a given sub-area are assumed to be identical to a representative or typical example of that type of building for that sub-area[2]. Without detailed surveys, the specifications (such as size, configuration and materials) of these typical examples is a matter of judgement and those best able to exercise this judgement are persons with an intimate knowledge of building construction in the study area, such as, staff of the planning department of the relevant shire or municipality.

This simplifying assumption of identical buildings of a given type takes no account of architectural detail even for the given style of house. In effect, it means that we are attempting to measure the average value of new buildings of given type in the flood prone areas and, therefore, the average AAD for that type of building.

After the introduction of the planning measures we are only concerned with new buildings and new extensions to existing buildings because the damage to existing buildings remains the same with and without the planning measures. In this situation, construction costs are the relevant values on which to base flood damage. These costs include preliminary costs, labour and materials, and an allowance for builder's profit.

It is assumed that future construction costs remain constant in real terms over time. In other words, there are no changes over time in the real value of resources used in construction. We also ignore what has

1 Clearly, depth of flood decreases as the outer edge of the LSIO is approached. It is important that the designation of sub-areas relates to average depth over the area.

2 An alternative approach would be to derive a weighted average construction cost. This would require data on the expected proportions of various forms of a given type of building, say, the expected proportions of brick veneer and weatherboard residences.

been termed ‘post disaster inflation’ of construction costs (R Blong, pers. comm.). This phenomenon may occur following an event that causes such severe and widespread damage that shortages of building materials and trades persons lead to increased building costs in the short term. The severe hailstorm in Sydney in April 1999 provided a notable example of such an increase in building costs.

The construction costs may be ascertained from building construction handbooks, for example, *Rawlinson’s Australian Construction Handbook*, but it is advisable that the services of an architect, building designer or builder be obtained to provide interpretation and adjustment of the costs, particularly when sloping sites or foundation problems are important considerations. For the 'without planning measures' the floor heights are those that would normally be used where flooding is not an issue.

If this process is not possible, it is believed that the construction costs presented here for the case study areas of the NCCMA (Sections 4 and 5) are likely to be reasonably typical of rural areas and provincial towns in Victoria.

It is important to note in the context of a rapid appraisal that *Rawlinsons* advise that the accuracy of data is less reliable for residential projects and for projects of less than $500,000. On this basis, the data, even though interpreted by a reputable architect must be used as generally indicative of construction costs.

6.4.2 Step 2b: With planning measures

Step 2a is repeated for the average floor height that is required to satisfy the planning provisions in each sub-area. This height needs to be the height above ground level, which may be estimated from the conditions on a sample of permits that have actually been granted. If height above ground level is not stated in the conditions it will need to be estimated by the Floodplain Manager, as will the heights where permits have not yet been granted.

The extra construction costs to meet the increased floor heights and any other conditions resulting from the planning measures are estimated by the advising architect, building designer or builder. Average cost per 100 mm to raise floor heights can be derived.

6.5 Step 3: Estimate the value of typical contents in the various types of buildings in the study area.

It is assumed that these are replacement costs of the contents and that all damaged items are replaced with new items. Contents are also measured in constant dollars. It is also assumed that the contents of a given type of building do not change over time. Clearly, this is a simplifying assumption that does not allow for changes in technology and taste. Examples include the rapid increase in the incidence of home computers and air conditioners in recent years, and the trend towards ‘home theatre’ video and audio equipment. It is beyond the scope of the study to predict how contents might change in the future.

There is, of course, likely to be considerable variation in the value of the contents of a given type of building, whether it is residential, commercial or industrial. Ignoring antique furniture and valuable collections of art or artefacts, the average values for typical contents of residences may be ascertained with relative ease.

Useful aids when estimating the value of residential contents are:

- the room by room checklist of contents provided by most insurance companies - to help ensure that the typical set of contents is obtained; and
- catalogues from department stores that handle differing qualities of products or visits to the stores - to help ensure that the range of values for a given item are investigated.

It may not be so easy to determine typical contents for a residential extension because of the variety of purposes for which extensions are used. If residential extensions have floor heights raised to the required level above the 100-year flood they are permitted to contain bedrooms. Extensions may, however, be permitted to be below the level of the 100-year flood provided they do not contain rooms, such as bedrooms, which could put residents at risk when flood waters rise rapidly. It is assumed that extensions are raised to the required level and that they contain, at least, a bathroom and a bedroom. The value of contents is assumed to be one-sixth of that of an entire residence.

The contents of commercial and industrial buildings can be subject to enormous variation within a sub-area depending on the type of business. The exception may be where similar businesses congregate together in reasonable numbers, but this is unlikely situation for most rural towns where business districts are usually heterogeneous.

The most vulnerable items in commercial buildings are perishables, electrical or stock containing paper-based packaging (Gissing 2001). Gissing provides an extensive list of the sorts of damages experienced by businesses in the Kempsey floods of 2001 and notes that depth exerted little influence on internal losses due to different degrees of flood preparation, the heterogeneous nature of the sector, and surveying uncertainty.

Because of the vast variation in the value of contents from one commercial or industrial building to another, we do not consider contents damage for these types of buildings as a separate item. Instead, we utilise recent estimates of *total direct damage* derived by Gissing (2001) from analysis of the Kempsey flood of 2001. The implicit assumption in this approach is that commercial (and industrial) damages per building in Victorian rural towns and cities are similar to those in Kempsey.

6.6 Step 4: Estimate AAD per building for each type of building in each sub-area of the study area without the planning measures

6.6.1 Step 4a: Flood events

The typical example of each type of building relevant to the sub-area is considered to be located at the site in the sub-area that would produce the average depth of flooding across the sub-area for any flood.

Because the depths of flooding vary between study areas it is not possible to lay down a strict procedure for a particular set of ARIs or damage levels to be used in the calculation of the AAD per building. To estimate the AAD we aim for at least 3 ARI/Damage coordinates on the loss-probability curve[3]. These coordinates may be obtained by considering some or all of the following floods.

1. ARI of the flood at which underfloor damage would just begin.
2. ARI of the flood at which overfloor damage would just begin, that is, ARI at which underfloor damage is at its maximum.
3. ARI of the flood that would produce flooding to an overfloor depth of 0.5m.
4. ARI of a flood that would produce overfloor flooding of 1.0m.
5. Depth of flooding produced by the flood with an ARI of 100 years.
6. If available, depth of flooding produced by a rare flood, that is, one with an estimated ARI greater that 100 years.

It is emphasised that these are estimates and cannot be regarded as exact information. Nevertheless, the floodplain manager with the assistance of staff of the FMU is the best-informed person to make such estimates. The depths produced by actual floods and the estimates of the ARIs of those floods will assist greatly in this process.

Floods 1 and 2 are essential information. Flood 1 indicates the highest probability flood that needs to be considered because any flood with an ARI greater than that for this flood will produce underfloor damage. Flood 2 indicates the probability of the flood that would produce the greatest underfloor damage.

Which of Floods 3, 4, and 5 need assessment depends on the depth of overfloor inundation produced by the 100-year flood.

- If Flood 5 (the 100-year flood) would result in an overfloor depth of less than 0.5m, we need be concerned only with Flood 5 (and Flood 6)[4].
- If Flood 5 (the 100-year flood) would result in an overfloor depth between 0.5m and 1.0m, we need be concerned only with Flood 3 and Flood 5 (and Flood 6)[5].

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3 When information about a rare flood ($p < 0.01$) is not available, the calculation of the AAD using only two points may have to suffice in the ‘with planning measures’ scenario.

4 Unless, of course, there are data on more than one rare flood, one of which would produce 0.5 m overfloor.

5 Unless, of course, there are data on more than one rare flood, one of which would produce 1.0 m overfloor.

- If Flood 5 (the 100-year flood) would result in an overfloor depth greater than 1.0m, we need be concerned with Flood 3, Flood 4, and Flood 5 (and Flood 6).

These combinations assume that Flood 6 produces a depth of overfloor flooding that is in excess of 1.0m. If this were not the case, a smaller set of relevant floods could be considered.

6.6.2 Step 4b: Depth/damage relationships

One of the main instruments of land use planning in relation to flooding is the requirement that floors be above the level of the 100-year flood. Therefore, the relationship between the depth of the floodwaters in the absence of the planning measures and the damage caused is a key relationship in estimating the benefits of those planning measures.

Generally speaking, the relationships between depth and damage of both contents and structures have been shown to be weak. This has been indicated in regression studies by low or very low proportions of the variation in damage that can be explained by the depth of inundation. This is the case even for single storey residences, probably the most closely researched building for these purposes, but more so for commercial and industrial buildings. Therefore, even if depth can be accurately predicted for a given flood there is wide and unknown variation in the estimates of resultant damage.

Residential buildings

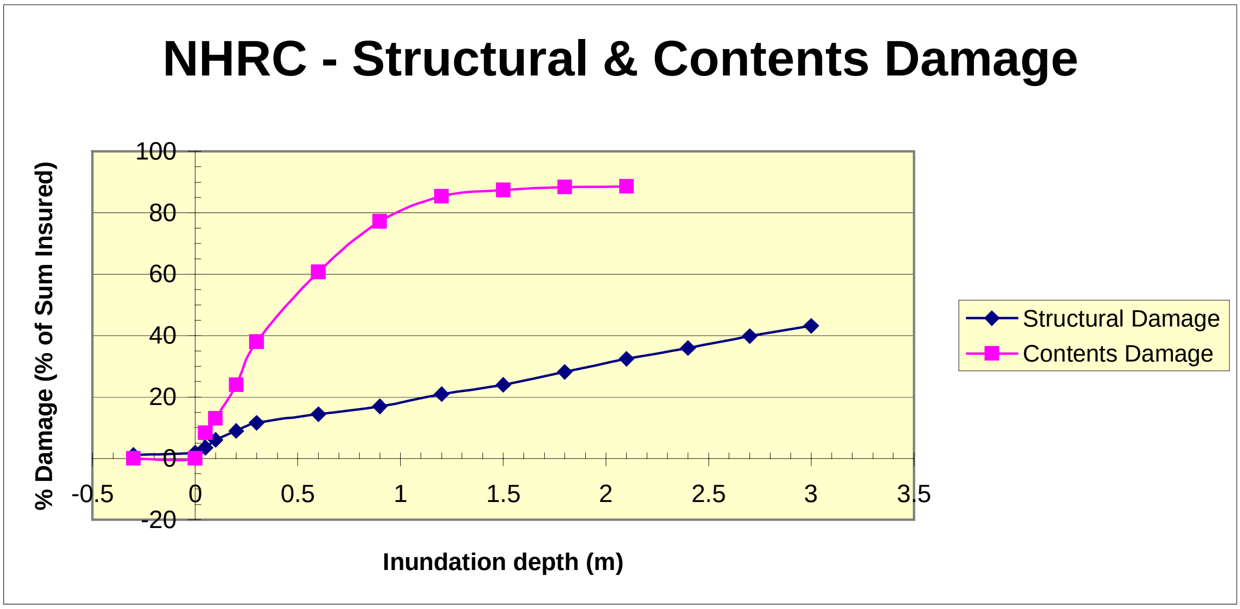
For residential buildings, the NHRC preliminary Risk Frontiers, previously termed Integrated Damage Curves (Blong 2001) provide the most appropriate relationships between depth of inundation and the percentage of the value of contents and structures that is damaged. *At the present stage of development of these curves, however, preliminary risk frontiers are only available for single storey residences*. Curves for two-storey residences are under development and new estimates for single storey residences are under construction (Blong 2002, pers.comm.).

The emphasis in these frontiers is on potential damage and the percentage of damages relates to the percentage of the sum insured. We, on the other hand, relate these percentage damages to the replacement values of the structure and contents, which is consistent with most insurance policies being on a ‘new for old’ basis.

Throughout this analysis we work entirely in terms of potential damage in preference to introducing a further judgemental matter, namely the size of the ratio of actual to potential damages. For this reason, it is the consultant's belief that when estimating losses that might be incurred by the community, it is prudent for the managers of floodplains to concern themselves with potential losses rather than uncertain actual losses. This means that the analysis will overestimate actual damages by an unknown amount.

Figure 6-1 shows the preliminary NHRC risk frontiers for both contents damage and structural damage.

Figure 6-1: Preliminary NHRC risk frontiers



Source: Preliminary figures supplied by R. Blong, NHRC.

For most rural areas and provincial towns and cities in Victoria, it is reasonable to assume that all residences are single storey. Where this is demonstrably not the case, the assumption of single storey dwellings would tend to overestimate the percentage damage to structures by a variable percentage depending on depth of inundation, but possibly by less than 10 per cent (see Blong 2001, Figure 9, p.12).

It is assumed that these percentages can also be applied to extensions using the construction costs discussed in Step 2.

Based on the curves of Figure 6-1, the percentage damage to the replacement values of contents and structure at selected inundation levels are shown in Table 6-1. The percentages shown are the means for the duration of inundation less than 12 hours and greater than 12 hours. These percentages are assumed to be the same for buildings constructed with and without the planning measures.

Table 6-1: Preliminary residential risk frontiers

Depth of overfloor inundation (m)	Average per cent damage (per cent of replacement cost)	
	Structure	Contents
-0.3	1.2	0.00
0 (assumed max. underfloor damage)	1.8	0.00
0.05	3.5	8.4
0.1	6.0	13.05
0.2	9.0	23.95
0.3	11.6	38.00
0.5 (by linear interpolation)	13.5	53.1
0.6	14.4	60.70
0.9	17.0	77.15
1.0 (by linear interpolation)	18.3	79.9
1.2	21.0	85.40
1.5	24.0	87.4
1.8	28.2	88.4
2.1	32.5	88.6
2.4	36.0	88.6
2.7	39.9	88.6
3.0	43.2	88.6

Source: Preliminary figures supplied by R,. Blong, NHRC.

Indirect costs per residential building, such as cleaning up and restoration, are assumed to be 20 per cent of the direct damage to structures and contents (Water Studies 1996, p.65). Indirect costs are added to direct cost to obtain the overall damage per building.

Commercial and industrial buildings

As indicated above, the total direct damages to commercial and industrial buildings, shown in Table 6-2, are based on those estimated by Gissing (2001, Figure 2) for the 2001 flood in Kempsey. These differ from the approach for residential damages because an estimate of the dollar damage per square metre at various depths of overfloor damage is used rather than a percentage of the value of the building. When using these figures, it must be remembered that they are derived from a very weak relationship between depth and damage.

Table 6-2: Assumed commercial and industrial risk frontier

Depth of overfloor inundation (m)	Damage per sq m
-0.3	0
0 (assumed max. underfloor damage)	$15
0.05	$27
0.1	$38
0.2	$50
0.3	$57
0.5	$75
0.6	$80
0.9	$95
1.0	$100
1.2	$120
1.5	$150
1.8	$160
2.1	$200
2.4	$200
2.7	$200
3.0	$200

Source: Based on Gissing (2001)

Indirect costs for commercial and industrial buildings are assumed to be 55 per cent of direct damages.

6.6.3 Step 4c: Calculate AADs for each type of building in each sub-area

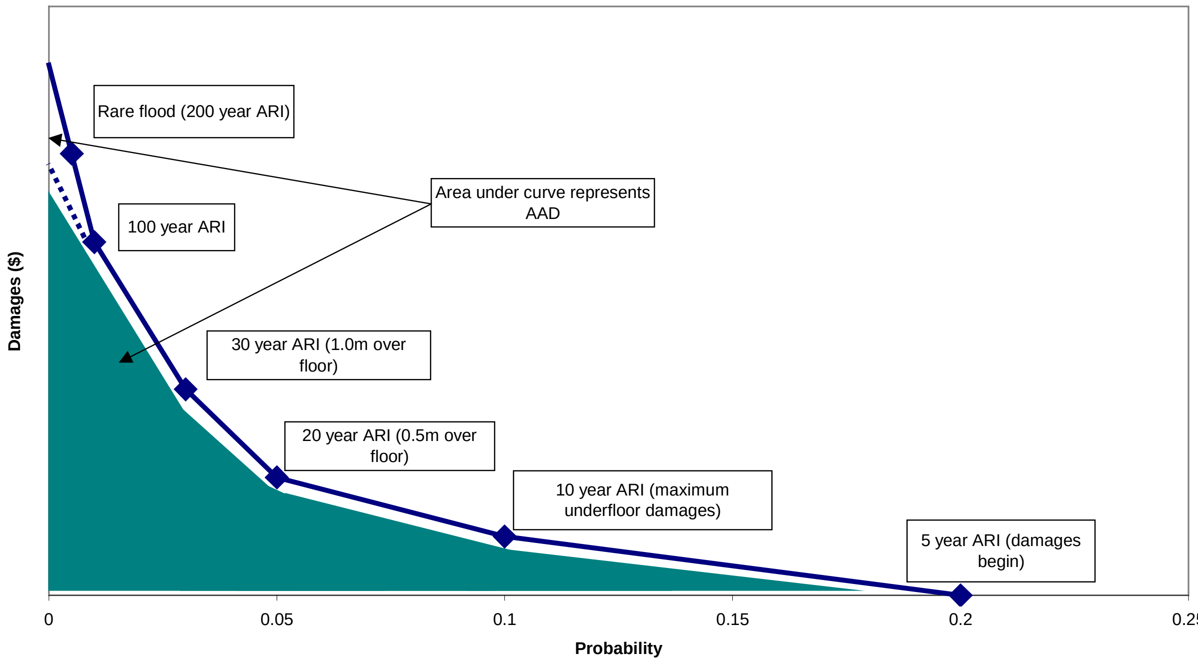
For a typical residential building in a sub-area, calculate the AAD per building as follows:

- multiply the value of the structure by the percentage of structural damage corresponding to the depth of flooding produced by each flood with the estimated ARIs (from Step 2) to obtain the dollar value of structure damage;
- multiply the value of the contents by the percentage of structural damage corresponding to the depth of flooding produced by each flood with the estimated ARIs (from Step 3) to obtain the dollar value of contents damage;

- add the dollar values of the damage to structure and the dollar value of damage to contents, add the estimate of indirect costs to obtain the total damages for each flood with the estimated ARIs; and
- construct the damage/probability curve and calculate AAD.

When information on the depth of flooding for a rare flood is available, say for the 200-year event (p = 0.005) and the resultant damages can be estimated, it is proposed that the damage curve without the planning measures be constructed using straight-line segments between all available points. Extrapolating the line from the 100-year flood that passes through the 200-year event to the damage axis, as shown by the solid line in Figure 6-2, is assumed to pass through the (unknown) point representing the possible maximum flood (PMF) - a flood with an extremely small AEP but displayed for graphical purposes as the intersection with the damage axis (p = 0). The AAD is the area under this curve.

Figure 6-2: Loss Probability Curve Without Planning Measures



If data on a rare flood are not available, the line passing through the 100-year flood is extrapolated to the damage axis, as shown by the broken line in Figure 2. This will underestimate the AAD relative to the situation where the damages caused by a rare flood are known.

A generalised spreadsheet model is available to carry out these calculations using the risk frontiers for residential buildings, and commercial and industrial buildings.

Generally, the analysis of the AAD per building in the UFZ might stop at this point and one would proceed to Step 8 if further analysis of the entire UFZ were desired. This is because new buildings are not permitted in the UFZ unless they replace an existing building. Therefore, it could be concluded that the AAD per building for each type of building is an estimate of the potential damage avoided by the prohibition on new buildings in the UFZ. One would proceed to Step 5 for the UFZ if an analysis were to be conducted of the reduction in the AAD per replacement building, where the replacement building was to confirm with the requirements for floor height, namely, 300 mm above the level of the 100-year flood.

6.7 Step 5: Estimate AAD per building for each type of building in each sub-area of the study area with the planning measures

Repeat Step 4 using the principles in Section 6.1, calculate the required increase in floor height in each sub-area and apply the building construction costs estimated in Step 2b. The same building contents as estimated in Step 3 are used.

6.7.1 Step 5a: Flood events

With the planning measures in place, underfloor damages commence in the flood with the same ARI as in the ’without measures’ scenario (Flood 1 of Step 4a). The key assumption for this scenario is that the maximum underfloor damage will occur at the 100-year flood. This is a simplification of reality that will tend to cause overestimation of the AAD per building with the planning measures in place. This is because the planning measures require that the floor level must be 300 mm above the level of the 100-year flood. This freeboard margin is intended as a safety factor to allow for uncertainty about flood levels and for wave action.

To include the freeboard margin in the analysis would require knowledge of the ARI of the flood that would give a depth 300 mm greater than the 100-year flood, that is, the true depth at which overfloor damage would commence. Such information may not be available. On the other hand, even when there is a good understanding of flood levels, there are many circumstances when the margin could be equalled or exceeded, such as, in strong winds or by the bow waves created by large vehicles on nearby roads. In these circumstances, maximum underfloor damage (even overfloor damage) at the 100-year flood would occur.

Abstracting from the freeboard issue, the maximum underfloor damage that occurs in the presence of the planning measures will be greater than in their absence due to the higher cost of the raised building.

An important variable in this Step, if the data are available, is the depth of flooding caused in each sub-area by the rare flood ($p < 0.01$). This is an important variable because it is the third data point for the estimation of the AAD. The value of damage in the rare flood, relative to the scenario 'without planning measures', will depend on the reduced depth of overfloor flooding caused by that flood in the raised building and the higher cost of the raised building.

6.7.2 Step 5b: Depth/damage relationships

It is assumed that the same risk frontiers used in Step 4b apply to the buildings with the planning measures in place.

6.7.3 Step 5c: Calculate AAD per building

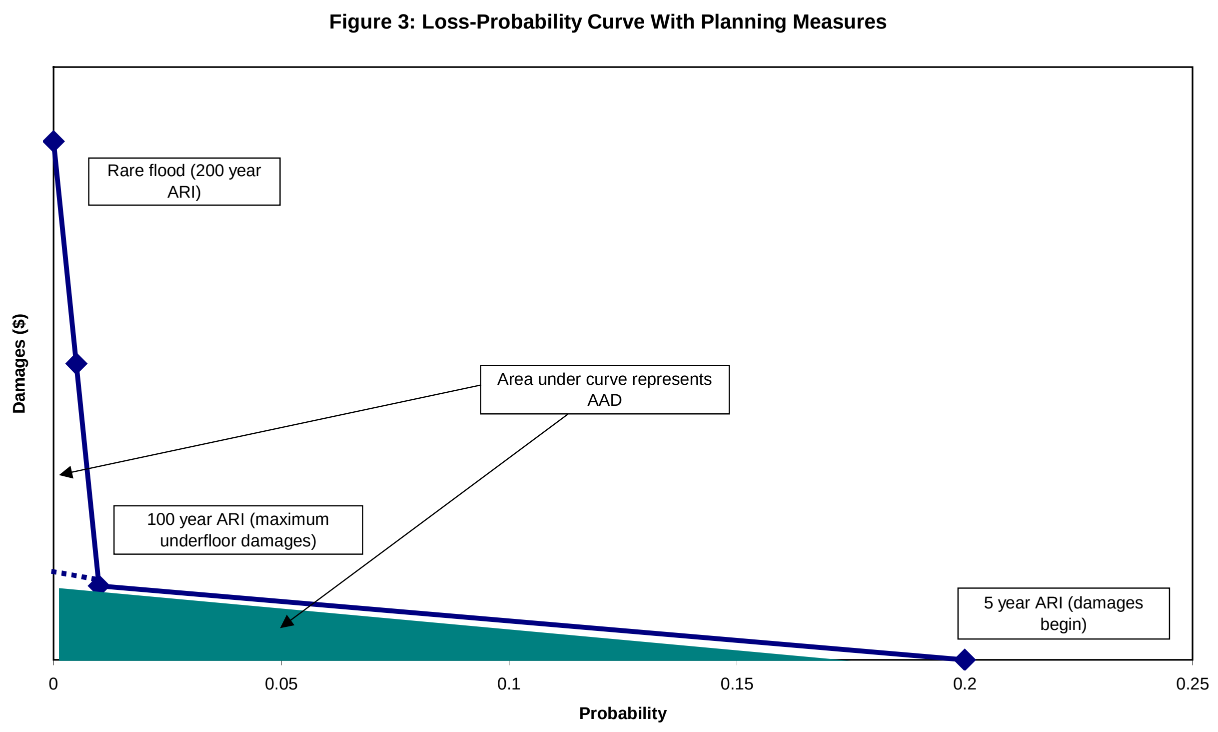
Repeat Step 4c using the depths of flooding estimated in Step 5a.

With the planning measures in place, damage is assumed to commence with the same flood as without the measures but the maximum underfloor damage is produced by the 100-year event. Again, it is proposed that the straight line joining the 100-year event to the 200-year event be extrapolated to the damage axis, as shown by the broken line in Figure 6-3. The AAD with the measures in place is the area under this new damage curve.

The damages caused by the 200-year event and the maximum possible flood may be less than 'without the planning measures' because the 200-year event would now flood the house to a lesser depth even though the value of the house would be greater.

The calculation of AAD with the measures in place is also contained in the spreadsheet model.

Figure 6-3: Loss Probability Curve with Planning Measures



6.8 Step 6: Estimate the gross annual benefit of the planning measures for each type of building in each sub-area

The AADs for each type of building in each sub-area estimated in Step 5c are subtracted from those estimated in Step 4c. The difference in the AAD for each type of building in each sub-area represents is the gross annual benefit, that is, the avoided damages, of the planning measures for that type of building in each sub-area. As noted in Step 4c, this would be the usual approach for buildings in the sub-areas of the LSIO outside the UFZ, but only for buildings in the UFZ if one were concerned with replacement buildings.

In the absence of data on a rare flood, the difference in the two AADs is only an approximation to the gross benefit forthcoming from the planning measures. Nevertheless, the difference between the two simplified lines can still be used in benefit-cost analyses. If the gross benefit so calculated exceeds the cost of the planning measure, the measures have been worthwhile (benefit > cost) but the true net benefit cannot be calculated. If the benefit so calculated is less than the cost of the planning measures a definitive assessment of the true net benefit cannot be provided – it may still be positive.

6.9 Step 7: Estimate the net benefit of the planning measures for each type of building in each sub-area

The main direct costs per building associated with the planning measures are the extra construction costs imposed by the measures (raised floor heights and waterproofing). The costs incurred by the CMA of evaluating permit applications with regard to flooding issues, about $120 per application, are insignificant compared to the extra building costs. Both these costs are of a one-off nature associated with the construction of the building.

Monitoring and policing costs, such as, checking that permit conditions are adhered to and that buildings are not constructed without a permit, and the costs of appeals to the Victorian Civil and Administrative Tribunal, may be recurrent and best treated on the basis of the whole study area rather than per building.

Two further simplifying assumptions which affect costs per building are made in relation to the scenarios with and without the planning measures. First, in relation to the UFZ, it is assumed that every building that might have been built in the area of UFZ in the absence of planning measures would have been constructed elsewhere with the measures in place. Therefore, there would be no change in the number of applications to the Council for building permits with or without the measures. This assumption may cause costs to be underestimated where, for whatever reason, the UFZ is a particularly attractive area, either for relocation by existing residents of the town or for people from outside the area, such as capital city retirees. Such relocation may not occur if development of the area of the UFZ is prohibited.

Second, in relation to the LSIO outside the UFZ, it is assumed that the number of buildings would be the same with and without the planning measures. In other words, someone wishing to build in such locations does so and bears the additional costs. Therefore, there would be no change in the number of applications for planning permits in this area. This assumption is based on the experience of officers of the Planning Department of the Shire of Campaspe (J Brennan and D Merrett pers. comm.).

The net benefit per building is the difference between the gross benefit per building and the costs per building. In order to compare the gross benefit per building with the cost per building it is necessary to convert the gross annual benefit to an equivalent lump sum by discounting the stream of annual benefits over the life of the building (see Appendix 2). The magnitude of this lump sum depends on the length of life of the building and the discount rate that is used. Building life is uncertain and for the purposes of the analysis is assumed to be 30 years for all classes of building. Two real (inflation free) discount rates should be used to show the sensitivity of the net benefit to this parameter. Discount rates of 4 per cent and 8 per cent are used in the case studies.

Another form of cost of the planning measures, particularly as they relate to the UFZ, which could be evaluated per building is any reduced profit (in the case of businesses) or reduced utility (in the case of home owners) from being prevented from building in the preferred location (see Section 5.1.1). The estimation of these cost is a complex exercise beyond the scope of a rapid assessment. While they are excluded from the formal analysis the existence of these costs cannot be ignored. The AAD per building in the UFZ in the absence of the planning measures is a guide to the maximum value such losses might attain for the measures to be economically sound. In other words, if the AAD of a new residence in the UFZ were $2,000, the measures would be economically sound provided the loss of utility to a household from living elsewhere were no more than the equivalent of $2,000 per year.

Indirect costs associated with the planning measures might include the following.

- Any additional building and infrastructure costs incurred at the second best site (off the floodplain). It is, of course, possible that building and infrastructure costs may be lower, in which case the planning measures would produce an indirect benefit. Such costs (or benefits) are unlikely to be sufficiently great in most rural areas of Victoria to be of consequence within the limits of accuracy of the rapid assessment. If they are considered relevant, they are best considered on an area basis rather than per building.

- Any environmental degradation at the second best building site may also constitute an indirect cost of the planning measures. This would need to be compared to the (possibly greater) benefit of enhancing the environment of the UFZ by preventing development close to the river with the added possibility of increased recreational opportunities. These costs and benefits are also best considered on an area basis.

6.10 Step 8: (Optional) Predict numbers of each type of building in each sub-area in the future with and without planning measures

This and subsequent Steps would be undertaken if it were desired to estimate the net benefits of the planning measures for the whole study area, such as, all of Echuca. If the purposes of the analysis were served by the results of Step 7 - the net benefits for each type of building in each sub-area - the analysis would stop at Step 7. An analysis that stops at Step 7 would not estimate the total benefits and costs because it would not give consideration to the environmental and infrastructure benefits or cost mentioned above. On the other hand, these could be considered as a separate issue.

This is the most difficult and challenging Step in the analysis because it involves hypothetical situations. For example, if measures are already in place we need to consider: "how many buildings of each type might there be in each sub-area each year for the next, say, 30 years if the measures were not in place?" These numbers would need to be compared with the prediction of the numbers of buildings over the same period with the measures in place - also a challenging and difficult task.

6.10.1 Who should make the predictions

These predictions should be undertaken by those with an intimate knowledge of the floodplain and who are in positions to gauge the pressure for development in various parts of it. Members of local government planning departments, the Floodplain Manager and, possibly, estate agents appear to be the most appropriate ‘experts’ to undertake the task.

There is no best method by which a consensus among the experts is sought, if indeed a consensus is possible. A small group discussion in which the experts strive for a consensus view by putting forward their views and revising them in light of discussion, justification and criticism proved useful in the case studies. Other possible approaches might include an averaging process used by the consultant after individual interviews with each of the experts, or a simplified "Delphi" method in which written responses were invited from the panel with the opportunity for each member to review and revise his estimates in isolation after considering the responses of the other members.

6.10.2 The UFZ

As indicated above, it will usually only be necessary to predict building numbers for the UFZ without the measures because new development is prohibited by the measures, although replacement of existing buildings is possible (see Step 4c). Nevertheless, prediction of building numbers without the measures in place is particularly difficult for the UFZ or sub-areas of it. In some towns, the land that is now the UFZ may have many desirable characteristics as residential land, such as closeness to the river with pleasing settings and outlooks. In the absence of the planning measure that restricts residential development there may well have been considerable pressures for development in the area. It is the result of this pressure that needs to be predicted.

When making such predictions, the expects should be encourage to consider how people might have adapted to the evolving history of flooding on the land that is now the UFZ. It might be argued that chaotic development would be unlikely because of the topography of the area and the cumulative experience of the community concerning flooding in these areas. For example, it is understood that no form of planning controls existed in Echuca before the 1940s, yet there was relatively little development of what is now the Echuca UFZ after the large flood of 1870. In any town, land that is now classified as a UFZ has had a long history of severe flooding and some parts, at least, may be recognised by the community a hazardous area. This suggests that individuals, developers, and councils (for example, by not having supplied services) give some consideration to the cost of damage from living in the severely flooded area compared to their next best area. Thus, for example, it was considered appropriate to define five sub-areas in the Echuca UFZ, but it was judged that development pressures would have been felt in only two of these without planning measures (Section 7.1).

6.10.3 LSIO outside the UFZ

During the course of the Echuca and Rochester case studies, the experts indicated their belief that the number of buildings (residential and commercial) in the LSIO outside the UFZ would be little different whether or not planning provisions were in place. The experts believed that the existence of the planning measures had little effect on a person's willingness to build in their desired location. With the provisions in place they are required to pay a higher cost, without the provisions they would still build the house but at lower cost. This is noticeably the case in Rochester where a large proportion of the town is within the LSIO. If this belief is generally true, the prediction of building numbers with and without the planning provisions is simplified because they would be the same in each case.

6.10.4 Possible outcomes

The ideal outcome from this step would be the growth in the number of buildings of each type in a given sub-area for the time period of interest. In the case of the UFZ, the growth without the provisions is all that would usually be required. For the LSIO, if the above assumption is judged reasonable, the growth in the number of buildings is the ideal outcome.

For the UFZ, prediction of the likely number of buildings is likely to be difficult but the experts may find prediction of the time pattern of growth impossible. In these circumstances a simplified benefit-cost analysis that does not make use of discounting future costs and benefits would be employed.

Confidence in the results of such explorations is low because of the limited degree to which respondents may be prepared to commit themselves to judgements about non-existent states of the world. Therefore, the level of confidence in estimates of the benefits of land use planning for a study area, such as, a town, will be lower than the estimates per building. 'What if' scenarios with wide ranging sensitivity analysis may need to be used.

When these predictions are being elicited, the number of buildings that would fully occupy a sub-area - the 'capacity' of the sub-area - must also be borne in mind. Under existing zoning arrangement (not related to flooding) no further development is possible once the 'capacity' of the sub-area is reached.

6.11 Step 9: Estimate net benefit for each sub-area

6.11.1 UFZ sub-areas

The predicted number of buildings of each type in each year multiplied by the AAD per building without the planning measures represents the stream of benefits due to foregone building over the period of interest. The present value of this stream of benefits can be interpreted as the aggregate building damages avoided in the UFZ by the planning measures.

This figure may be adjusted by other benefits or costs for the area that are associated with fewer buildings in the UFZ, if those benefits or costs can be quantified. If quantification is not possible the potential for such benefits/costs should be noted.

As discussed above, environmental and recreational benefits associated with open space might be significant, as might reduced disruptions to business. Fewer people in the sub-areas may also lower indirect costs, such as emergency response, emergency food and accommodation. Intangible social costs, such as anxiety and stress, and illnesses would also be lower because of fewer people being exposed to flooding.

6.11.2 The LSIO sub-areas

The above benefits may also be relevant to the LSIO sub-areas if the planning measures result in fewer buildings and people exposed to risk compared to the situation without the measures. On the other hand, if the assumption that the number of buildings is not affected by the planning measures is generally true, the scope for environmental benefits is reduced but benefits due to reduced indirect costs and intangible costs may remain.

This Section describes the analysis of the urban area of the rural city of Echuca using the Steps of the methodology.

7.1 Step1: Divide the study area into sub-areas according to depth of flooding

On the advice of the Floodplain Manager of the NCCMA (Mr G Hall), the Echuca UFZ was divided into five approximately homogeneous sub-areas on the basis of the depth of flooding that would occur in a flood of a given ARI. On the same basis, three sub-areas in the remainder of the LSIO were defined. The Echuca sub-areas of the UFZ are defined below. It was deemed appropriate to exclude three of these from further consideration because it was judged that development was unlikely in the absence of planning measures.

EUFZ1 That part of Echuca UFZ influenced by the Campaspe River and known as Echuca West. West of Campaspe River and fringed by Campaspe Esplanade. This area is included in the analysis because it was judged that development was likely in absence of planning measures. Indeed, 33 houses have been acquired by government in this area during recent years.

EUFZ2 Echuca UFZ east of the Campaspe River in the vicinity of Martin Street. Included in the analysis because it was judged that there would be some pressure for development in the absence of planning measures.

EUFZ3 Golf course. Excluded from the analysis.

EUFZ4 Echuca UFZ in the vicinity of High Street South. Excluded from analysis because area lies in a basin and development was judged to be unlikely in the absence of planning measures.

EUFZ5 Echuca UFZ in East Echuca, north of Anstruther St and south of Murray River. Excluded from analysis because area is forested and without services, it was judged that development would be unlikely in the absence of planning measures.

The three sub-areas in the remainder of the Echuca LSIO were:

ELSIO1 Shallow outer edge of Echuca LSIO on the eastern edge of city with levee protection in vicinity of Goulburn Rd. and Moore St. Levees give protection up to 30-year flood.

ELSIO2 Deeper areas closer to levees of Echuca LSIO on the eastern edge of city with levee protection in vicinity of Goulburn Rd. and Moore St. Levees give protection up to 30-year flood.

ELSIO3 Narrow segments of the Echuca LSIO along the Campaspe River, such as, at the end of Martin St., and in the vicinity of Rutley Crt and Tangey Lane.

ELSIO4 Echuca LSIO in the city centre in the vicinity of High, Pakenham, Anstruther, and Heygarth Sts. This sub-area is protected by levees up to 100-year flood.

7.2 Step 2: Estimate the value of typical examples of the types of buildings in the study area.

7.2.1 Step2a: Without planning measures

Average construction costs were estimated for all types of buildings using *Rawlinson's Australian Construction Handbook* (2002) and with the assistance of Peter Scully, Architect.

Residential

For the entire Echuca study area it was estimated that more than 80 per cent of new houses are single storey, brick veneer on slab with a pitched metal roof of Colorbond or tiles (J Brennan and D Merrett, Planning Department, Campaspe Shire, and G Hall, CMA, pers. comms.). For the 'without planning measures' scenario, the slab is at the height that is usual when flooding is not an issue - 250 mm above ground. Sites are generally flat. Floor area is about 200 sq m. The house consists of three bedrooms, master bedroom with *en suite*, combined living/dining area, study, kitchen, bathroom, and separate toilet. Bedrooms, study and living/dining are carpeted and there are built-in robes in all bedrooms (chipboard with veneeer). Internal walls are of plasterboard over the wooden frame. The kitchen, bathroom, *en suite*, and toilet have mid-range tiles on floors and mid-range fittings. The house has ducted gas heating and an in-built evaporative cooling unit to cool the whole house. The numbers, sizes and frames of windows are typical of this style of house. A double garage is attached within the roof line and a simple pergola stretches along one long side of rectangle.

The construction cost (excluding GST) used in the case study for this typical residence was $227,000 (for details, see Appendix 3).

A weatherboard house of the same floor area with hard wood flooring at 450 mm above ground is estimated to costs about $192,000 (Appendix 3).

Residential extensions

It was assumed that a typical extension is single storey with a floor area of about 60 sq m and contains a bathroom. The construction cost used in the case study for an extension was $70,000

Commercial

A typical commercial building in Echuca has a slab floor, three masonry walls, a glass front with parapet and a verandah. The roof may be pitched or flat. Typical floor area is assumed to be about 150 sq. m. The construction cost used in the case study for this building was $110,000.

Industrial

A typical industrial building in Echuca has a slab floor, a masonry front with a bull-nosed section containing an office, a separate display room, and three colourbond walls. Typical floor area is assumed to be about 1,000 sq. m. The total cost was assumed to be $417,000.

7.2.2 Step 2b: With planning measures

The average floor height above ground level stipulated in approved permit applications for residential buildings over the last four years in Echuca was estimated by the Floodplain Manager to be about 700 mm. Costs per 100 mm were estimated as set out below and applied to the necessary floor heights in each sub-area to estimate total costs for each building - see Step 5.

The costs of other requirements, such as the height of power outlets and sewerage fittings were assumed to be negligible.

Residential

The estimated cost of the typical brick veneer residential building with slab floor to 700 mm above ground in Echuca was $245,000 (Appendix 3). The cost per 100 mm to raise a slab floor is assumed to be $4,000. The cost for a weatherboard house with a hardwood floor to 700 mm above ground was estimated to be $195,000, an extra cost of about $1,000 per 100 mm. Replacement buildings in the EUFZ1 and 2 may be required to be on steel pillars rather than high slabs. The extra cost for such construction was assumed to be about $1,500 per 100 mm.

Residential extensions

Raised extensions of 60 sq m on slabs were assumed to have a cost per 100 mm proportional to a full residence, namely, $1,200 (calculated as $90 sq m x 60 sq m)/4.5). Raised extensions on steel pillars were assumed to cost $450 per 100 mm.

Commercial

Raising the floor level to 700 mm is assumed to cost the same per sq m as a residential building with a slab floor, namely, $90/ sq m. The total cost of the typical commercial building was assumed to be $125,000, an extra $15,000 or about $3,300 per 100 mm.

Industrial

The total cost of a typical industrial building with floor raised to 700 mm above ground was assumed to be $510,000, an extra $93,000 or about $20,600 per 100 mm.

7.3 Step 3: Estimate the value of typical contents in the various types of buildings in the study area.

7.3.1 Residential

The contents of a typical residence were assumed to be the same for all the sub-areas of Echuca. An insurance company room by room checklist was used to guide pricing expeditions to a cross section of stores supplying household goods. The total value of contents was assessed at $51,000 in round figures (details are provided in Appendix 4). This figure compares with the average sum insured assumed by Blong (2001) for the Georges River catchment of NSW of $54,274.

7.3.2 Residential extension

The value of the contents of a residential extension is assumed to be one-sixth of a full residence, namely, $8,500.

7.4 Step 4: Estimate AAD per building for each type of building in each sub-area of the study area without the planning measures

7.4.1 Step 4a: Flood events

For the various sub-areas of Echuca, floods with the following ARIs were estimated to produce the indicated depths of flooding. The rare flood is based on the flood of 1870 for which it is estimated that the depths of flooding were about 600 mm greater than the 100-year flood. It is believed that such a flood may have an ARI of about 200 years and that estimate is used in the analysis. The estimates were provided G Hall, Floodplain Manager, NCCMA.

If damage data were available for all types of buildings, these depths and the associated ARIs would be relevant for all types of buildings.

Echuca Urban Flood Zone

Table 7-1: EUFZ1

Flood	Damage condition and depth of water overfloor	Estimated ARI
Flood 1	Underfloor damage commences	5
Flood 2	Max. underfloor damage	10
Flood 3	0.5 m	17
Flood 4	1.0 m	50
Flood 5	1.3 m	100
Flood 6	1.9 m	200

Table 7-2: EUFZ2

Flood	Damage condition and depth of water overfloor	Estimated ARI
Flood 1	Underfloor damage commences	5
Flood 2	Max. underfloor damage	8
Flood 3	0.5 m	20
Flood 4	Na	Na
Flood 5	1.0 m	100
Flood 6	1.6 m	200

Na not applicable. In this sub-area, 1.0 m overfloor depth is produced by the 100-year flood.

Remainder of Echuca LSIO

Table 7-3: ELSIO1

Flood	Damage condition and depth of water overfloor	Estimated ARI
Flood 1	Underfloor damage commences	30 (levee protection to this ARI)
Flood 2	Max. underfloor damage	70
Flood 3	Na	Na
Flood 4	Na	Na
Flood 5	0.1 m	100
Flood 6	0.7 m	200

Na not applicable. In this sub-area, the ARI of a flood producing a depth of 0.5 m is unknown but greater than 100 years. A flood of 1.0 m does not occur within the observed range of floods.

Table 7-4: ELSIO2

Flood	Damage condition and depth of water overfloor	Estimated ARI
Flood 1	Underfloor damage commences	30 (levee protection to this ARI)
Flood 2	Max. underfloor damage	30
Flood 3	Na	Na
Flood 4	Na	Na
Flood 5	0.5 m	100
Flood 6	1.1 m	200

Na not applicable. In this sub-area, the ARI of a flood producing a depth of 0.5 m is 100 years.

Table 7-5: ELSIO3

Flood	Damage condition and depth of water overfloor	Estimated ARI
Flood 1	Underfloor damage commences	10
Flood 2	Max. underfloor damage	18
Flood 3	0.5 m	50
Flood 4	Na	Na
Flood 5	0.9 m	100
Flood 6	1.5 m	200

Na Not applicable. The ARI of a flood producing 1.0 m depth is unknown but greater than 100 years.

Table 7-6: ELSIO4

Flood	Damage condition and depth of water overfloor	Estimated ARI
Flood 1	Underfloor damage commences	100 (levee protection to this ARI)
Flood 2	Max. underfloor damage	105
Flood 3	Na	Na
Flood 4	Na	Na
Flood 5	see Flood 1	See Flood 1
Flood 6	0.6 m	200

Na Not applicable. In this sub-region, a flood producing a depth of 0.5 m is unknown but greater than 100 years. A flood producing a depth of 1.0 m does not occur within the observed range of floods.

7.4.2 Step 4b: Depth/damage relationships

The risk frontiers described in Section 6.6.2 were applied to the structure and contents of the typical residential, and commercial and industrial buildings in Echuca. The structural damage for the typical residential extension was assessed using the risk frontier for the entire residence.

7.4.3 Step 4c: Calculate AADs for each type of building in each sub-area

The estimated AADs per building in the absence of planning measures are shown in Table 7-7.

Table 7-7: Estimated AADs per building without planning measures in sub-areas of Echuca

Echuca sub-area	Residential building	Residential extension	Commercial building	Industrial building
EUFZ1	$7,441	$1,827	$2,104	$14,028
EUFZ2	$7,555	$1,850	$2,101	$14,008
ELSIO1	$931	$227	$257	$1,715
ELSIO2	$1,908	$463	$500	$3,333
ELSIO3	$3,430	$844	$996	$6,639
ELSIO4	$764	$183	$186	$1,237

7.5 Step 5: Estimate AAD per building for each type of building in each sub-area of the study area with the planning measures

Step 4 was repeated using the building construction costs with the planning measures in place as estimated in Step 2b and the same building contents as estimated in Step 3. The following were the assumed increases in floor height in each sub-area, the additional costs and total costs for residences and residential extensions for consistency with the planning provisions. It was assumed that commercial or industrial development would be likely only in ELSIO1 and ELSIO3. In other areas, zoning restrictions or the expense of compliance with the planning measures would make development unlikely.

Table 7-8: Estimated floor heights and building costs with planning measures

Sub-area	Extra floor ht. (mm)	Res. Extra cost	Res. Total cost	Ext. Extra cost	Ext. Total cost	Comm. Extra cost	Comm. Total cost	Ind. Extra cost	Ind. Total cost
EUFZ1	1,200	$18,000	$245,000	$5,400	$75,400	na	na	na	na
EUFZ2	1,000	$15,000	$242,000	$4,500	$74,500	na	na	na	na
ELSIO1	100	$4,000	$231,000	$1,200	$71,000	$3,300	$113,300	$20,600	$437,600
ELSIO2	500	$7,500	$234,500	$2,250	$72,000	na	na	na	na
ELSIO3	900	$13,500	$240,500	$4,050	$74,050	na	na	na	na
ELSIO4	$0	$0	$0	$0	$0	$0	$0	$0	$0

7.5.1 Step 5a: Flood events

The following damage conditions and depths of overfloor flooding were assumed to be caused by floods with the indicated ARIs in each of the sub-areas of Echuca.

Echuca UFZ

Table 7-9: EUFZ1

Flood	Damage condition and depth of water overfloor	Estimated ARI
Flood 1	Underfloor damage commences	5
Flood 2 (synonymous with Flood 5)	Max. underfloor damage	100
Flood 6	0.7	200

Table 7-10: EUFZ2

Flood	Damage condition and depth of water overfloor	Estimated ARI
Flood 1	Underfloor damage commences	5
Flood 2 (synonymous with Flood 5)	Max. underfloor damage	100
Flood 6	0.6	200

Echuca LSIO

Table 7-11: ELSIO1 and ELSIO2

Flood	Damage condition and depth of water overfloor	Estimated ARI
Flood 1	Underfloor damage commences	30
Flood 2 (synonymous with Flood 5)	Max. underfloor damage	100
Flood 6	0.6	200

Table 7-12: ELSIO3

Flood	Damage condition and depth of water overfloor	Estimated ARI
Flood 1	Underfloor damage commences	10
Flood 2 (synonymous with Flood 5)	Max. underfloor damage	100
Flood 6	0.6	200

Table 7-13: ELSIO4

Flood	Damage condition and depth of water overfloor	Estimated ARI
Flood 1 (synonymous with Flood 5)	Underfloor damage commences	100
Flood 2 (synonymous with Flood 6)	Max. underfloor damage	200

7.5.2 Step 5b: Depth/damage relationships

See Step 4b.

7.5.3 Step 5c: Calculate AADs for each type of building in each sub-area

The estimated AADs per building with the planning measures in place are shown in Table 7-14.

Table 7-14: Estimated AADs per building in sub-areas of Echuca with planning measures

Echuca sub-area	Residential building	Residential extension	Commercial building	Industrial building
EUFZ1	$1,358	$361	na	na
EUFZ2	$1,286	$344	na	na
ELSIO1	$829	$203	$227	$1,511
ELSIO2	$836	$204	na	na
ELSIO3	$1,021	$262	na	na
ELSIO4	$764	$183	$186	$1,237

7.6 Step 6: Estimate the gross annual benefit of the planning measures for each type of building in each sub-area

The AADs for each type of building in each sub-area in Echuca estimated in Step 5c are subtracted from those estimated in Step 4c. The difference in the AAD for each type of building in each sub-area represents is the gross annual benefit of the planning measures for that type of building in each sub-area in Echuca (Table 7-15).

Table 7-15: Estimated gross annual benefit of planning measures per building in sub-areas of Echuca

Echuca sub-area	Residential building	Residential extension	Commercial building	Industrial building
EUFZ1	$6,083	$1,466	na	na
EUFZ2	$6,269	$1,506	na	na
ELSIO1	$102	$24	$30	$204
ELSIO2	$1,072	$259	na	na
ELSIO3	$2,409	$582	na	na
ELSIO4	$0	$0	$0	$0

7.7 Step 7: Estimate the net benefit per building of the planning measures for each type of building in each sub-area

The discounted (present) value of the gross annual benefits for a period of 30 years for each type of building in each sub-area of Echuca are shown Table 7-16 for discount rates of 4 and 8 per cent.

Table 7-16: Present (lump sum) value of gross annual benefit of planning measures per building in sub-areas of Echuca

Echuca sub-area	Residential building		Residential extension		Commercial building		Industrial building	
	4 per cent	8 per cent	4 per cent	8 per cent	4 per cent	8 per cent	4 per cent	8 per cent
EUFZ1	$105,187	$68,481	$25,350$	$16,503	na	na	na	na
EUFZ2	$108,403	$70,575	$26,041	$16,054	na	na	na	na
ELSIO1	$1,764	1,148$	$415	$270	$519	$337	$3,527	$2,206
ELSIO2	$18,537	$12,068	$4,478	$2,015	na	na	na	na
ELSIO3	$41,656	27,120$	$10,064	$6,552	na	na	na	na
ELSIO4	$0	$0	$0	$0	$0	$0	$0	$0

The total extra costs for the various buildings in each sub-area to comply with the planning measures were set out in Table 7-8. Subtracting those costs from the benefits in Table 7-16 gives the net benefits per building of the planning measures in Echuca that are shown in Table 7-17.

Table 7-17: Estimated net benefits (benefit cost ratio) of planning measures per building in sub-areas of Echuca

Echuca sub-area	Residential building		Residential extension		Commercial building		Industrial building	
	4 per cent	8 per cent	4 per cent	8 per cent	4 per cent	8 per cent	4 per cent	8 per cent
EUFZ1	$87,187 (5.84)	$50,481$ (3.81)	$19,950 (4.69)	$11,104 (3.05)	na	na	na	na
EUFZ2	$93,403 (7.22)	$55,575 (4.71)	$21,541 (5.78)	$12,454 (3.76)	na	na	na	na
ELSIO1	-$2,236 (0.44)	-$2,851 (0.29)	-$785 (0.34)	-$929 (0.23)	-$2,781 (0.16)	-$2,962 (0.10)	-$17,072 (0.17)	-$18,303 (0.11)
ELSIO2	$11,037 (2.47)	$4,568 (1.61)	$2,228 (2.00)	$665 (1.29)	na	na	na	na
ELSIO3	$28,056 (3.06)	$13,520 (2.00)	$6,013 (2.48)	$2,502 (1.61)	na	na	na	na
ELSIO4	$0	$0	$0	$0	$0	$0	$0	$0

7.8 Conclusions from the benefit-cost analysis of buildings

Bearing in mind the considerable uncertainty surrounding the results, we draw the following indicative conclusions from the analysis of each type of building in each sub-area.

The prohibition of new buildings in EUFZ1 and EUFZ2 has avoided annual damages (the AAD without the measures) estimated to be of the order of $7,500 per typical residence in each sub-zone, about $2,000 per commercial building, and about $14,000 per industrial building, for each building that might otherwise have been constructed. If the life of a building were 30 years, these annual losses would correspond to the following present values over the life of the building.

Residence	about $130,000 (4% discount) or $85,000 (8% discount)
Commercial	about $40,000 (4% discount) or $28,000 (8% discount)
Industrial	about $236,000 (4% discount) or $152,000 (8% discount)

- Requiring any replacement residential buildings in EUFZ1 and EUFZ2 to comply with the floor heights consistent with the 100-year flood would produce net benefits equivalent to present values (over 30 years) of avoided loses (less extra building costs) of the order of:

EUFZ1	about $87,000 (4% discount) or $50,000 (8% discount)
EUFZ2	about $93,000 (4% discount) or $56,000 (8% discount)

The benefit-cost ratios relevant to replacement buildings in these two sub-area (Table 7-17) are close to 4:1 or greater. A ratio of 4:1 indicates that for every extra $1 of building cost, $4 worth of damage is avoided (AAD 'without' minus AAD 'with'). This conclusion would remain valid even if extra building costs were up to more than double those assumed in the analysis.

- Ensuring that any residential extensions in the two sub-areas of the UFZ comply with floor height requirements also avoids considerably more damage than the cost of the buildings. This conclusion would also remain valid even if extra building costs were up to more than double those assumed in the analysis.

- The analysis of buildings in ELSIO2 and ELSIO3 shows that requiring buildings to comply with the floor heights consistent with the 100-year flood avoids a greater value of damage than the extra building costs. Indicative benefit cost ratios are about 2.

- The indicative conclusion that could be drawn from the analysis of ELSIO1 is that the extra building costs exceed the damages avoided for all types of building. This may be a valid conclusion but there is a high level of uncertainty concerning the flooding depths and the ARIs in this shallow flooding area on the fringe of the LSIO.

- Because ELSIO4 is protected by levees to the estimated height of the 100-year flood, there is no gain from compliance with the floor height requirements.

7.9 Step 8: Predict numbers of each type of building in each study area in the future with and without planning measures

7.9.1 EUFZ1

In the absence of planning measures, the Floodplain Manager believed that about one-third of this area might have been developed leading to about an additional 60 houses. The time pattern by which this development might have occurred could not be predicted. Also, over time, there would have been extensions to some of these residences.

7.9.2 EUFZ2

The Floodplain Manager believed there might have been about ten additional residences in this sub-region in the absence of planning measures, probably in the form of rural residences on large blocks. The time pattern of development could not be predicted.

7.9.3 ELSIO1, ELSIO2, ELSIO3 and ELSIO4

Residential development

Members of the Planning Department of the Shire of Campaspe (J Brennan and D Merrett) believed that the numbers of units or single dwellings might grow at a maximum rate of about 7 to 10 per year with or without the planning measures. That rate of growth would persist for about 10 years at which time there would be no room in these areas for further development of single dwellings. Extensions to existing and new houses would continue to grow for a longer period at around 10 per year. It is assumed that these numbers of residences and extensions are equally distributed across the four sub-areas.

Commercial development

Members of the Planning Department of the Shire of Campaspe believe that commercial development would tend to concentrate ELSIO4 on the west side of High St. The expectation was for about there might be about one or two applications for planning permits per year where flooding was an issue. Heritage controls are also an important issue in this area. We have also assumed that there may also be some commercial development in ELSIO1.

7.10 Step 9: Estimate net benefit for each sub-area

7.10.1 EUFZ1

If 60 additional typical residences had been constructed in this sub-area, the annual average losses would have been about $450,000 ($7,441 x 60) when all the houses had been built. A present value of this potential annual benefit cannot be estimated because the time pattern of the development is unknown. An upper limit is established by assuming that all houses were built in year 1 of a 30 year time period. The present value of $450,000 per year at a discount rate of 4 per cent (8 per cent) for 30 years is $7.1 million ($5.1 million).

Such benefits from avoided building damage are enhanced by the open space and recreational opportunities created by the prohibition on new development. This has not been valued due to lack of data on numbers of users.

7.10.2 EUFZ2

If 10 additional typical residences had been constructed in this sub-area, the annual average losses would have been about $75,000 when all the houses had been built. Using the same reasoning as for EUFZ1, an upper limit on the present value of these avoided damages at a discount and of 4 per cent (8 per cent) would be $1.3 million ($0.8 million). Open space was also created by the planning measures but no information on use is available.

7.10.3 ELSIO1, ELSIO2, ELSIO3 and ELSIO4

Residential development

We assume a total of 8 new residences per year, two in each sub-area, for 10 years. Ten extensions per year are assumed, 2.5 in each sub-region for a period of 30 years. Using new residences in ELSIO2 as an example, we note that the two in year 1 would have a present value of net benefits over 30 years of $22,074 (2 x $11,037, Table 7-17) at a discount rate of 4 per cent. The two built in year 2 would have the same net benefit discounted to year 2. To obtain the present value of this net benefit in year 1, the $22,074 would have to be discounted over one year ($21,224) and added to the net benefit of the two built in year 1 to give the total benefit measured in year 1 ($43,298). This process is repeated for each of the 10 years for new buildings and 30 years for extensions (Table 7-18).

Table 7-18: Estimated residential benefits in LSIO sub-areas at 4 per cent (8 per cent)

Sub-area of LSIO	New residences	Residential extensions
ELSIO1	-$36,000 (-$38,000)	-$34,000 (-$26,000)
ELSIO2	$179,000 ($61,000)	$96,000 ($19,000)
ELSIO3	$455,000 ($181,000)	$260,000 ($70,000)
ELSIO4	$0 ($0)	$0 ($0)
Total for building type	$598,000 ($204,000)	$322,000 ($63,000)
Total for all sub-areas	$920,000 ($267,000)	

If the true value for ELSIO1 were zero, the total benefit for all sub-areas at the predicted rates of growth would be $990,000 ($331,000).

Commercial development

It appears from the indicative conclusions that there would be little, if any, net benefit from compliance with the floor height requirement for commercial or industrial development in the LSIO of Echuca. This is because the main commercial area is protected up to the 100-year flood and there may be little development in ELSIO1.

7.11 Total for Echuca

Aggregating these indicative conclusions across all sub-areas suggests a total net benefit over a period of 30 years at a discount rate of 4 per cent (8 per cent) of up to about $9.3 million ($6.2 million). Most of this benefit would derive from the prohibition of new development in EUFZ1.

Finally, it is again emphasised that these must be regarded as indicative results because of the considerable uncertainty about the data that forms the basis of the analysis.

This Section describes the analysis of the urban area of the town of Rochester using the Steps of the methodology.

8.1 Step1: Divide the study area into sub-areas according to depth of flooding

On the advice of the Floodplain Manager of the NCCMA (Mr G Hall), the Rochester UFZ was divided into two approximately homogeneous sub-areas on the basis of the depth of flooding that would occur in a flood of a given ARI. On the same basis, two sub-areas in the remainder of the LSIO were defined. The sub-areas of the Rochester UFZ are defined below.

RUFZ1 Rochester UZF west of Campaspe River, east of railway line and north of Elizabeth St. in the vicinity of Moore and Mackay Sts, together with the area east of Campaspe River in vicinity of Church St and Stephen St.

RUFZ2 Rochester UFZ west of Campaspe River in the vicinity of Campaspe St.

The two sub-areas in the remainder of the Rochester LSIO were:

RLSIO1 Outer one-third of Rochester LSIO area

RLSIO2 Remaining two-thirds of Rochester LSIO area.

8.2 Step 2: Estimate the value of typical examples of the types of buildings in the study area.

8.2.1 Step2a: Without planning measures

Average construction costs were estimated for all types of buildings using *Rawlinson's Australian Construction Handbook* (2002) and with the assistance of Peter Scully, Architect.

Residential

The residential building judged to be typical of Rochester had the same basic characteristics and configuration as the typical residence in Echuca. However, it was judged that the standard of finish would be somewhat lower. A construction costs of $800/sq m was used, which, with the same 'extras' (garage, heating etc.) as the Echuca house, gave a total cost of $197,000.

Residential extensions

As for Echuca. Total cost is $70,000.

Commercial (retail) building

As for Echuca. Total cost (rounded) is assumed to be $110,000.

Industrial building

As for Echuca. Total cost is assumed to be $417,000.

8.2.2 Step 2b: With planning measures

The average floor height above ground level stipulated in approved permit applications for residential buildings over the last four years in Rochester was estimated by the Floodplain Manager to be about 700 mm.

The costs of other requirements, such as the height of power outlets and sewerage fittings were assumed to be negligible.

Residential

The estimated extra cost of the typical brick veneer residential building with slab floor to 700 mm above ground in Rochester was the same as for Echuca, bringing the total cost to $215,000 (Appendix 3). The cost for a weatherboard house with a hardwood floor to 700 mm above ground was estimated to be $195,000. Costs per 100 mm were calculated as for Echuca.

Commercial

As for Echuca. Total cost is assumed to be $128,000. Costs per 100 mm were calculated as for Echuca.

Industrial

As for Echuca. Total cost is assumed to be $510,000. Costs per 100 mm were calculated as for Echuca.

8.3 Step 3: Estimate the value of typical contents in the various types of buildings in the study area.

Residential

As for Echuca. Total cost is assumed to be $51,000.

Residential extension

The value of the contents of a residential extension is assumed to be one-sixth of a full residence, namely, $8,500.

8.4 Step 4: Estimate AAD per building for each type of building in each sub-area of the study area without the planning measures

8.4.1 Step 4a: Flood events

For the various sub-areas of Rochester, floods with the following ARIs were estimated to produce the indicated depths of flooding. The rare flood is based on the flood of 1906 that records suggest is the largest flood in Rochester. The ARI is estimated at 1 in 200 but the depth of flooding for this ARI is uncertain. In the first instance, it is assumed to be about 300 mm greater than the 100-year flood. Indeed the flat country of Rochester makes it very difficult associate ARIs and the resultant depths of flooding.

Rochester Urban Flood Zone

Table 8-1: RUFZ1

Flood	Damage condition and depth of water overfloor	Estimated ARI
Flood 1	Underfloor damage commences	10
Flood 2	Max. underfloor damage	18
Flood 3	Na	Na
Flood 4	Na	Na
Flood 5	0.6 m	100
Flood 6	0.9 m	200

Na Not applicable. In this case, 0.5 m overfloor depth is produced by a flood close to the 100-year flood and depths do not reach 1.0 m in the observed range of floods.

Table 8-2: RUFZ2

Flood	Damage condition and depth of water overfloor	Estimated ARI
Flood 1	Underfloor damage commences	10
Flood 2	Max. underfloor damage	15
Flood 3	0.5 m	70
Flood 4	Na	Na
Flood 5	0.9 m	100
Flood 6	1.2 m	200

Na not applicable. In this sub-area, the ARI of the flood producing 1.0 m overfloor depth is unknown but greater than the 100-year flood.

Remainder of Rochester LSIO

Table 8-3: RLSIO1

Flood	Damage condition and depth of water overfloor	Estimated ARI
Flood 1	Underfloor damage commences	10
Flood 2	Max. underfloor damage	100
Flood 3	Na	Na
Flood 4	Na	Na
Flood 5	see Flood 2	See Flood 2
Flood 6	0.2 m	200

Na not applicable. In this sub-area, the ARIs of floods producing an overfloor depths of 0.5 m and 1.0 m are unknown and outside the observed range of floods.

Table 8-4: RLSIO2

Flood	Damage condition and depth of water overfloor	Estimated ARI
Flood 1	Underfloor damage commences	20
Flood 2	Max. underfloor damage	50
Flood 3	Na	Na
Flood 4	Na	Na
Flood 5	0.2 m	100
Flood 6	0.5 m	200

Na Not applicable. The ARI of a flood producing 1.0 m depth is unknown but greater than 200 years.

8.4.2 Step 4b: Depth/damage relationships

As for Echuca, the risk frontiers described in Section 0 were applied to the structure and contents of the typical residential building in Rochester. The structural damage for the typical residential extension was assessed using the risk frontier for the entire residence. The assumed risk frontier for commercial and industrial buildings based on total direct damage (Table 6-2) was used.

8.4.3 Step 4c: Calculate AADs for each type of building in each sub-area

The estimated AADs per building in the absence of planning measures are shown in Table 8-5.

Table 8-5: Estimated AADs per building in sub-areas of Rochester without planning measures

Rochester sub-area	Residential building	Residential extension	Commercial building	Industrial building
RUFZ1	$2,687	$706	$801	$5,343
RUFZ2	$3,124	$851	$970	$6,466
RLSIO1	$551	$168	$273	$1,821
RLSIO2	$1,015	$286	$389	$2,596

8.5 Step 5: Estimate AAD per building for each type of building in each sub-area of the study area with the planning measures

Step 4 was repeated using the building construction costs with the planning measures in place as estimated in Step 2b and the same building contents as estimated in Step 3. Set out in Table 8-6 are the assumed increases in floor height in each sub-area, the additional costs and total costs for residences and residential extensions for consistency with the planning provisions. It was assumed that commercial or industrial development would be likely only in RLSIO1 and RLSIO3.

Table 8-6: Estimated floor heights and building costs with planning measures

Sub-area	Extra floor ht. (mm)	Res. Extra cost	Res. Total cost	Ext. Extra cost	Ext. Total cost	Comm. Extra cost	Comm. Total cost	Ind. Extra cost	Ind. Total cost
RUFZ1	700	$28,000	$225,000	$8,400	$78,400	na	na	na	na
RUFZ2	700	$28,000	$225,000	$8,400	$78,400	na	na	na	na
RLSIO1	200	$8,000	$205,000	$2,400	$72,400	$6,600	$116,000	$41,200	$458,200
RLSIO2	200	$8,000	$205,000	$2,400	$72,400	$6,600	$116,000	$41,200	$458,200

8.5.1 Step 5a: Flood events

The following damage conditions and depths of overfloor flooding were assumed to be caused by floods with the indicated ARIs in each of the sub-areas of Rochester.

Rochester UFZ

Table 8-7: RUFZ1

Flood	Damage condition and depth of water overfloor	Estimated ARI
Flood 1	Underfloor damage commences	10
Flood 2 (synonymous with Flood 5)	Max. underfloor damage	100
Flood 6	0.1 m	200

Table 8-8: RUFZ2

Flood	Damage condition and depth of water overfloor	Estimated ARI
Flood 1	Underfloor damage commences	10
Flood 2 (synonymous with Flood 5)	Max. underfloor damage	100
Flood 6	0.5 m	200

Rochester LSIO

Table 8-9: RLSIO1

Flood	Damage condition and depth of water overfloor	Estimated ARI
Flood 1	Underfloor damage commences	10
Flood 2 (synonymous with Flood 6)	Max. underfloor damage	200

Table 8-10: RLSIO2

Flood	Damage condition and depth of water overfloor	Estimated ARI
Flood 1	Underfloor damage commences	10
Flood 2 (synonymous with Flood 5)	Max. underfloor damage	100
Flood 6	0.3 m	200

8.5.2 Step 5b: Depth/damage relationships

See Step 4b.

8.5.3 Step 5c: Calculate AADs for each type of building in each sub-area

The estimated AADs per building with the planning measures in place are shown in

Table 8-11: Estimated AADs per building in sub-areas of Rochester with planning measures

Rochester sub-area	Residential building	Residential extension	Commercial building	Industrial building
RUFZ1	$461	$146	na	na
RUFZ2	$908	$257	na	na
RLSIO1	$44	$16	$35	$233
RLSIO2	$717	$210	$289	$1,930

8.6 Step 6: Estimate the gross annual benefit of the planning measures for each type of building in each sub-area

The AADs for each type of building in each sub-area in Rochester estimated in Step 5c are subtracted from those estimated in Step 4c. The difference in the AAD for each type of building in each sub-area represents is the estimated gross annual benefit of the planning measures for that type of building in each sub-area in Rochester (Table 8-12).

Table 8-12: Estimated gross annual benefit of planning measures per building in sub-areas of Rochester

Rochester sub-area	Residential building	Residential extension	Commercial building	Industrial building
RUFZ1	$2,206	$560	na	Na
RUFZ2	$2,216	$594	na	Na
RLSIO1	$507	$152	$238	$1,588
RLSIO2	$298	$76	$100	$666

8.7 Step 7: Estimate the net benefit per building of the planning measures for each type of building in each sub-area

The discounted (present) value of the gross annual benefits for a period of 30 years for each type of building in each sub-area of Rochester are shown for discount rates of 4 and 8 per cent.

Table 8-13: Present (lump sum) value of gross annual benefit of planning measures per building in sub-areas of Rochester

Rochester sub-area	Residential building		Residential extension		Commercial building		Industrial building	
	4 per cent	8 per cent	4 per cent	8 per cent	4 per cent	8 per cent	4 per cent	8 per cent
RUFZ1	$38,146	$24,834	$9,683	$6,304	na	na	na$	Na
RUFZ2	$38,319	$24,947	$10,271	$6,687	na	na	na$	Na
RLSIO1	$8,767	$5,708	$2,628	$1,711	$4,115	$2,679	$27,459	$17,877
RLSIO2	$5,153	$3,354	$1,314	$855	$1,729	$1,125	$11,516	$7,497

The total extra costs for the various buildings in each sub-area to comply with the planning measures were set out in Table 8-6. Subtracting those costs from the benefits in Table 8-13 gives the net benefits per building of the planning measures in Rochester that are shown in Table 8-14.

Table 8-14: Estimated net benefits (benefit cost ratio) of planning measures per building in sub-areas of Rochester

Rochester sub-area	Residential building		Residential extension		Commercial building		Industrial building	
	4 per cent	8 per cent	4 per cent	8 per cent	4 per cent	8 per cent	4 per cent	8 per cent
RUFZ1	$10,146 (1.36)	-$3,165 (0.89)	$1,283 (1.15)	-$2,095 (0.75)	$	$	$	$
RUFZ2	$10,319 (1.36)	-$3,052 (0.89)	$1,871 (1.22)	-$1,712 (0.80)	$	$	$	$
RLSIO1	$767 (1.09)	-$2,292 (0.71)	$228 (1.09)	-$688 (0.71)	-$2,484 (0.62)	-$3,920 (0.41)	-$13,740 (0.67)	-$23,322 (0.43)
RLSIO2	-$2,846 (0.64)	-$4,645 (0.42)	-$1,085 (0.55)	-$1,544 (0.37)	-$4,870 (0.26)	-$5,474 (0.17)	-$29,683 (0.28)	-$33,702 (0.18)

8.8 Some Sensitivity tests

These results alter little if the 200-year flood were 600 mm deeper than the 100-year flood.

The results are sensitive to the costs required to raise floor heights. Table 8-15 shows the costs to raise floors in each case for RLSIO1 and RLSIO2 such that the benefit-cost ratio equals 1.0, that is, the benefits are equal to the costs. The costs assumed in the model are also shown for comparison.

Table 8-15: Breakeven costs to raise floor heights

Rochester sub-area	Residential building		Residential extension		Commercial building		Industrial building	
	4 per cent	8 per cent	4 per cent	8 per cent	4 per cent	8 per cent	4 per cent	8 per cent
Costs assumed in model	$8,000	$8,000	$2,400	$2,400	$6,600	$6,600	$41,200	$41,200
RLSIO1	$8,700	$5,600	$2,600	$1,700	$4,000	$2,700	$28,000	$18,000
RLSIO2	$5,200	$3,300	$1,300	$850	$1,700	$1,100	$11,000	$7,500

Thus, for example, if the costs to raise the floor in a 1,000 sq m building by 200 mm in RLSIO1 were $28,000 rather than the assumed $41,200, the outlay would be returned by reduced flood damages at a discount rate of 4 per cent. For the same to be true at a discount rate of 8 per cent, the cost should not exceed $18,000.

Systematic variation of ARIs and depths to test the sensitivity of results is a complex task that is not attempted here.

8.9 Conclusions from the benefit-cost analysis of buildings

Bearing in mind the considerable uncertainty surrounding the results, we draw the following indicative conclusions from the analysis of each type of building in each sub-area.

- The prohibition of new buildings in the UFZ of Rochester has avoided annual damages (the AAD without the measures, Table 8-5) estimated to be of the order of $2,700 per typical residence in RUFZ1 and $3,100 in RUFZ2, between about $800 and $1,000 per commercial building, and between about $5,300 and $6,400 per industrial building, for each building that might otherwise have been constructed. If the life of a building were 30 years, these annual losses would correspond over the life of the building to the present values shown in Table 8-16.

Table 8-16: Present values of avoided losses from not building in UFZ

Sub-area	Residential buildings		Commercial buildings		Industrial buildings	
	4 per cent	8 per cent	4 per cent	8 per cent	4 per cent	8 per cent
RUFZ1	$46,400	$30,200	$12,200	7,900$	$92,400	$60,100
RUFZ2	$54,000	$35,100	$14,700	$9,600	$111,800	$72,800

- Requiring any replacement residential buildings in RUFZ1 and RUFZ2 to comply with the floor heights consistent with the 100-year flood would produce net benefits equivalent to present values (over 30 years) of avoided loses (less extra building costs) of the order of:

RUFZ1 about $10,100 (4% discount) or minus $3,100 (8% discount)
RUFZ2 about $10,300 (4% discount) or minus $3,000 (8% discount)

The benefit-cost ratios relevant to replacement buildings in these two sub-area are around 1.40 in RUFZ1 and around 0.9 in RUFZ2. A ratio of 1.4:1 indicates that for every extra $1 of building cost, $1.40 worth of damage is avoided (AAD 'without' minus AAD 'with'). For a benefit-cost ratio of 1.0 in RUFZ1 and RUFZ2 at a discount rate of 8 per cent the cost to raise the floor would need to be about $25,000 in both cases, compared to the assumed $28,000. Such a difference would seem to be within the likely confidence levels of the model.

- Ensuring that any residential extensions in the two sub-areas of the UFZ comply with floor heights requirements also avoids more damage than the cost of the buildings at a discount rate of 4 per cent but the case is less clear at 8 per cent.

- The model suggests that there is a clear case for raising floor heights of residences and extensions in RLSIO1 but not in RLSIO2. The case is not clear in either RLSIO1 or RLSIO2 for commercial or industrial buildings. It was shown in Table 8-15 that breakeven increases in building costs need to be reduced considerably below the assumed values for the measures to produce a benefit-cost ratio of 1.0. These breakeven costs may be closer to the costs of waterproofing strategies and raised storage areas rather than increased slab heights. Even so, when interpreting the results for commercial buildings one must be mindful of the weak relationship between depth and damage (see Section 6.6.2).

8.10 Step 8: Predict numbers of each type of building in each study area in the future with and without planning measures

RUFZ1

In the absence of planning provisions this area north of Bridge Rd. may have had some development pressure but the extent could not be predicted.

RUFZ2

Little development expected in this area.

RLSIO1 and RLSIO2

With or without provisions, the expectation of the Planning Officers of the Shire of Campaspe was about 2 applications for permits per year in which flooding would be an issue. There appears to be some scope for commercial development in the Rochester LSIO outside the UFZ.

8.11 Step 9: Estimate net benefit for each sub-area

RUFZ1 and RUFZ2

As determined above (Table 8-16), the prohibition of new houses in these sub-area has avoided damages with present values between about $30,000 and $50,000 depending on the discount rate, for each house that might have been constructed.

RLSIO sub-areas

From our indicative results, there would be a positive benefit from the planning measures if these were residences in RLSIO1. Other types of buildings would experience reduced average annual damages but the reduction appears to be less than the estimated increase in building costs. If those two houses per year were built in RLSIO1 there would be a net benefit with a present value of $1,534 at a discount rate of 4 per cent (2 x $767, Table 8-14). The present value (at 4 per cent) of this stream of annual reduction in damages would be $26,500.

If commercial development were to be considered in these areas, the indicative results suggest that careful consideration would need to be given by potential developers to the costs that might be imposed by permit conditions.

This study has produced a logical and robust methodology for assessing the economic benefits and costs of land use planning in flood affected areas in regional Victoria. Land use planning measures are aimed at reducing the damages associated with new developments on the floodplain. These measures generally involve land use controls, such as zoning, and design characteristics for buildings, such as minimum floor heights and water proofing. Planning measures can reduce the costs of flood risk by excluding some activities from the floodplain and by providing conditions under which particular developments would be allowed at locations with given flood risk.

The methodology

The core of the methodology is benefit-cost analysis in which the benefits of planning measures are evaluated as the difference between the average annual damage per building with and without the planning measures for a typical example of relevant types of buildings in various sub-areas of the floodplain. If required, the total net benefits for the LSIO may be estimated by forecasting the number of buildings of each type under each scenario, and aggregating across building types and sub-areas.

The methodology is applied using the following steps.

Step1: Divide the study area into sub-areas according to depth of flooding.

Step 2: Estimate the value of typical examples of the types of buildings in the study area with and without the planning measures.

Step 3: Estimate the value of typical contents in the various types of buildings in the study area.

Step 4: Estimate AAD per building for each type of building in each sub-area of the study area without the planning measures.

Step 5: Estimate AAD per building for each type of building in each sub-area of the study area with the planning measures.

Step 6: Estimate the gross annual benefit of the planning measures for each type of building in each sub-area.

Step 7: Estimate the net benefit of the planning measures for each type of building in each sub-area.

Step 8: (Optional) Predict numbers of each type of building in each sub-area in the future with and without planning measures.

Step 9: (Optional) Estimate net benefits for each sub-area.

The methodology was developed for, and applied to, the existing flood provisions of the Victorian Planning Provisions. By design, however, it is sufficiently general so that it could be used to evaluate any future refinements of the Victorian Planning Provisions.

While it is emphasised that the methodology itself is logical and robust, the results from its application must be regarded cautiously and should be described as indicative. This is because of the considerable uncertainty associated with the data that must be used in the methodology. Major sources of uncertainty have been emphasised throughout the report and include:

- the weak relationships between flood depth and flood damage for various types of buildings;
- the need to use the concept of representative buildings in designated sub-areas of the floodplain;
- the judgements involved in predicting the average return intervals of floods of given depths; and
- the judgements involved in predicting the numbers of buildings that might have existed without the controls.

The application of the methodology to various types of buildings was demonstrated using two urban case studies – Echuca and Rochester. It was concluded that application to planning provisions related to earthworks in rural areas, such as, levees, raised roads and drains, would be inaccurate and expensive due to the complexity of predicting the proliferation of earthworks in the absence of planning provisions and the effects of those works on flooding.

Bearing in mind the considerable uncertainty surrounding the results, the following indicative conclusions can be drawn from the application of the methodology to the defined sub-areas of the floodplains of Echuca and Rochester.

Benefits of planning measures in Urban Floodway Zones

In broad terms, the prohibition of new buildings in the UFZ has avoided annual damage estimates for Echuca (Rochester) in the order of $7,500 ($3,000) per typical residence, about $2,000 ($1,000) per typical commercial building, and about $14,000 ($6,000) per typical industrial building, for each building that might otherwise have been constructed. If the life of a building were 30 years, these annual losses would correspond to present values of benefits (at a discount rate of 4 per cent) over the life of the building that range from about $12,200 for a commercial building in Rochester, to about $130,000 for a residence in Echuca, and up to about $236,000 for an industrial building in Echuca.

Requiring any replacement residential buildings in the UFZ to comply with the floor heights consistent with the 100-year flood would produce estimated benefit-cost ratios per building ranging from around 1:1 in Rochester up to about 4:1 in Echuca. A ratio of 4:1 indicates that for every extra $1 of building cost, $4 worth of damage (present value) is avoided. Ensuring that any residential extensions in the two UFZs comply with floor height requirements was also estimated to avoid more damage than the extra cost of the buildings.

Using a prediction of the number of additional residential buildings (70 residences) that might have been constructed on the Echuca UFZ in the absence of the planning measures (Step 8), it was estimated that the present value of the net benefits (Step 9) of the planning measures (discounted at 4 per cent over 30 years) might have been up to about $8.4 million. This figure is regarded as an upper limit on the estimated present value of avoided damage because the time pattern of the hypothetical development could not be predicted. Furthermore, the estimate is subject to considerable uncertainty because of the difficulty of making predictions for such hypothetical situations. Similar predictions were not possible for Rochester.

These benefits from avoided building damage in the UFZ would be enhanced by the open space and recreational opportunities created by the prohibition of new development. These benefits could not be valued due to lack of data on numbers of users. On the other hand, the benefits from avoided building damage would be reduced by any loss of utility (residences) or loss of income (commercial) resulting from the prohibition of building in the UFZ (the preferred site).

Overall, on the basis of these case studies, it is concluded that the planning measures related to UFZs have produced positive net benefits. In other words, the value of avoided damages in the UFZ appears greater than the costs induced by the planning measures.

Benefits of planning measures in the remainder of the LSIO

The two case studies indicated that the planning provisions have produced positive net benefits for residences and residential extensions in most areas of the LSIO outside the UFZ. For example, estimated benefit-cost ratios per building (at a discount rate of 4 per cent) ranged from about 1.0 in Rochester up to about 2.5 to 3.0 in Echuca. Nevertheless, benefit-cost ratios less than one were estimated for residences in some sub-areas in the LSIO in each town. In other words, the estimated present value of the damages avoided is less than the additional building costs imposed by the planning provisions.

The results from the case studies suggest that the planning measures are not effective for commercial and industrial buildings in the LSIO. Although the planning measures produce gross benefits (a reduction in the AAD per building), these benefits are exceeded by the estimated extra building costs. In the Rochester LSIO, for example, extra building costs for raising floors in commercial buildings would need to be reduced considerably below the assumed values for the measures to produce a benefit-cost ratio of 1.0. These breakeven costs may be closer to the costs of waterproofing strategies and raised storage areas rather than increased slab heights.

Although this may be a valid conclusion for commercial and industrial buildings, it must be remembered that there is a high level of uncertainty concerning the flooding depths and their associated ARIs in the shallow outer areas of the LSIOs, and the depth/damage relationships for these types of buildings are weaker than those for residential buildings.

It was only possible to form estimates of the number of extra residential buildings in the remainder of the LSIO for Echuca (Step 8). In total, the present value of the resultant net benefits (Step 9) was estimated to be $0.9 million (at a discount rate of 4 per cent over 30 years). Thus, the estimated total net benefits (at a discount rate of 4 per cent) of the planning measures for the Echuca floodplain were up to about $9.3 million ($8.4 million plus $0.9 million).

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Water Studies Pty.Ltd. (1995), *A Review of Floodplain Management in Rural and Provincial Urban Victoria*, a report prepared for the Department of Conservation and Natural Resources, Victoria.

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THE RAPID APPRAISAL OF PLANNING MEASURES IN RURAL AREAS

Land use planning measures that affect buildings in a rural area can be analysed in the same way as for urban areas. The other major constructions in rural areas that are affected by planning measures are 'earthworks', in particular but not limited to, levee banks, raised roads and drains. Inappropriate earthworks have the potential to obstruct or divert flood flows, reduce natural storage areas, affect environmental values and increase flood flows, flow velocity and flood damage.

Levees constructed in the past by landholders to protect their land, buildings, livestock and crops have had a major influence on the behaviour of floods in many areas of Victoria. The effect of levees is to channel floodwaters downstream and increase the extent of flooding in those downstream areas where levees cease or become ineffective, while providing protection for those behind the levees.

Current planning provisions restrict the construction of earthworks that would raise the natural surface levels above 200 mm in the LSIO and 100 mm on the rural FO. For proposed works with greater heights, an hydraulic impact assessment may be required. The purpose of the planning measures is to minimise damage to all parties.

In the absence of planning provisions there would be proliferation of earthworks because those responsible for the construction receive no signals about the damage the works cause while protecting themselves. The construction of impediments to flood flows could proceed in an unpredictable fashion as farmers continued to construct or enlarge levees, raised roads, and drain banks. Just as the location and amount of construction would be unpredictable so, too, would be the location and extent of the resultant damage to downstream agriculture, infrastructure and urban areas.

The prediction of urban development in the absence of planning controls in the more confined spaces of rural towns has proved sufficiently difficult that the level of confidence in the results is relatively low. It is our belief that attempting to predict the proliferation of earthworks in rural areas and the resultant damages is not a matter for a robust rapid appraisal. Furthermore, we believe that even a painstaking attempt to do so would not be rewarded with results of sufficient reliability to justify the time and expense. For these reasons we have not attempted to develop a methodology to assess planning measures related to earthworks in rural areas.

The best that we believe is possible in the context of a rapid appraisal is to employ the method originally proposed by Water Studies (1995 and Section 1) and suggested in the *Rapid Appraisal Method (RAM) for Floodplain Management* (DNRE 2000, pp.94-95) for the assessment of planning measures. Because of the conceptual difficulty of going back in time to estimate the AAD at the point the current provisions were introduced in the rural area in question, the evaluation could be handled by estimating the AAD at the present time using the approach detailed in the RAM and making use of the most recent flood maps. 'Best guess' assessments of the future growth in the AAD with continuation of the provisions and with the cancellation of the provisions, with wide-ranging sensitivity analysis of those assessments would give broad bounds to the benefits of the planning provisions.

BENEFIT-COST ANALYSIS

Benefit-cost analysis is a conceptual framework for the evaluation of programs and projects in the public sector. It differs from financial analysis conducted by firms in the private sector in that it accounts for gains (benefits) and sacrifices (costs) irrespective of to whom they accrue. The following are some key concepts and calculations involved in benefit-cost analysis.

Concepts and calculations

Present Value (PV) is the equivalent value today of a future benefit or cost. It is calculated as the value of a future sum or sums discounted at a given discount rate. The present is usually referred to as year zero. The present value of a sum of money S (benefit or cost) which is to be received in year t is calculated as:

$$PV = S_t\,[1 / (1 + i)^t] \qquad (1)$$

Where i is the discount rate specified as a decimal fraction (for example, 0.08 for 8 per cent). If $100 is to be received as a benefit in year 10, the present value of that benefit at a discount rate of 8 per cent is $46.32 (that is, $100/(1.08)^{10}$). Thus, $46.32 now is equivalent to $100 in year 10. This is because $46.32 invested now at 8 per cent would grow to $100 in year 10. If the discount rate were 4 per cent, $100 in year 10 has a present value of $67.56.

The present value of stream of benefits (costs) in years 1 to T is the sum of the present values of the amounts received (paid) in each year.

$$PV = S_0 + S_1[1 / (1 + i)] \ldots + \ldots S_t[1 / (1 + I)^t] \ldots + \ldots S_T[1 / (1 + I)^T] \qquad (2)$$

Net Present Value (NPV) is the present value of all benefits minus the present value of all costs. This is equivalent to the sum of the flow of annual net benefits, each of which is expressed as a present value.

An annuity is a series of equal annual sums of money. The present value of a *fixed term annuity* 'a' that ends in year t (say, year 30) is calculated as:

$$PV = a\,[(1 + i)^t – 1] / [i(1 + i)^t]$$

The present value of a *perpetual annuity* is calculated as:

$$PV = a / i$$

The annuity or annualised amount equivalent to a given PV is obtained by making 'a' the subject in the appropriate formula.

The discount rate is a complicated phenomenon that can be thought of as the rate of exchange between value today and value in the future. We do not delve into the issues that help to determine the appropriate rate - the interested reader is referred to the references at the end of this Appendix.

It is recommended that the rate used in the analysis be regarded as the 'real' or inflation-free discount rate. The real rate is approximately equal to the nominal rate minus the rate of inflation. Use of a real rate of discount means that year zero values of benefits and costs can be used throughout the analysis. If the nominal rate were used, benefits and costs would have to be measured in the dollar values in the year they accrue.

As the above formulae show, PV is inversely related to the rate of discount, therefore, a project may be acceptable at a low discount rate but not at a higher rate. As illustrated by Investments A and B below, this can occur if the project yields benefits in the distant future. It is prudent, therefore, to test the sensitivity of the results of a benefit-cost analysis to this key parameter.

Investment A (cost = $550 in year 0, benefit = $1,200 in year 10)

Discount rate (%)	PV benefit ($)	PV cost ($)	NPV ($)
4	810	550	260
6	670	550	120
8	556	550	6

Investment B (cost = $550 in year 0, benefit = $1,500 in year 15)

Discount rate (%)	PV benefit ($)	PV cost ($)	NPV ($)
4	833	550	283
6	626	550	76
8	473	550	- 77

Conclusions:

- at a discount rate of 4 per cent, both investments are sound but B would be preferred;
- at a discount rate of 6 per cent, both investments are sound but A would be preferred; and
- at a discount rate of 8 per cent, only Investment A is profitable and would be preferred. Investment B is not profitable at this discount rate.

It should be noted that these sorts of results are not uncommon. The example shows the importance of demonstrating to the decision makers the sensitivity of the results to the discount rate. Their funding decisions will be influenced by the beliefs about the appropriate rate at the time.

Decision rules in benefit-cost analysis

(i) The NPV rule.

The prime decision rule in benefit-cost analysis is that a program or project should, subject to budget constraints, be accepted if the PV of benefits exceeds the PV of its costs, that is, the program's NPV is greater than zero.

(ii) The Benefit:Cost Ratio (BCR) rule

The BCR of a program is calculated by dividing the PV benefits by the PV of its costs:

BCR = PV benefits / PV costs

A program with a BCR greater than one is acceptable because the PV of benefits exceeds the PV of costs. A benefit:cost ratio of 1.3 indicates that $1.30 PV of benefit is received for each $1.00 PV of cost.

The BCR is a useful adjunct to the NPV but it should not be used as the sole decision rule because it may give an incorrect ranking if the projects differ in size.

References

The following texts on benefit-cost analysis are recommended for the interested reader.

Sinden J.A. and Thampapillai D.J. (1995), *Introduction to benefit-cost analysis*, Longmans Australia Limited.

Department of Finance (1991), *Handbook of cost-benefit analysis,* Australian Government Publishing Service.

CONSTRUCTION COSTS FOR TYPICAL BUILDINGS WITHOUT PLANNING MEASURES

In order to obtain an estimate of the real resource costs of the various types of buildings, all the costs detailed below are exclusive of GST.

Residence

Description

Single storey, brick veneer on concrete slab with a pitched metal roof of Colorbond material was judged to be typical of Echuca and Rochester. A level site is assumed with the slab at 250 mm above ground level

Building features

- Floor area of 200 sq m.
- Timber wall framing with plaster board internal linings.
- Three bedrooms (one with *en suite* bathroom), combined living/dining area, study, kitchen, bathroom, laundry and separate toilet.
- Mid-range standard of finish throughout.
- Ceramic tiles to wet areas.
- Built-in wardrobes in all bedrooms.
- Standard electrical services.

Costs

With reference to Rawlinson's (2002) it was assumed that the house for Echuca was of the type described as an 'individual house with medium standard of finish'. Construction cost was assumed to be $950/ sq m. For Rochester a house more in the style of a 'project house' was assumed with a lower construction costs, say, about $800/ sq m.)

Description	Cost
Total construction cost for 200 sq m (Echuca)	$190,000
Total construction cost for 200 sq m (Rochester)	$160,000
Garage with concrete floor (50 sq m), cavity brick walls and roller doors @ $477/ sq m	$23,850
Ducted gas heating, single furnace in roof plus ducting	$3,500

Description	Cost
Evaporative cooling unit, single unit and ductwork, located in roof and requiring single-phase electricity supply	$3,000
Pergola with timber posts, beams and joists and concrete paving	$6,727
Total cost Echuca (rounded)	$227,000
Total cost Rochester (rounded)	$197,000

Notes

- A tiled roof would add about $470 to the total cost.
- For Rawlinsons' individual house with medium standard of finish the construction cost rate of $950 is applicable with in the floor area range of 150 sq m to 350 sq m.
- A weatherboard house of the same floor area with hard wood flooring at 450 mm above ground and medium standard of finish is estimated to costs about $192,000.
- Factors such as site topography and the availability of services would affect overall construction costs.

Residential extensions without planning measures

It is assumed that a typical extension is single storey with a floor area of about 60 sq m and contains a bathroom. Construction costs is assumed to be $900/sq m and a bathroom costs about $16,000. Total cost is $70,000.

Commercial (retail) building without planning measures

It is assumed that a typical commercial building is single storey, with brick walls, concrete slab, glass shop front, front parapet walls and veranda with a floor area of about 150 sq m and construction cost of $610/sq m (including fitout), with a front awning ($4,000), air conditioning ($4,000) and toilets ($10,000). Total cost (rounded) is assumed to be $110,000.

Industrial building without planning measures

A typical industrial building in Echuca has a slab floor, a masonry front with a bull section containing an office, a separate display room, and three colourbond walls. Typical floor area is assumed to be about 1,000 sq. m.

The construction cost used in the case study for this building was $390/sq m plus $7,000 for fitout, $10,000 for staff toilets and $10,000 for display room. Total cost was assumed to be $417,000.

CONSTRUCTION COSTS FOR TYPICAL BUILDINGS WITH PLANNING MEASURES

These costs are crucial to the evaluation because they set the level of cost against which the benefits are compared. We have assessed the cost of raising floors to the average height given in planning permits in Echuca and Rochester and converted these to a cost per 100 mm in order to apply them to the requirements in individual sub-areas.

Residence

Description

As for typical residence but with floor raised 700 mm above ground level.

Building features

As for typical residence.

Costs

As for typical residence but with additional costs to raise slab.

Additional slab height is 450 mm (700 - 250). Applicable technique is a conventional raft slab with increased edge beams, internal beams and fill material. Estimated concrete volume of beams is 450 mm W x 450 mm D x 110 lineal metres = 22.3cu m.

Estimated cost is 22.3 cu m @ $575/ cu m	$12,822
plus additional form work cost (say)	$3,000
plus additional cost for extra wall height	$2,000
Total extra cost (rounded)	$18,000
Total cost of building	**$245,000**

It is assumed that the typical residence would cost $4,000 ($18,000/4.5) for each 100 mm by which the floor is raised.

Other buildings

Weatherboard Dwelling

Estimated additional cost for a weatherboard house raised from a floor height of 450 mm above ground to 700 mm above ground (including cladding for extra wall height) is $2,600 (say, about $1,000 per 100 mm) bringing the total cost to, say, $195,000.

Residential extensions

Assumed to have the same cost per sq m as a full residence, namely, $90 ($18,000/200 sq m). Therefore, total cost of a residential extension with a floor height of 700 mm is assumed to be $75,400.

Commercial

Raising the floor level to 700 mm is assumed to cost the same per sq m as a residential building with a slab floor, namely, $90/ sq m ($18,000/200 sq m). Therefore, in round figures, the total cost for a building of 150 sq m is assumed to be $123,500 ($110,000 + 150 sq m x $90/sq m).

The costs of 'water proofing' of a commercial building are difficult to estimate and it is assumed that all walls are of masonry construction, all electrical services are mounted higher than 700 mm above ground and 'drop boards' would be provided at external entry points. It is assumed that these would bring the total cost to, say, $125,000.

Industrial

Cost to raise the floor level of a typical industrial building was assumed to be the same as for the commercial building, namely, $90/sq m. Therefore the total cost was assumed to be $510,000 ($417,000 + 1,000 sq m x $90 + $3,000 allowance for water proofing).

TYPICAL CONTENTS AND VALUES

Lounge/Family Room	
Lounge suite	$2,000
Stereo equipment	$1,000
Records, tapes, CDs	$500
TV	$1,500
Video recorder and tapes	$450
Pictures, art	$500
Curtains and blinds	$1,500
Sundry items	$500
Total	**$7,950**
Dining Room	
Dining suite	$1,500
Wall unit, sideboard, contents	$1,500
Pictures, art	$500
Curtains, blinds	$500
Sundry items	$300
Total	**$4,300**
Kitchen	
Table and chairs	$600
Refrigerator	$1,200
Freezer	$500
Dishwasher	$1,000
Microwave	$250
Crockery	$300
Saucepans and utensils	$400
Glassware	$200
Blender, frypan, toaster, elec. Jug	$250
Cutlery	$150
Food and beverages	$500
Stove	$1,000
Sundry items	$200
Total	**$6,550**
Master Bedroom	
Mattress and base	$1,500
Bedhead and side table	$500
Lamps	$200
Dressing table and mirror	$700
Chest of drawers	$300
Blankets and sheets	$1,000
Curtains and blinds	$800
Clothing and shoes	$2,000
Sundry items	$300
Total	**$7,300**

Other bedrooms	
Mattresses and bases	$1,200
Bedheads and side tables	$600
Lamps	$200
Chests of drawers	$400
Blankets and sheets	$1,000
Curtains and blinds	$1,000
Clothing and shoes	$1,500
Sundry items	$300
Total	**$6,200**
Bathrooms	
Hair dryers	$100
Shavers	$100
Towels	$400
Toiletries	$300
Sundry items	$100
Total	**$1,000**
Laundry	
Washing machine	$1,000
Dryer	$300
Iron and ironing board	$150
Sundry items	$100
Total	**$1,550**
Study or spare room	
Desk	$500
Bookcase and books	$500
Home computer, printer	$2,500
Toys and games	$500
Sundry items	$100
Total	**$4,100**
General items	
Sewing machine	$300
Vacuum cleaner	$300
Carpets (150 sq.m @ $35/sq.m)	$5,250
Other loose floor coverings	$600
Photograhic equipment	$300
Sporting equipment	$500
Battery operated sound and visual equip	$700
Jewellery	$1,000
Total	**$8,950**
Garage and outdoor furniture	
Mower	$300
Tools and gardening equipment	$500
Ladders	$100
Garden furniture	$500
Barbecue	$800
Bicycles	$500
Sundry items	$200
Total	**$2,900**
Total contents	**$50,800**