Natural Resources and Environment

AGRICULTURE
RESOURCES
CONSERVATION
LAND MANAGEMENT

ADVISORY NOTES FOR DELINEATING FLOODWAYS

These notes are to be used as a guide for delineating floodways. They are not prescriptive and reliance should not be placed on any single risk factor or consideration when delineating floodway areas.

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1. Introduction

These notes were prepared by DNRE"s Floodplain Management Unit (FPMU) for use by consultants in flood mapping. They *are not to be taken as prescriptive and considerable professional judgment will still be required in their use*. *In many cases, consideration should be given to a number of risk factors used to identify floodway areas rather than relying on a single risk factor.*

The notes:
- cover a general definition of floodway;
- provide a general framework for evaluating floodway;
- describe some of the flood risk factors which underscore the risk management approach adopted;
- provide specific notes on how floodways could be delineated; and
- provide a few general notes on methodology.

It is expected that the boundary between floodway and land subject to inundation will not be clear for many areas. Therefore, details relevant to the assessment of flood risk, or to the interpretation of the flood maps, are to be preserved, whether an area is to be delineated as floodway or not. This is to be achieved by the inclusion of explanatory notes on flood maps and the identification by cross hatching of high risk areas not defined as floodway.

Information considered relevant for inclusion in notes includes floodway types, qualifications on flood hazard or flood behaviour and notes about levees. These should be also documented in flood mapping reports.

2. Purpose

The purpose of these notes is to facilitate a consistent approach to the delineation of floodways in flood maps across the State of Victoria.

They provide methods of delineating floodways which:

- are cost effective and time efficient;
- are simple and easily understood by professionals experienced in hydrology and flooding issues;
- enable flood maps to be incorporated into municipal planning schemes; and
- are compatible with current best practice procedures for floodplain management.

3. General Definition of Floodway

Floodways are those areas of the floodplain where significant discharge or storage of water occurs during major floods and they are often associated with a significant flood hazard. They are often aligned with naturally defined channels and include areas which, if filled or even partially blocked, would cause a significant redistribution of flood flow, or significant increase in flood levels.

Floodways are often, but not necessarily always, areas of deeper flow or areas where higher velocities occur. The extent and behaviour of floodways may change with flood severity. Floodway areas that are benign for small floods may cater for much greater and more hazardous flows during larger floods.

4. Planning Controls

A floodway zone or overlay is a planning tool for identifying and maintaining main flow paths and, through appropriate controls for proposed development and works, ensuring the free passage and temporary storage of floodwaters through them.

By incorporating and using appropriate planning controls for these areas:

- the potential for accelerating flood flows, increasing flood levels and/or velocities, and flow diversion, is minimised; and
- degradation of environmental values are reduced.

When finalised, flood maps will be incorporated as zones and overlays into Victorian municipal planning schemes (Ref. 1). The schemes have only 3 categories of flood prone land:

- land subject to inundation overlays;
- urban floodway zones; and
- rural floodway overlays.

This restricts the numbers of the various categories of flood prone land that can be shown.

5. Best Practice Procedures

The definition of “floodway” can be linked to a risk management approach advocated in the Victoria Flood Management Strategy (Ref. 2) and AS/NZ 4360:1995: Standards for Risk Management (Ref. 3). This is discussed further in Appendix A.

This approach considers the assessment of a level of risk, based on a consideration of 2 factors:

- the probability or frequency of flooding; and
- the consequences of flooding.

The consequences of flooding relate to the impacts of a flood of a given frequency on existing and potential development as determined by the floodplain’s hydraulic and environmental characteristics.

6. Flood Risk Factors

Assessing the flood risk requires consideration of a large number of factors. They can be broadly categorized into 3 groups:

- flooding characteristics;
- socio-economic factors; and
- environmental values.

These are discussed in detail in Appendix A and more generally in the following sections.

6.1 Flooding Characteristics

A convenient way to define floodway is by determining the combinations of velocity and depth which are considered to be hazardous to occupants of a floodplain. This is useful for the upper reaches of watercourses, particularly where their floodplains are relatively narrow.

Caution should be exercised in using this approach for defining floodways for the floodplains of major water courses as in many cases their floodplains are wide, and separating out the deeper, faster portions as floodways may not provide sufficient capacity to convey flows.

Appendix A refers to a number of other flooding characteristics. These can usually be linked to depth-velocity considerations. For example significant flood storage areas, or areas subject to flooding of long duration, often correspond to areas where flooding depths are greater than 0.5 m and flow velocities are low. Similarly, well defined floodplains in steeper catchments with rapid rates of rise and fall often indicate areas where flooding to significant depths and velocities can occur.

6.2 Socio-Economic Factors

The socio-economic factors which relate to flood mapping are mainly concerned with flood damages (to people and property) and therefore are related to the consequences of flooding.

Defining the more hazardous areas as floodway (using velocity-depth considerations) minimises the potential for flood damages to increase. However if such areas have already been developed, the function of a floodway to convey and store floods has already been significantly compromised and the potential for an increase in flood damages is minimal (assuming future development recognises the flood risk).

Socio-economic factors are also relevant when deciding how much effort is to be expended when defining floodways. Areas where the development potential is high (close to centres of increasing population for example) may warrant more work than sparsely populated rural areas.

6.3 Environmental Values

It may be appropriate to define as floodway, areas where environmental values are high, either because of a need to maintain continuity of flows or because wetlands (levees, billabongs etc.) are significant.

6.4 Areas Protected By Levees

Levees are raised embankments or retaining structures which provide a degree of protection to areas liable to flooding. They include channels, railway embankments, roads or other structures, whose function as levees may be secondary to their main purpose.

In deciding whether areas protected by levees should be defined as a floodway consideration needs to be given to:

- the frequency of flooding;
- the standard of levees (urban or rural);
- whether they are strategic or non strategic; and
- the flood hazard associated with their failure.

Where levees have been constructed by individuals and have no *strategic significance*[1], they may be assumed to protect small areas (such as houses) or to have a low standard of protection, being ineffective in major floods. In such cases floodways will be delineated by ignoring the levees.

Where levees are strategic, their impact must be considered. Advisory notes in Table 2 (Section 8) suggest a process for delineating floodways where flooding is influenced by levees.

6.4.1 Notes and Cross Hatching

Where flood prone areas have been identified as having a high or significant flood risk but they have not been delineated as floodway, they should be identified by cross hatching on the flood maps. In addition, the area should be appropriately annotated. Typical examples of notes are included in Appendix A.

7. Principles For Delineating Floodways

In applying the attached notes the following principles apply:

1. Flood prone areas of moderate to low flood risk will be defined as land subject to inundation even if severe access problems raise compelling reasons to control development. They may however be identified as high hazard areas because of the access problems. The exception to this is for undeveloped flood storage areas where pockets of relatively high land in the middle of a wide floodplain should be preserved as floodway.

[1] A “strategic levee” is considered to be a levee which, from a broader regional viewpoint, protects important areas or assets. It may be a single levee, or it may be part of a larger system.

2. Where floodways cannot easily be defined, and a decision is required on how much effort should be expended, most effort should be directed to areas of high population, intensive agriculture, or of strategic significance. Floodways should still be defined wherever possible for the other areas using less rigorous techniques.

3. Although one layer is to be used for all types of floodway, areas not defined as floodways but which still have a high flood hazard should be identified as such by cross hatching, to ensure relevant details are not lost.

4. Notes on maps shall be used liberally to convey information on flood hazard, not just to floodways but also cross hatched areas (see note 3 above). Relevant information may include how a floodway has been determined, qualifications on flood hazard or flood behaviour or information about levees.

5. Areas which would normally be defined as floodway under natural conditions under these notes but which have already been substantially developed, may be defined as land subject to inundation providing the flood risk is appropriately identified (as per notes 3 & 4 above).

6. The primary considerations in defining floodways shall be documented in sufficient detail in flood mapping reports for the reader to be aware of the basis of their delineation.

8. Notes

Table 2 contains notes to assist in the delineation of floodways. It should be noted that these are not prescriptive; nor can it be expected that all possibilities have been included.

Table 2 Notes for Defining Floodways

Consideration	Where this factor may be relevant	Notes
General		
Frequency Of Flooding	Everywhere provided sufficient information exists	Generally areas which flood fairly frequently (at intervals of about 10 years or more) will be defined as floodway. Where the frequency of flooding is less, a more detailed assessment of the consequences will be necessary.
Flooding Characteristics		
Velocity - Depth Criteria	Steep, confined floodplains, particularly in upper catchments	Use fig. 1 (attached) to assist determination of floodway. This requires **v** and **d** to be determined. These are average values not precise values. Use information from flood studies or modelling where available. If detailed ground level contour information exists use a basic hydraulic analysis (e.g. Mannings equation) or a more rigorous analysis if warranted. Where no detailed ground level contour information exists consider the use of flood photography in conjunction with a coarse hydrologic/hydraulic analysis (see Appendix B - Notes on Methodology).
Duration Of Flooding		Flood storage considerations take precedence. Flooding greater than 7 days duration may indicate where flood depths are greater than 0.5 m in a 1% flood.
Rate Of Rise And Fall, Flood Warning Time	Steep, narrow and confined catchments, where time between the storm event causing a flood and the peak flow rate is short.	Reliable evidence of rapid rate of rise and fall shall be used in support of defining whole floodplains as floodway together with evidence of little to no flood warning lead time, particularly if the sides of the floodplain are steep relative to the direction of flow.
Flood Storage	Rural floodplains which are wide and slow moving.	Flood storage areas are often characterised by wide floodplains and flat grades. In some cases there may be evidence of significant flood attenuation. Areas which flood to depths generally greater than 0.5 m should be identified as floodway. In general, isolated pockets of land which flood to lesser depths should not be excluded from the floodway if they are surrounded by areas of deeper flooding.

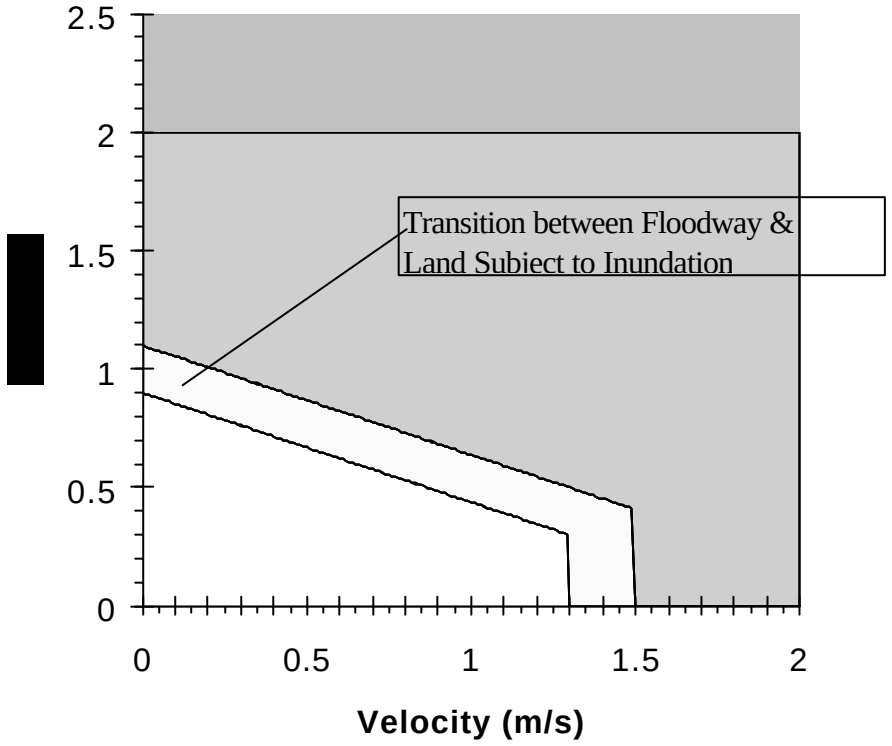
Table 2 Notes for Defining Floodways, continued

Consideration	Where this factor may be relevant	Notes	
Flooding Characteristics, Continued			
Strategically Significant Sites	Important areas of flood flow exchange	Preserve enough of the flow exchange area as floodway, by defining all depressions as floodway, and/or allowing sufficient width to maintain flood flow transfer functionality.	
	Effluent flow paths which have been blocked off.	If reopening the flow path is a viable option and has a significant beneficial effect on flood levels or flows within the main water course, it may be appropriate to preserve the effluent flow path as floodway. Consultation with FPMU is recommended.	
Areas Where Flooding is Influenced By Levees	Urban areas which are substantially developed and protected by levees.	Do not show as floodway but include notes (as per Look Up Tables) clarifying the flood risk (refer Appendix A).	
	Rural Levees which are regarded as Strategic. A strategic levee is considered to be a levee which, from a broader regional viewpoint, protects important areas or assets. It may be a small, isolated levee, or it may be part of a larger system	1	Conservatively estimate 1% flows outside the levees assuming they fail. Treat each side of the river independently and allow for reasonable "worst case" scenarios. The sum of the flows will exceed the 1% flow.
		2	Estimate corresponding average velocities and depths and use Fig. 1 to assist assessment of the flood hazard.
		3	If there are any levee spillways (i.e. levee segments which are designed to overtop when a flood exceeds a predetermined level) estimate the area immediately downstream where obstructions should be minimised to ensure the spillway is effective.
		4	If portions of levee are located too close together and throttle flood flows, estimate the minimum desirable width between the levees. This may have been previously determined from flood studies or strategies. If it hasn't been determined, adopt the median width for the general area as a minimum.
		5	Identify effluent flowpaths and depressions which will fill to greater depths than the rest of the floodplain if levees overtop or fail, and/or areas with a history of catastrophic or frequent failure.
		6	On the basis of the above analysis, identify areas outside the levees (if any) where the flood risk is significant enough to warrant being defined as floodway. Show these as a cross hatched, separate layer - "preliminary floodway".
		7	Consult with FPMU and the relevant municipality prior to the finalisation of the floodway for these areas.
	Non Strategic Levees	Assess as if levees didn't exist.	

Table 2 Notes for Defining Floodways, continued

Consideration	Where this factor may be relevant	Notes
Environmental Values		
Continuity Of Flow Paths and Fauna Habitat	Reasonably defined depressions and watercourses	Major depressions and effluent flow paths should be defined as floodways. These can often be identified from soil maps and/or flood photography, supplemented with ground level contour plans where available. Care needs to be taken where flood photography shows discontinuous portions of drainage lines. This may indicate that the flood has receded or the drainage line has been blocked off by an obstruction. Intermittent or discontinuous drainage lines should be defined as floodways unless they have no strategic value in conveying flood flows and have no environmental significance. In cases where a flow path has been obstructed refer to “Strategically Significant Sites” above.
Wetlands and Environmentally Sensitive Areas	Major water courses, significant wetlands, swamps, lakes, cutoff meanders, billabongs, water courses identified as providing a habitat to threatened species of fauna, areas with siltation or erosion problems.	It is desirable for most of these areas to be delineated as floodway. The Victorian Planning Provisions require some consideration be given to environmental factors but far greater consideration is given to flood hazard factors. Therefore look to other risk factors in support of environmental considerations.

Figure 1
Assessment of Floodway based on Depth and Velocity



9. Methodology

There are a number of different methods of defining floodway. Which is used depends on the data available, and other factors. Further advice is provided in Appendix B.

10. References

1. Victorian Planning Provisions (1997) Sections 37 & 44.

2. State Flood Policy Committee: Victoria Flood Management Strategy, (1998) Chapter 4.

3. AS/NZ 4360: 1995 Australian/New Zealand Standard Risk Management.

4. Keller RJ & Mitsch B: Research Report No. 69, (1993), "Safety Aspects of the Design of Roadways as Floodways", Urban Water Research Association of Victoria.

5. Standing Committee on Agriculture and Resource Management: Best Practice Principles - Floodplain Management in Australia (1996) Water Studies Pty Ltd (DRAFT).

6. Grayson RB, Argent RM, Nathan RJ & Mein RG: Hydrological Recipes - Estimation Techniques in Australian Hydrology (1996), Pg. 108, Cooperative Research Centre for Catchment Hydrology.

APPENDIX A FLOOD RISK FACTORS

CONTENTS

A1. Best Practice Procedures For Defining Floodway

The definition of "floodway" can be linked to a risk management approach advocated in the Victoria Flood Management Strategy (Ref. 2) and AS/NZ 4360:1995: Standards for Risk Management (Ref. 3).

This approach considers the assessment of a level of risk, based on a consideration of 2 factors:

- the likelihood of flooding; and
- the consequences of flooding.

The likelihood of flooding is a measure of the probability or frequency of flooding.

The consequences of flooding relate to the impacts of a flood of a given frequency on existing and potential development as determined by the floodplain's hydraulic and environmental characteristics. The consequences of flooding can also relate to the impacts of not doing something, e.g. not preserving wetlands.

Table A1 shows a flood risk matrix taking the 2 factors into account.

Those parts of the floodplain regarded as having a significant or high risk of flooding will generally be defined as floodway.

Table A1 Flood Risk Matrix

Likelihood (Frequency)		**Flood Risk**		
		Minor Cons.	**Moderate Cons.**	**Major Cons.**
A	Generally floods on average every 5 years or less.on average.	Significant	High	High
B	Floods every 5 to 10 years on average.	Significant	Significant	High
C	Floods every 10 to 20 years on average.	Moderate	Significant	High
D	Floods every 20 years to 100 years on average.	Low	Moderate	Significant

A2. Flood Risk Factors

To assess the level of flood risk (low, moderate, significant or high) requires consideration of a number of "flood risk factors." These can be broadly characterised into 3 groups:

- flooding characteristics;
- socio-economic factors; and
- environmental values.

These are summarised in Table A2 and covered in more detail in the following sections.

Table A2 Flood Risk Factors

	Comments
Flooding Characteristics	
Velocity And Depth	Flood flows with high velocities and/or significant depths can constitute a significant flood hazard.
Duration Of Flooding	Long duration flooding often corresponds with areas of deep flooding. This could be useful where flood photography exists but no contour information is available.
Rate Of Rise And Fall	Rapid rate of rise and fall can indicate areas of significant depth or velocity.
Flood Storage	Flood storage areas are often associated with long duration flooding and they are usually where flooding to significant depths could occur.
Effluent Flowpaths/Strategically Significant Flow Exchange Paths	These can be very important considerations when defining floodways, because of their impact on flood flow distribution and flood levels. They include effluent paths which have been blocked off.
Shape Of Floodplain Perpendicular To Flow	This can be a relevant consideration, particularly when other data is lacking. E.g. if the floodplain is narrow and its slope perpendicular to the direction of flow is steep then most of the floodplain is likely to be affected by high velocity floods to significant depths.
Hydraulic Grade/Conveyance	Useful indicator of velocities, significant flood storage areas, etc.
Areas Protected By Levees	Levees are a special category. Refer Section A2.6.
Socio-Economic Factors	
Population At Risk	While it is desirable to define floodway for all areas (to minimise existing & potential flood damage) these 3 factors can affect the amount of effort spent on defining floodway for sparsely populated or sparsely developed areas or raise questions on the appropriateness of defining areas which have already been substantially developed as floodway.
Properties Affected - no. & type	
Economic Impacts, Including Flood Damages	
Access To Flood Free Areas	These factors are more relevant to flood preparedness and emergency management.
Ease Of Evacuation	
Flood Awareness	
Flood Warning Lead Time	
Environmental Values	
Water Courses (Continuity Of Flow and fauna habitat)	Preservation of water courses is an important consideration when defining floodways.
Water Courses Subject to Siltation or Erosion	These should be picked up by considering flooding characteristics (e.g. depth-velocity criteria, flood storage).
Wetlands, including Cut Off Meanders And Billabongs	Desirable to preserve as floodway. Would expect them to be associated with the more active part of the floodplain.

Referring to Table A1, areas which flood frequently (Category A or B) are generally regarded as areas associated with significant or high flood risk. They are regarded as being important for conveying flood flows for the larger and less frequent floods and failure to preserve often has significant environmental impacts.

Areas which flood less frequently (categories C and D) and which are associated with significant or high flood risk generally correspond to areas with:

- high velocities and depths of flooding;
- long duration flooding and or areas of significant flood storage;
- rapid rates of rise and fall;
- areas sensitive to flow obstructions; and/or
- wetlands and depressions (continuity of flows and environmental values).

Flood risk factors are discussed further in the following sections.

A3. Flooding Characteristics

A3.1 Velocity and Depth of Floodwaters

Both velocity and depth are critical factors in determining flood hazard, particularly in terms of personal safety and the potential for major structural damage. They are perhaps the most measurable flooding characteristics, being dependent on the size of the flood and the hydraulic characteristics of the floodplain.

Wading by able bodied adults becomes difficult and dangerous when velocities are relatively high even when depths are comparatively low. Conversely wading is also dangerous when depths are large and velocities are low. This risk increases when depressions, pot holes, fences and other structures and features are hidden.

The passage of small motor vehicles through floodwaters is considered a risk when water depths exceed 0.3 m. For larger vehicles the depth increases to about 0.5 m provided the flow velocity doesn't exceed 0.5 m/s (Ref. 5).

For caravans and buildings of light construction, flooding of sufficient depth to cause these structures to float and/or sufficient velocities to cause them to move, will lead to structural damage or destruction. In a similar manner, debris (such as floating logs) can cause significant damage to buildings and bridges.

At velocities around 1.2 m/s (for some of the lighter alluvial materials) to 2 m/s, the stability of house foundations and poles can be affected by scour.

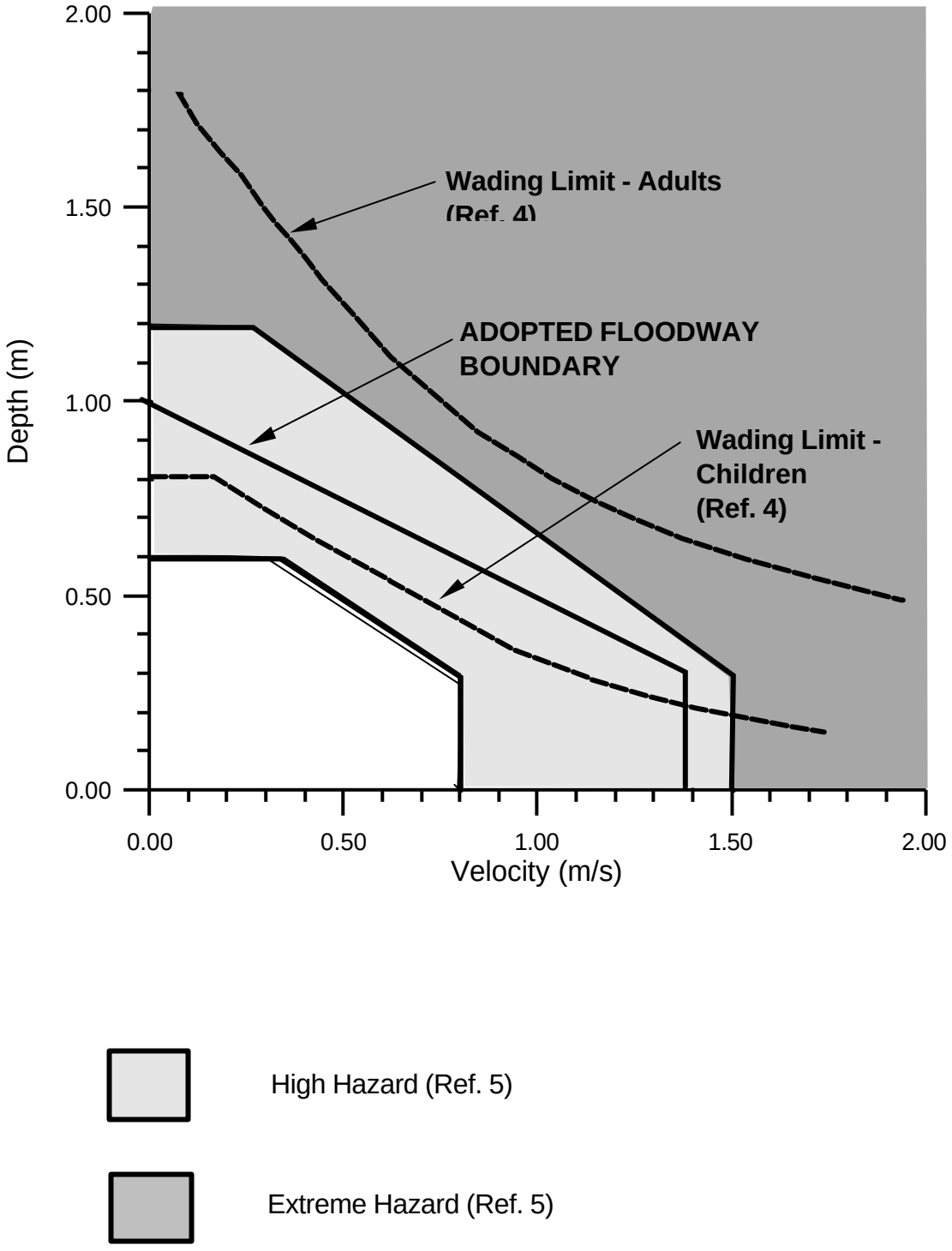
In water depths greater than 2 m, light framed buildings are at risk of floatation and/or structural damage, even if velocities are low.

Figure A1 shows the combinations of the depths and velocities of flooding considered hazardous. It takes into account research conducted on wading through floodwaters

(Ref. 4) and best practice principals for Floodplain Management in Australia (Ref. 5). In using the graph, average velocities and depths are to be used, rather than specific values.

Figure A1 is useful for the upper reaches of watercourses, particularly where their floodplains are relatively narrow. For the floodplains of major water courses however, Figure A1 may underestimate the amount of floodway required to provide sufficient capacity to convey flows. Where floodplains are wide, average depths of flooding may be 0.5 metres or less and average velocities may be low. In such cases, other factors such as environmental values and preservation of flood storage areas may be more relevant in defining floodway than velocity depth criteria.

Figure A1
Assessment of Flood Hazard Based On Depth and Velocity



A3.2 Afflux

A special case of depth velocity criteria is afflux.

Expressed qualitatively, afflux is defined as the increase in flood level caused by an obstruction or obstructions. Expressed mathematically:

Afflux = $\alpha v^2/2g$, where: α is a coefficient
v = average velocity
g = gravitational acceleration =9.8 m^2/s

Obstructions to flood flows can significantly increase flood damage and the flood risk to occupants by increasing flood depths and velocities. Obstructions include buildings, earthworks of all types (such as levees, embankments, bridge abutments, farm channels and drains, land fill), dense clusters of trees and shrubs, fences, etc.

Areas where afflux effects can be significant include narrow floodplains where even minor works can significantly obstruct flows, and wide and relatively flat floodplains where large areas have been (or have the potential to be) protected by raised earthworks.

Where detailed modelling has been carried out, and due consideration has been given to the cumulative effects of obstructions both locally and regionally, defining afflux limits can be a useful method for defining floodways. This would normally only be considered for:

- areas where changes in flooding patterns are known to have occurred as a result of unregulated works;
- areas having a high population, high value crops or intensive agriculture; and/or
- areas of strategic significance in relation to flood flow transfer or potential for rapid growth.

However, in view of the lack of data, and the relative ease by which incorrect conclusions can be drawn by not having sufficient regard for cumulative impacts, the use of this method is not warranted on its own for the Flood Data Transfer Project.

A3.3 Duration of Flooding

The duration of flooding is the time taken for a flood to pass. The longer the duration of flooding (i.e. the longer a community, town or single dwelling is cut off or adversely affected by floodwaters) the greater the stress and trauma, period without water and food, cost of emergency response, etc.

Flood duration can usually be considered in conjunction with other hazard factors such as depth of flooding, ease of access, flood storage requirements, etc.

A3.4 Rate of Rise and Fall of Floodwaters

When floodwaters rise slowly, people have time to respond (move stock to higher areas, evacuate in comparative safety, etc.). A rapid rise in floodwater over a short period of time can be quite hazardous, as people can have little time to assess and respond to the flood event. Typically, rapid rates of rise occur in small, steep catchments and flow velocities tend to be high.

A3.5 Flood Storage

Flood storage areas are those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. Flows through such areas may be almost stationary (as with inflows into a swamp or lake) or slow moving (as occurs within wide floodplains adjacent to perched watercourses).

Flood storage is important for all floodplains. If water is prevented from occupying some part of the floodplain by obstructions (such as levees, channels, raised roads, etc.) the loss of flood storage causes higher flows downstream. A prime example of this (but by no means the only one) is poorly designed farm works which protect large areas of land from flooding.

Action taken by one individual can cause reactive responses by adjacent landowners. The impact of an individual proposal may not have much significance but the *cumulative effects of many proposals* may be significant.

Planning controls now introduced into Planning Schemes require consideration to be given to flood storage for planning permit applications (Ref. 1). Consequently, areas where flood storage is deemed to be a major consideration should be defined as floodways.

The effects of flood storage will be more critical for floodplains in rural areas with wide, slow moving floodwaters. Narrow floodplains and/or fast flowing water will result in the rate of recession of floodwaters in the floodplain being similar to that of the river/creek.

A3.6 Areas Protected By Levees

Levees are raised embankments or retaining structures which provide a degree of protection to areas liable to flooding. They include channels, railway embankments, roads or other structures, whose function as a levee may be secondary to their main purpose.

All levees have some effect on the floodplain, causing flow redistribution, increases in flood levels, reduced flood attenuation, etc. If the area protected is comparatively small in relation to the floodplain the effect is usually minimal. Where substantial areas are protected the effect may be significant. The benefits of providing levee protection for one area often have disbenefits in other areas.

All levees have a risk of failure (however small). Modes of failure include overtopping, breaching or foundation failure. If they fail catastrophically, the damage can be greater than would occur under natural conditions.

A3.6.1 Urban Levees

In general, all urban areas, either developed or proposed for development, which under natural conditions would have been defined as a floodway and which are now protected by levees, will not be classified as floodway.

Where these levees have been constructed to an "urban standard" the area protected will not be shown as liable to flooding. If they have not been constructed to an "urban standard" the area protected will be shown as land subject to inundation.

Levees constructed to an "urban standard" are regarded as those having a 1% level of protection with 0.6 m minimum freeboard, and which are being regularly maintained by an authority.

A3.6.2 Rural Levees

Floodways for rural areas protected by levees can be delineated in a number of ways:

- by ignoring the levees all together (i.e. applying the notes under so called natural conditions); or
- by evaluating likely flow mechanisms when levees breach and evaluating the consequences of flooding under these scenarios; or
- by calculating the minimum width required to convey a reasonable flood flow (where portions of levees are considered to be too close together); or
- by using the levees as the boundary (in effect recognising the status of the levees in providing protection).

A3.6.3 Notes & Cross Hatching

Where flood prone areas protected by levees have been identified as having a high or significant flood risk but they have not been delineated as floodway, they should be identified by cross hatching on the flood maps. The Project Manager's e-mail of 15/7/98 provides additional clarification. These may include areas adjacent to levees where catastrophic failure of the levees could constitute a significant flood hazard (use velocity-depth considerations as a guide). Notes should also be used to clarify the flood risk.

Examples of notes are as follows:

- Areas protected by urban levees should be identified on flood maps by a note stating:

"*Area liable to flooding under natural conditions, now protected by levees to 1 in X year level of protection. The top of the levees are about Y mm above the level of protection.*"
"X" is the design flood and "Y" is the freeboard.

- Areas protected by rural levees with spillways should be identified on flood maps by a note stating:

"*Area liable to flooding, now protected by levees, sections of which will start to overtop when floods exceed about a 1 in X year Average Recurrence Interval. Levees may fail even if they don't overtop."*

"X" is to be specified. The location of the spillways should be shown and wherever possible, areas where the flood hazard has increased appreciably downstream from the spillways should be identified on flood maps.

- Areas protected by rural levees without spillways should be identified on flood maps by a note stating:

"*Area liable to flooding, now protected by levees which could overtop if flood exceeds about a 1 in X year Average Recurrence Interval. Levees may fail even if they don't overtop."*

If X can't be specified the note will need to be modified.

A3.7 Effluent Flow Paths/Areas of Significant Flow Exchange

For certain areas alterations to the natural flooding regime may have occurred which warrant special consideration. Examples include:

- effluent water courses which have now been totally or partially blocked off;
- artificially enhanced watercourses diverting flood flows away from areas (usually associated with flood mitigation works);
- drainage improvement works; and
- works which enable flushing of lakes to improve water quality.

Definition of these areas as "floodway" can usually be determined by considering other methods. However, in some cases there might be strategic implications which override all other criteria.

Consider for example a natural effluent path which has been blocked off by a channel. If removal of the obstruction to alleviate local flooding has substantial benefits and cannot be ruled out at some stage in the future, it would be appropriate to identify the flow path as "floodway" even though it isn't active.

Another example might be where there are shallow but significant flow exchange paths between watercourses where the potential for obstruction might be minimised by defining the area as floodway.

A3.8 Shape of Floodplain Perpendicular to Flow

Where a floodplain is narrow and well defined, the slope, measured perpendicular to the direction of flow, is often quite steep. In such cases a fairly rudimentary analysis of depth and velocity would indicate most of the floodplain could be delineated as floodway[1]. In such cases it may be appropriate to use the notes to define the entire floodplain as floodway rather than go to the trouble of delineating land subject to inundation, i.e. 1% flood extent as a narrow strip at the edge of the floodplain.

A3.9 Hydraulic Grade

The hydraulic grade can be a useful tool for evaluating flood behaviour. For instance a steep hydraulic grade often indicates a high velocity. A flat grade can indicate areas where flood storage may be important.

A4. Socio-Economic Factors

A4.1 Population at Risk, Properties Affected & Economic Impact

The larger the population at risk the greater the flood damage and the greater the number of people requiring evacuation. The incorporation of flood maps into planning schemes will help minimise future flood damage by identifying areas not appropriate for development.

For some municipalities certain land use practices have occurred which are hazardous to the health of surrounding communities. Examples include storage sites for hazardous chemicals and sewage treatment works. The temptation of delineating these sites as floodway on the basis of their land use rather than the flood risk is to be avoided. Used correctly, planning scheme ordinances should control their development.

A4.2 Access to Flood Free Areas

The availability of easy and safe vehicular and pedestrian access to flood free areas is important for evacuation. If safe evacuation is not provided communities or dwellings can be isolated. This includes isolated high spots of land and canal subdivisions.

1 Appendix B (B7.1) contains a useful formula for estimating the approximate 1% flow which may be useful for the rudimentary analysis.

A4.3 Ease of Evacuation

Any evacuation requires a mixture of factors to consider including:

- the resources available (people and equipment);
- access routes to safe ground;
- the level of preparatory planning;
- communication networks;
- the number of people to be evacuated; and
- the danger to those involved in the process (mainly a function of velocity, depth and accessibility); etc.

Identification of floodway areas will assist with flood preparedness and flood response plans.

A4.4 Flood Awareness

Flood awareness relates to the population at risk knowing what to do to and how to minimise the consequences of a flood (essentially how to protect ones stock and goods as much as possible and evacuate safely if required). Effective flood awareness is underpinned by promotion through public awareness campaigns. Generally flood awareness diminishes in time after flooding.

Flood maps which show as floodway the more flood hazardous areas or areas having a greater risk from flooding, are a useful tool in raising flood awareness. However, flood awareness is not a factor which can be considered in defining floodways.

A4.5 Flood Warning

Flood warning lead time is linked to the rate of rise and fall of a flood. The more time people have to prepare for protection of moveable goods and possible evacuation the less hazardous the flood will be to those affected and the lower the flood damage. Effective action depends on effective flood warning systems.

Even if people and possessions are fully evacuated a flood will still cause damage to buildings and infrastructure, and substantially disrupt communities.

Generally larger catchments have slower rates of rise and fall and a longer warning time than smaller and steeper catchments.

The existance or lack of a flood warning system is not a factor which can be considered in defining floodways.

A5. Environmental Values

A5.1 Continuity of Flowpaths

Flowpaths include natural depressions and channels through which water flows either continuously or intermittently. They have important implications for preservation of water quality and preservation of aquatic habitat.

To preserve the passage of flood flows, *main flow paths* should be kept free from obstructions wherever possible.

It may not be practical to show all flow paths as floodway. For instance, some of the broader floodplains might contain a large number of poorly incised, low capacity drainage lines and depressions which convey minor flood flows but allow floodwaters to spill out into the broader floodplain when their capacities are exceeded. Delineating each drainage line or depression is clearly not warranted.

A5.2 Wetlands

For many areas of the State degradation of wetlands and water quality is of increasing concern. Consideration should be given to defining areas having recognizable environmental values as floodway in order to reduce further degradation.

Wetlands play an important role in trapping sediment and recycling nutrients. Apart from the more obvious swamps and lakes, they include billabongs and cut offs and other forms of linear wetlands which occur naturally along the water courses.

Failure to preserve wetlands may lead to a reduction in water quality, increased sedimentation and erosion.

Wetlands also play an important part in the life cycles of many animal species.

A5.3 Fauna Habitat

Preservation of the habitat of fauna (including native fish and macrophytes) requires the adoption of catchment management strategies that incorporate, among other things, the maintenance of minimum environmental flows, sensitivity to flow regimes under natural conditions, improvement of water quality and preservation of breeding habitat.

Defining floodways can assist these strategies by controlling the amount of inappropriate development on the floodplain.

A5.4 Water Courses Subject to Siltation or Erosion

Erosion of banks and deposition of silt are natural processes associated in some degree with all water courses. However some land practices can accelerate these processes,

reducing water quality, causing bank instability and leading to changes in flood flow distributions and flood levels.

Defining watercourses which are sensitive to siltation or erosion as floodway won't redress abuses of the past, but can lead to a reduction in the rate of their proliferation.

APPENDIX B
GUIDELINES ON METHODOLOGY

CONTENTS

APPENDIX B
GUIDELINES ON METHODOLOGY

B1. General

There are a number of methods available for defining a floodway. For some areas there may be results from a detailed flood study or enough ground level contour information and flood data to define it with reasonable precision. However, often the available information is limited and less reliable methods will have to be employed.

The following notes have been developed as a guide on methodology.

B2. Consider The Available Data

Generally reasonable amounts of flood data exist for areas where flood problems are significant and impact on development, and where there is ample flood warning time for aerial flood photography to be arranged.

Detailed ground level contour information is available for many towns which have sewage systems and for irrigation districts in middle and lower catchments.

Flood photography is available for many areas for both minor and major events.

Soil maps are often useful to show (as prior streams) depressions and areas of flood storage (alluvial deposits).

Further types of flood data have been listed in Project Briefs.

B3. Consider The Catchment Characteristics

As a guide:

	Upper Catchment	**Middle Catchment**	**Lower Catchment**
Slopes	steep	varies	flat
Floodplain Width	narrow	varies	wide
Catchment Area	small	medium	large
Rate of Rise and Fall	often rapid	usually slow	slow to very slow
Flood Warning Time	little to none	some	usually plenty for the larger catchments
Flood Storage	no	yes	yes
Flow Obstruction Issues	check narrow parts	check narrow parts	check for raised earthworks in flatter parts
Natural Features	lakes	swamps, wetlands(including billabongs and meander cutoffs), significant fauna	swamps, wetlands(including billabongs and meander cutoffs), significant fauna
Erosion or Siltation problems	erosion	erosion/siltation	siltation
Significant Levees	some	often	often

Flooding for steep and narrow river reaches are often characterised by rapid rates of rise and fall, little to no flood warning lead time, relatively high velocities and significant flood depths. Flood storage isn't an issue but the consequences of obstructions can be significant.

On the other hand, lower river reaches might be characterized by broad floodplains, where flood depth isn't as large, but the effects of obstructions (which accelerate flood flows and reduce flood storage) might be significant.

In both cases environmental considerations might be high.

B4. Consider Approach

Identify for each water course whether velocity-depth, environmental values or levee considerations apply. This will depend on socio-economic considerations and on what data is available.

B5. Consider what effort is to be put in.

Wherever possible floodways should be delineated. However where information is limited the law of diminishing returns applies.

For example, for non irrigated rural areas, where properties tend to be large, there may be little value in delineating floodway with great precision. On the other hand, for urban areas or intensively cultivated areas, a more rigorous method of defining floodways is most likely warranted, particularly for strong growth areas.

B6. Apply the Guidelines

Divide each catchment into areas and, having regard for the available information and the catchment characteristics, apply the guidelines. Look for easy ways of defining floodway for rural areas not intensely developed, e.g. continuous flow paths, use of flood photography.

For the more intensely developed rural areas consider additional data (if available) and methods, e.g. flood storage considerations, velocity-depth considerations coupled with flood photography, etc.

B7. Special Techniques

There are a number of ways in which data can be used to define floodways without carrying out an elaborate analysis. Two methods are considered below.

B7.1 Velocity Depth Analysis

Where flood studies have been undertaken or where sufficient flood information and ground level contour information exists, floodways can be delineated by estimating average velocities and depths and using the velocity-depth curve (Fig. 2).

In the absence of detailed modelling, Mannings formula ($Q = AR^{2/3}s^{1/2}/n$) is usually sufficient to estimate average velocities and depths, provided Q can be estimated.

If there is insufficient data available to estimate the 1% flow rate, the following formula can provide a reasonable estimate for rural areas (Ref. 6).

$Q\ (m^3/s) = 4.67\ Area^{0.763}$; where

Q ≅ the 1% flow rate +/- 30%; and

Area = the catchment area in km^2 less any flood storage areas

This formula has been derived by plotting the estimated flows (major or 1%) against the catchment area for about 70 studies around the Great Dividing Range, with catchments exceeding 30 km^2. The formula does not take into account any breakaway flows.

For urbanised catchments the formula is:

$Q = 10.29\ Area^{0.71}$

The effect of urbanisation is significant for smaller catchments. The difference in flows calculated by the 2 equations decreases with larger catchments.

FPMU can make curves available if requested.

For rural areas, if ground level contour information is unavailable, field measurements of the hydraulic slope, and the approximate width and shape of the bed and banks of a water course, may be sufficient to estimate the portion of flows expected to be carried between the banks and therefore (by deduction) an estimate can be made of the flows expected to occur on the floodplain outside the banks. If the floodplain is reasonably uniform, Mannings formula can then be used to obtain a rough estimate of the corresponding depths and velocities in the floodplain. This approach is useful for analysing areas protected by levees (refer Section 8).

B7.2 Flood Photography

The use of flood photography to define floodways can be invaluable, particularly where sufficient data exists to estimate the difference in flood levels at the time of the photo and those corresponding to the 1% flood.

Information from stream gauging stations can provide an indication of flood duration and rate of rise and fall.

In many cases a simple hydrologic/hydraulic analysis may be sufficient to enable flood photography taken a number of days after the peak to be used to define floodways where there is no ground level contour information.

If the Average Recurrence Interval of flood photography can be estimated, along with the margin between the flood levels and the 1% flood, then, in the absence of any further data, the photography could be used to delineate floodway areas if the margin is sufficiently large.