PREPARING COMMUNITIES FOR FLOODING: SOME RECENT

LESSONS AND SOME WAYS FORWARD

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There can surely be no doubt, after the widespread and frequently severe floods in New South Wales during 1990, that much remains to be done to prepare the state adequately for flooding. In that year the inundation of one small town, Nyngan, led to a damage bill estimated at $50 million, and numerous other communities also sustained serious losses. From time to time public criticism implied that government agencies were seen to be at fault for not having prepared communities appropriately for flooding or for having given them insufficient time to respond effectively to the arrival of flood waters.

There are numerous ways by which communities can be prepared for flooding. Probably the best known to the public at large are the so-called 'structural' or engineering works which attempt to modify the behaviour of flood waters so as to lessen the frequency or seriousness of impact of floods: levee banks, bypass channels, retarding basins and mitigation dams are examples. Less familiar to most are the 'non-structural' approaches which have no effect on flooding itself but which modify human activities in ways which mitigate the **impacts** of floods. Removing houses from the path of flood waters, discouraging future development by means of zoning provisions or financial disincentives, educating communities on flood risks and on appropriate behaviours to follow before and during flood periods, developing flood forecasting and warning systems and equipping emergency services for flood planning and flood combat work are cases in point. Actual experience of flooding, too, helps communities to be prepared.

These different preparatory 'devices' are variously preventative or predictive of flooding or otherwise mitigating of its actual effects on life and property. Some, like levees and other engineering works, operate for long periods of time once constructed, whereas others like flood warning messages are necessarily short-term in application to particular locations. Some are dependent on local initiative or activity; others may originate some distance away from flood prone communities. Traditionally, structural works have dominated investment in flood mitigation initiatives: the vast bulk of the estimated $375 million in 1991 terms which has been spent since the late 1940s by public authorities to lessen the effects of flooding in New South Wales has gone to these types of measure (Clarke, 1991). Particularly since the seventies, though, there has been a strong trend towards a more even balance of structural and non-structural approaches, reflecting a shift of emphasis from construction works to the broader **management** of flooding (Smith and Handmer, 1984, 111).

In New South Wales, as in the other states of Australia, a wide range of flood preparedness strategies is employed. Nowhere in the state are all of the available devices appropriate or applied, of course, and not all are equally well developed. In some of the most seriously flood-affected areas where past flood losses have been high - the Hunter Valley and parts of western Sydney, for example - large amounts of money have been spent on mitigation measures. But for most flood prone areas the scope of the preparedness which exists, apart from whatever experience individual communities may have garnered from actual flood events, is limited to basic structural works like levees and/or the provision of a warning service operated by the Bureau of Meteorology to give predictions of river heights immediately before and during periods of flooding. Formal flood education remains poorly developed and flood planning is far from being widespread. It is difficult to escape the conclusion that preparedness for flooding remains severely deficient in most parts of the state.

At best, then, flood preparedness for many communities is partial. Moreover, the preparedness devices which **are** used are necessarily imperfect, as recent history demonstrates with respect to levee banks and flood forecasting systems.

Almost certainly, the public has faith in engineering works like levees: such works have the important characteristics of being highly visible and having purposes which are readily apparent. Moreover, substantial levee failure is rare, and high levels of protection can be achieved even against quite serious flooding. Nevertheless, as was argued more than a decade ago, the "construction of dikes and levees is probably the most reactionary engineering method of protecting flood plains" (United Nations, 1978, 21; underlining added). Worse still, levee protection under some circumstances can be positively **dangerous**, especially when communities have grown used to or learned to trust the embankments. It is then that people are least likely to feel a need for alternative or additional means of protection.

None of this means that levees have no place in flood preparedness. It does indicate, however, that levee protection can sow unfortunate and misleading messages, even to the extent of creating an unjustifiably strong sense of security and resulting in a positive **worsening** of the impact of flooding on a community once a really serious flood occurs. The results of levee failure or overtopping can be catastrophic, as became clear last year at Nyngan, when the permanent levee was overtopped, and as a number of leveed towns in New Zealand had discovered previously (Ericksen, 1986). Such disasters are particularly likely if levees are poorly managed - as can happen when there are long periods without severe floods - or have their design standards compromised.

Flood forecasts, too, are flawed as preparedness measures. In large, relatively lightly populated areas the network of rain gauges is likely to be dispersed, large rivers will be ungauged over considerable distances and many tributary streams - especially those which flow only intermittently - will not be gauged at all. In some areas, too, floods can develop so rapidly as to tax even the most modern and complete of predictive systems to the point that they cannot keep up with events. Moreover the relationships governing river levels are complex and predictions must be made in the absence of detailed information on environmental changes which are often critical to flow behaviour. The real world is much more complicated than any hydrologic model.

Understandably, because of these problems, height predictions will sometimes miss the mark in terms both of accuracy and of timeliness. The Bureau of Meteorology is periodically criticised for this, often unjustifiably, as are those emergency services which are responsible for contributing to or disseminating the predictions. After almost every serious flood, criticisms of height forecasts can be

heard, and evidence of the public's less-than-complete trust in them mounts further.

CONTRASTS IN PREPAREDNESS: NYNGAN AND WARREN

In the extensive flooding which afflicted western New South Wales for much of the autumn and winter of 1990, the small towns of Nyngan (population 2500) and Warren (2000) became major focal points of flood response action. Nyngan achieved instant fame late in April when its levee banks proved not to be high enough to hold out the worst flood ever recorded in the Bogan river valley; the town became the first in Australia to be evacuated, virtually in its entirety, by helicopter. Just over three months later Warren made news by virtue of its co-ordinated and ultimately successful effort, backed by defence force assistance, to rebuild and raise its levees against the flood waters of the Macquarie River. The two towns are interesting examples of differing styles and degrees of preparation for flooding.

In Nyngan's case, discussions with public officials and townspeople suggest that a perception existed, before the April flood, that the levee banks would provide adequate protection against flooding and would prevent flood waters from entering the town. The levees had been built during the early 1980s with an intended design freeboard giving protection from floods up to a metre higher than the levels reached by the worst in the town's more than a century of existence. As it happens the actual freeboard was rather less than this along much of the embankment's length as a result of road construction works (Department of Water Resources, 1991), though it is unlikely that this was well known within the town. Almost certainly it was widely believed that the levees ensured Nyngan a flood-free future.

Initially, the April flooding caused little concern. As the water level rose past those reached in earlier major floods, though, a large-scale community effort was mounted to raise the levees with sandbags. Most of the town's able-bodied people were involved, a considerable esprit de corps was created and optimism built up that the newly-enhanced levee banks would hold back the water. As it happened, the water rose beyond the crest of the permanent levees and punched through the hurriedly-constructed sandbag barrier. Within hours, virtually all the buildings within the town were inundated and a mass evacuation became unavoidable.

With all the benefits of hindsight it is clear that Nyngan placed the whole of its trust in its efforts to raise the levees with sandbags. No other preparatory measure was seriously pursued: few people sought to lift belongings above the reach of potential flood waters, and no plan of evacuation appears to have been devised until very late except for Police efforts to move elderly people to the hospital on the highest ground in Nyngan. Three days before the levees were breached, Nyngan's road and rail links to the outside were cut, ensuring that when evacuation was necessary it would have to be by air.

There was no shortage of response to the flood from the community, but it was focussed in only one direction. Moreover, offers of help from the Divisional Headquarters of the State Emergency Service in seeking defence force assistance were turned down - presumably because it was felt in Nyngan to be unnecessary. The threat was met and responded to in ways and to a degree considered appropriate. The evidence implies strongly that actual inundation was not thought to be a real probability until very late in the episode.

None of this should be taken as implying criticism of any individual in Nyngan. It does demonstrate, however, the danger of placing too much faith in a single preparedness device: such faith can tend to blind people to the necessity of considering alternative forms of action and developing real choices of approach. In Nyngan's case, it is likely that the belief that the town had been rendered flood-free also militated against the formation of an SES unit and consequently against the development of local flood information, expertise and awareness.

Warren's case was quite different. The April flood had caused concern by scouring the town's levees, and continuing high flows in the succeeding months made restorative work difficult. When, at the start of August, a flood loomed which appeared likely to reach a level close to the top of the banks, a large-scale, multi-faceted and co-ordinated response effort was mounted. A number of function-specific groups were established under the leadership of the local SES, the Council and the Police to handle the expected work in a host of areas including earthworks, intelligence, media liaison, welfare, floodboat rescue, engineering, levee patrolling and assistance to landholders in surrounding rural areas. The individuals in charge of these groups met each evening for the duration of the emergency to review events and plan future activities.

Numerous initiatives were organised. All available earthmoving equipment owned by the shire and by local agricultural companies was brought in to work on the levees, and the assistance of an army engineering unit was obtained. As at Nyngan, the levee-enhancing operation was set in train several days before the flood peak was expected to arrive, but in Warren the approach was based on heavy machinery and engineering expertise rather than on local townspeople deploying sandbags from small trucks and floodboats in a highly labour-intensive manner. In a matter of a few days, the town's several kilometres of levee banks were raised by half a metre and considerably broadened.

Meanwhile public utilities were sandbagged and motors lifted above the predicted flood level, telephone poles were marked at the level of the predicted peak as a guide for the raising of furniture in the event of levee failure, a daily information sheet was produced and distributed to the populace, hospital patients were moved to other towns and an evacuation plan to transport the entire population away from Warren was devised. Agricultural levees upstream were deliberately breached and a road which was acting as a dam to flood waters was lowered; these actions probably had the effect of dispersing and speeding the flow into creeks and cowals away from Warren and lowering the peak level experienced at the town.

Probably Warren's greatest assets were the flood of April and Nyngan's experience at that time. Nyngan had had no serious flooding for several years and none at all since its levees had been built, while Warren had seen the failure of Nyngan's efforts to stem the flow of water which reached levels higher than had been anticipated. Most importantly, Warren's community leaders were well aware of the criticisms which had been levelled at their counterparts in Nyngan, and quickly saw the need for a broader, more multi-dimensional response to the threat.

TOWARDS IMPROVED PREPAREDNESS

What, then, should be done to improve preparedness so as to minimise the possibility of future disasters like Nyngan's? Perhaps the most important **principle** to enshrine is that flood preparedness should be multi-faceted; that is, for each flood prone community an appropriate **range**

of preparations should be developed, by local people or in concert with various government agencies as necessary. The problem with individual devices or strategies is that they will fail or perform sub-optimally on some occasions, and as a counter it is important that a **layering** of preparations of different kinds be established. Different systems will fail at different times and under different stresses, and having a multitude of preparedness measures will have the effect of maximising the chance that at least some of them will withstand the pressures which major floods impose.

Several kinds of preparedness measures are currently being developed and improved in New South Wales. Flood warning systems are being upgraded, flood planning is being given a high priority and public education programmes are being devised. None of these is new, but in each case there is considerable scope for improvements to what has existed in the past. In all three areas the SES - the 'combat agency' for floods in this state - is active. From being primarily a hazard response agency in the past, the SES under its recently-proclaimed legislation has been given a clear responsibility for developing an anticipatory stance as far as flood disasters are concerned. Preparedness, then, is becoming a major focus of its activity.

UPGRADED FLOOD WARNINGS: GAUGE NETWORKS AND INTELLIGENCE SYSTEMS

Flood warning systems can be demonstrated to be useful in helping to mitigate against flooding, in terms of protection of both life and property (Smith, 1990), but there is little doubt that their potential is far from being reached. Such warning systems are complex, being made up not only of hardware elements but also of arrangements for disseminating flood-relevant information to communities liable to be affected by flooding. Undeniably, there is much scope for improving the performances of the various parts of these systems.

As far as hardware is concerned, the past two years have seen the installation of radio-telemetered data collection (ALERT) systems in the Tweed, Wilsons, Shoalhaven and Georges River catchments in New South Wales. Beyond this, a five-year programme has been agreed in which the Bureau of Meteorology, in conjunction with state and local government, has committed a total of $1.8 million to new gauging equipment for the state's river catchments. This programme will involve the progressive upgrading of telephone-based to radio-telemetered recording in the faster-responding catchments and from manually-read stations to telephone telemetry in others. For some catchments, previously ungauged tributaries will be gauged, and some locations for which there has been no real warning system in the past will soon have one.

Beyond this, the SES is currently investigating the distribution of the more than 2000 river gauges in New South Wales so as to identify areas of deficiency and more importantly to integrate the networks of gauges owned by a multitude of organisations including the Bureau, state government departments such as Public Works, Water Resources and the SES, universities and local government authorities. No single agency maintains a complete inventory of gauges indicating their locations and capacities, with the consequence that individual data users are unable fully to access the water-related data which is collected. The solution is to properly integrate the various systems of gauges so that information can be made readily available to a **number** of participating users (Kneen, 1983). Such integration will almost inevitably produce information which is useful for flood-predicting purposes but which is not currently available to the Bureau of Meteorology.

Beyond new hardware installation and the improved integration of currently-operating hardware networks lie other means of raising the quality of flood warnings. Existing flood warnings in New South Wales are simply predictions of river heights, usually indicating also the **class** of flooding (minor, moderate or major) which is forecast. To provide more meaningful warnings to threatened communities, additional information is required - notably on the areas which are likely to be inundated at the forecast height and on what people in those areas should do to mitigate the effects of the flood waters (Heatherwick, 1990, 8). The optimal warning system integrates **height predictions** with information on the anticipated **effects** of the flood and with **advice** to people as to how the problems may be mitigated immediately before or during the event.

Too often, gauge height predictions are not well understood in the community because knowledge is lacking as regards what will happen at given heights by way of impacts on houses, stock, utilities, roads and the like. This position can be redressed by more effectively cataloguing the consequences which flow from flood waters reaching particular gauge heights, and by ensuring that the resulting information is better communicated to those who can use it - the residents. Local governments, especially their engineering departments, can contribute significantly to the development of flood intelligence given their knowledge of flood prone land and the floor heights of buildings and utilities and their ability to carry out accurate surveying work. With appropriate liaison, SES personnel will be able to relate this information to gauge heights.

Some communities already have well developed flood intelligence systems. Deniliquin, in the far south of the state, is a case in point. For sites outside the town's levees - caravan parks, bridges, a sewage pumping station, sports facilities and a few houses - critical river-gauge heights at which inundation would occur have been identified. For those locations within the town proper which would be inundated in the event of the levee failing or being overtopped, the information indicates the phasing of the inundation and the depth which the water would reach - all this on a street-by-street basis covering the entire town. Few communities yet have a flood intelligence system as complete as Deniliquin's, but most have an embryonic system capable of further development or at least some of the data needed to build one.

A mass of data on the effects of flooding at particular gauge heights is of maximum use only if community members understand its applicability to them as individuals or families. One way of using the information to raise awareness might be to provide all dwellings in a flood liable area with measures indicating the gauge height at which waters would reach a critical level or levels - say floor height or the level at which isolation from surrounding areas would occur. A piece of dymostrip giving these heights and attached to the electricity meter would provide a means of ensuring the passage of the relevant data to the householder.

It is likely, though, that an initiative seeking to achieve this would meet with strong political opposition of the kind which forced the state's publicly available flood inundation maps to be withdrawn during the mid-1980s (see Handmer, 1985). If so, other ways of using the information to inform the community would be needed. One approach might be for the SES to produce, for individual towns, its own series of inundation maps - each map corresponding to a particular gauge height. Such maps could be used to identify, for given height predictions, which householders should be advised to raise their furniture and furnishings and which should be advised to prepare to evacuate. **Computerised** flood height mapping, of course, would allow quick appreciations of the likely consequences of predicted floods to be achieved and a rapid communication of information to residents by means of doorknocking campaigns or messages relayed by the electronic media.

FLOOD EDUCATION

Flood intelligence, then, can be used to raise flood awareness through community education, which in turn should make warnings more meaningful and more useful to the population. Traditionally, in this state, public education for weather-created disasters has been limited, confined largely to a small number of publications produced by the Natural Disasters Organisation and not widely distributed. At present the State Emergency Service is working to make these booklets and pamphlets more readily available through councils, police, schools and interested community groups. In addition, cards are being designed which will suggest things that people can do before, during and after a flood so as to mitigate its effects. Tear-off sections to such cards could include checklists and telephone contact numbers and could be magnetised so as to be stuck on to refrigerator doors.

Such cards must reach their markets, of course, and at present negotiations are going on with potential distributors. Possibilities include Neighbourhood Watch, councils (with rate notices) and corporate sponsorship through insurance companies willing to distribute the cards with their premium renewal notices. Beyond these possibilities lie the usual media outlets. Stories in local and regional newspapers about preparing for floods are useful for many reasons, not least as reminders, because people tend to forget what happened last time they were struck and because all communities experience a steady infusion of newcomers unfamiliar with their new environments and the hazards they may face.

It can be argued, of course, that public education material is largely wasted if it does not reach its targets when they are most receptive to it. Information on floods is probably most likely to be noticed and acted upon when a flood is actually occurring: this is the time when such information is most needed, and when psychological defences such as denial are likely to be at their weakest (Handmer, 1990). It would be unwise, however, to restrict **all** flood education to this most 'teachable moment' (Filderman, 1990, 223). Better, perhaps, to pursue a range of awareness-creating strategies - newspaper articles, radio messages, pamphlet drops and the like - to implant information in people's minds for later 'activation' from the subconscious once flooding is imminent. That said, it makes sense to utilise the 'rhythm' of particular hazards in educating the community about them: if there is a reasonably distinctive flood season, the dissemination of material intended to raise awareness should be biased towards that time of year. Using a **range** of education strategies, too, will have the effect of increasing message penetration since different people respond to different media. Some may learn effectively from lengthy newspaper articles; others may be more likely to do so from graphic pictures on television.

FLOOD PLANNING

It is virtually axiomatic that response to disaster is facilitated if it has been thought about beforehand - that is, if it has been anticipated and planned for. But until very recently, emergency planning in New South Wales was poorly developed. There were few trained planners who were experienced in emergency management, and the legislative base for disaster preparedness was too flimsy even to ensure that the appropriate emergency service agencies co-operated in planning to cope with disasters. Consequently, the state was ill-prepared to cope with major emergencies.

This general situation was mirrored in the field of flood planning. Some plans existed, but the quality was uneven and the coverage of the state very poor. Areas with severe flood hazards had, in many cases, no effective flood plans at all.

Under these circumstances, planning endeavours contributed little to the preparedness of New South Wales communities for flooding. Much has changed, though, in recent times, as a result of the passage of the State Emergency Service Act 1989. That Act recognises precisely and formally the role of the SES as the combat agency for floods, enshrines preparation and planning as required activities and ensures that supporting organisations such as the Disaster Welfare Service are more fully involved in the planning process than was earlier the case (see Haines, 1990). Much work remains to be done in New South Wales before it will be possible to say that floods are effectively planned for, but that work is now well under way.

The central initiative in this field is the New South Wales State Flood Plan, which lays down procedures for flood planning, flood warning arrangements and response and recovery operations throughout the state. The plan also requires each SES Division and each local government area in which a flood threat exists to prepare a plan within the next two years - which means that by mid-1993 a set of interlocking flood plans covering all the state's flood liable areas will have been produced. These State, Division and Local flood plans will be sub-plans of the various disaster plans (DISPLANS) produced at the same or similar levels (Haines, 1991).

These plans will have as their purpose the mobilisation and co-ordination of resources in ways which will allow communities to respond effectively to the threats which flooding poses. They will spell out the agreed roles of a range of actors from both the public sector (for example, the Bureau of Meteorology, local councils, police and other emergency service organisations) and the private (including media and welfare organisations), and they will be tested and updated periodically so that freshness and relevance is maintained. The process by which the plans are developed will ensure that the participants - those with roles to play - achieve real ownership of and commitment to them, and that the plans continue to be documents which the users can genuinely use in protecting their communities.

In addition to these plans dealing with 'natural' floods, special plans are being written to facilitate the response to superfloods which would occur in the event of the failure of major water storage dams. The New South Wales Dams Safety Committee has identified several dams which may be at risk of failure, mainly because of spillway capacities too small to pass the probable maximum flood in their catchment areas. For some of these dams the plans have already been produced and for others the planning process is well advanced. In some cases the process will need to produce several plans to cover the different local government areas in the path of a superflood caused by dam failure. In some instances, too, it has been felt necessary to combine planning for dam failure flooding with planning for very large (current planning level and above) 'natural' floods: planning for the Nepean-Hawkesbury river system, which includes Warragamba Dam (the state's largest water storage), is a case in point.

The planning process for 'natural' floods is being developed by the SES in its combat agency role, the various plans being co-ordinated by full-time staff in the department's state headquarters and regional division offices and utilising considerable volunteer input at regional and local levels. For dam failure planning, considerable use is being made of a new tier of specialist emergency planners, the District Emergency Management Officers, who were appointed in 1990. This reflects the multi-

agency response that catastrophic events like dam failure would necessitate, and recognises that response operations generated by such events may need to be controlled by State, District and Local Emergency Controllers rather than their counterparts in the SES who will, nevertheless, retain control responsibilities for the vast bulk of 'natural' flood events.

To co-ordinate, over the next few years, the development of a large number of flood plans will be no small task. It will involve, as flood intelligence systems are developed, hazard analyses giving improved appreciations of floods and their consequences. It will require thoughtful resolutions of thorny problems relating to the definition of worst-case planning scenarios for events some of which have not been experienced historically, together with careful analyses of threatened communities, skilfully devised public education programmes and effective management of the contributions of a wide range of organisations with roles to play. These endeavours should ensure that flood planning plays an important role in community preparedness, helping to minimise the losses which flooding inevitably brings.

CONCLUSION

It has been argued here that flood preparedness has been too narrowly defined in the past, and that an appropriate step forward would be to think of it as a layering of several strategies upon one other. These strategies should be varied in their nature, some being developed from engineering and scientific approaches and others from the behaviourial science and planning disciplines. Other things being equal, communities which have developed a range of appropriate preparatory measures will be the most disaster-ready and will survive serious flooding with less damage and trauma inflicted on them than communities which have not done so. In particular, towns protected by levees should have contingency plans to cope with the possibility that the levees will be overtopped in an extreme event or will fail for any other reason. The experience of Nyngan should be taken as salutary: levees, by themselves, may create only the illusion of genuine preparedness.

None of this represents radical thinking. In other fields, the notion of layering different protective devices or strategies one upon the other as an insurance against system failure is well entrenched. Industrial firms which use or produce dangerous chemicals have numerous systems to prevent them from escaping into the environment - and even then there are cases of total or near-total system failure. The gas leak from BHP's Newcastle plant in April 1991 was a case in point; another, much more tragic instance was the one at Union Carbide's Bhopal (India) factory in 1984. Security firms like Armaguard and Wormald treat protection as a problem to be dealt with using several devices or systems, not simply as grilles or buzzers on doors. Again, the purpose is to ensure that protection is maintained even when some measures are compromised, bypassed or otherwise rendered less than fully effective.

Preparedness then, should take several different forms: as a matter of principle a broad rather than a narrow view of it must be taken if the damage done by environmental disasters such as floods is to be mitigated. Over the next few years we can expect flood preparedness to take on a much more multi-dimensional flavour in New South Wales as the planning process develops and as increasingly creative warning systems, backed by public education programmes, are developed and implemented.

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