ANUFLOOD IN NEW ZEALAND: PART I

Approaches to urban flood-loss reduction in New Zealand

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FOREWORD

This Working Paper is one of a set of three containing papers presented at a Seminar-Workshop entitled ANUFLOOD An Integrated Computer Package for Flood-loss Adjustment and Abatement held at the University of Waikato, Hamilton, New Zealand from December 11-13, 1985. The meeting was sponsored jointly by the Geography Department of the University of Waikato, the Water and Soil Directorate of the Ministry of Works and Development and CRES. ANUFLOOD is an interactive computer package developed in CRES and commercially available from ANUTECH at the Australian National University. It is designed to assess tangible urban damage and to evaluate the likely effects of a wide range of mitigation options.

The aim of the Workshop was to discuss the various forms of urban flood damage, possible mitigation strategies and the applicability of ANUFLOOD to flood problems in New Zealand. Some 25 participants drawn mainly from New Zealand Catchment Boards and the Ministry of Works and Development attended the Workshop. To provide data for a practical demonstration of ANUFLOOD the flood-prone parts of Paeroa, a town near Hamilton, were mapped. In addition to the demonstration five papers were presented at the meeting. Four of these were contributed by CRES staff and the fifth by the Workshop organiser, Dr Neil Ericksen of the University of Waikato.

The five papers, plus a summary of the Workshop conclusions, will be published in New Zealand by the University of Waikato in collaboration with the Ministry of Works and Development. Publication as CRES Working Papers will enable rapid initial circulation to interested workers in the field.

The papers are published as three linked CRES Working Papers under the general title of ANUFLOOD in New Zealand.

Part I (CRES Working Paper 1986/2) contains the paper by Neil Ericksen entitled Approaches to Urban Flood-loss Reduction in New Zealand.

Part II (CRES Working Paper 1986/3) Background to Flood Loss Measurement comprises two papers by John Handmer.

Part III (CRES Working Paper 1986/4) ANUFLOOD Development and Application consists of two papers by David Ingle Smith. These provide a background to the use of ANUFLOOD as presented in the programmer's guide and user's manual.

Enquiries concerning the availability of the Seminar-Workshop Proceedings should be sent to:

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Details regarding the availability of ANUFLOOD should be directed to David Ingle Smith at CRES or to:

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Canberra City, 2601

The authors would like to acknowledge the value of the discussions at the Workshop with representatives of the Water and Soil Directorate of the Ministry of Works and Development and staff from a number of New Zealand Catchment Boards.

ABSTRACT

Flooding is a serious problem in New Zealand with annual average losses exceeding NZ$100 million (1984 NZ dollars) and increasing. The past approach to flood hazard management focussed on engineered structures, reinforced by post-disaster relief that reinstated people and property in flood prone locations, steadily increasing the people and property at risk. Thus, while the frequency of smaller floods has been reduced the potential for major disasters has escalated. To reverse this trend the paper argues that flooding must be seen as a social rather than an engineering problem. Such a perspective requires a comprehensive approach to flood hazard management, new means for evaluating flood hazards and mitigation strategies, and the development of an integrated or unified flood loss reduction policy.

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INTRODUCTION

Recent estimates indicate that the annual cost of flooding in New Zealand over the last 15 years exceeds $100 million* and that the flood-loss trend is increasing. Nearly 100 urban places are affected. Analyses of specific places show that most of the losses from flooding and many of the popular means for reducing losses are eventually paid for by people beyond the affected area.

Past approaches to the flood problem in New Zealand, as in other countries, have tended to focus on the flood event. The most well developed action taken to reduce the flood problem has emphasised the need for scientific understanding of the physical processes that lead to flooding and on physical engineering structures for averting flood losses. It is reinforced by post-disaster relief and rehabilitation efforts that reinstate people and property in flood-prone locations behind renovated engineering structures.

This paper will illustrate how this approach has reduced the number and frequency of floods, but has contributed to the growing flood hazard potential and thereby actual disasters in urban communities. This unexpected result is in part due to an approach which focusses on flooding as a physical event rather than on flood hazard as a social phenomenon. The flood hazard is a function of the flood event, human use of the flood-prone area, and measures taken to reduce potential flood losses. This interactive definition of flood hazard is central to the arguments in this paper.(1)

To reduce the number and size of disasters and the growing flood-loss trend in New Zealand, it is argued that it is necessary to examine much more carefully than hitherto the complex linkages between human occupance of flood-prone land and the consequences that flow from any measures that are adopted for combatting flood losses. This will require a new perspective on the flood problem whereby it is seen not just

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* all prices are in 1984 New Zealand dollars.

as a physical event to be controlled through river control works, but as a hazard that has been largely created by people occupying flood-prone land and which may be modified through land use management. Such a perspective requires a comprehensive approach to floods and flood hazards, new means for evaluating flood hazards and adjustments to them, and the development of an integrated or unified flood-loss reduction policy. The agencies most affected by these new needs are the 20 regional catchment authorities and the local territorial authorities, that is, the cities, boroughs, and counties.

The paper is in four parts. The first outlines the magnitude of the urban flood problem; the second, the main approaches to flood-loss reduction; the third, the consequences of the existing piecemeal approach; and, finally, the need for a new, integrated approach, including better methods for assessing flood losses and their abatement.

MAGNITUDE OF THE PROBLEM

Between 1920 and 1953 New Zealand experienced 820 damaging floods, both large and small (Cowie, 1957 and Ericksen, 1971a). In the next 30 years, 115 large damaging floods occurred, in spite of large-scale investment in engineering protection works since the 1940's (Figure 1) (Ericksen, 1985).

Currently, nearly 100 communities are flood-prone. Of 136 places with more than 1,000 people in 1956, 64 percent (88 places) had experienced one or more floods since 1920. From the early 1950's to 1984, over two thirds of these 88 places were revisited by floods, some several times, and many in spite of being 'protected' (Figures 2 and 3). To these communities must be added another eight that had not been flooded prior to 1954 (Figure 4).

Within these flood-prone communities reside over 1.64 million people or 67 percent of the New Zealand total (1976 census). Over two thirds of the settlements have populations of less than 10,000. Nearly 70 percent of New Zealand towns and cities with populations in excess of 20,000 have a riverine flood problem (Table 1). Obviously, only a portion of the population of any community is at direct risk from flooding, but many more are indirectly affected by the social disruption of damaging events.

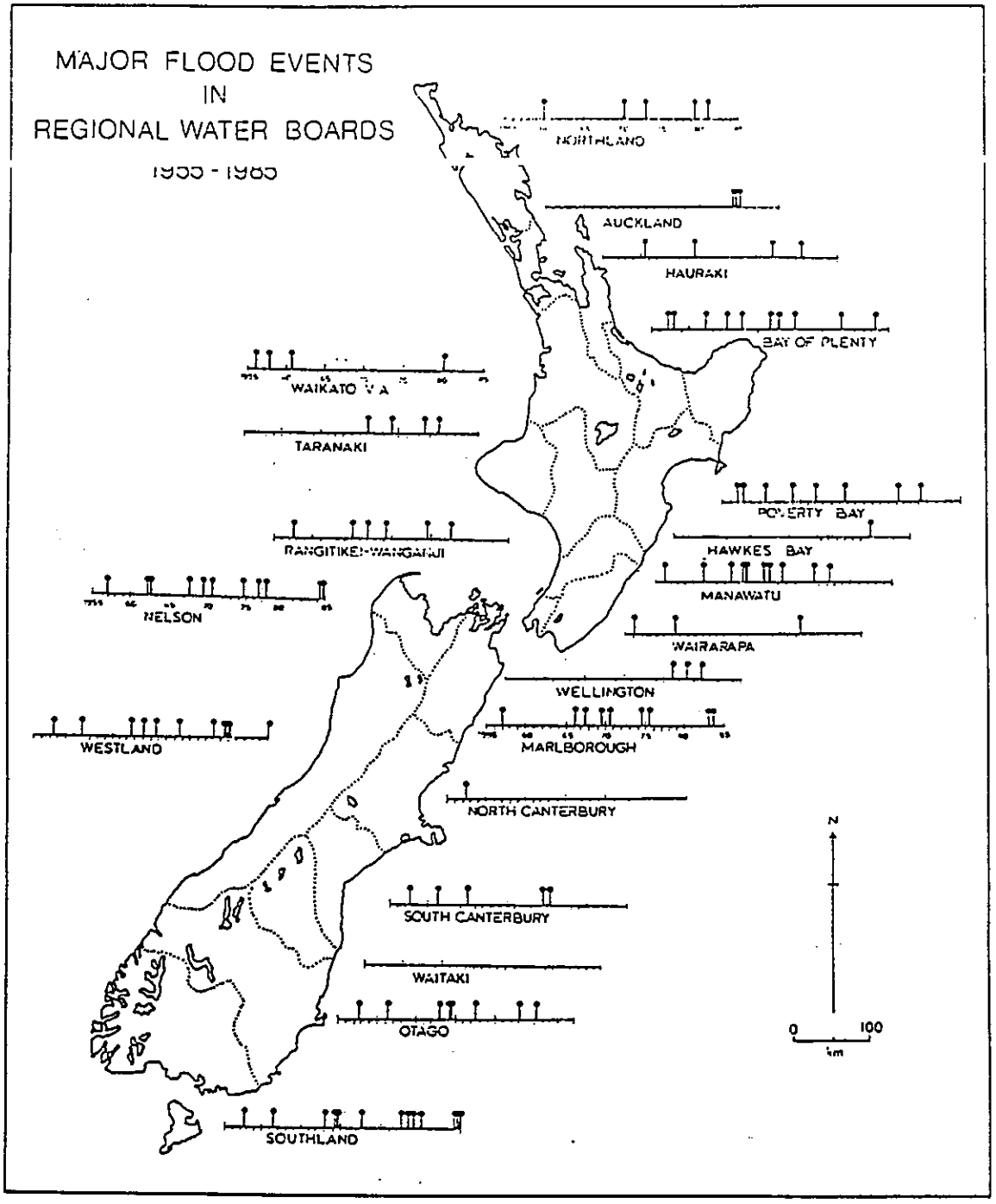


Figure 1. Number and occurrence of major floods in Regional Water Boards of NZ, 1954-1984. (Source: Adapted from Trebilco, 1980.)

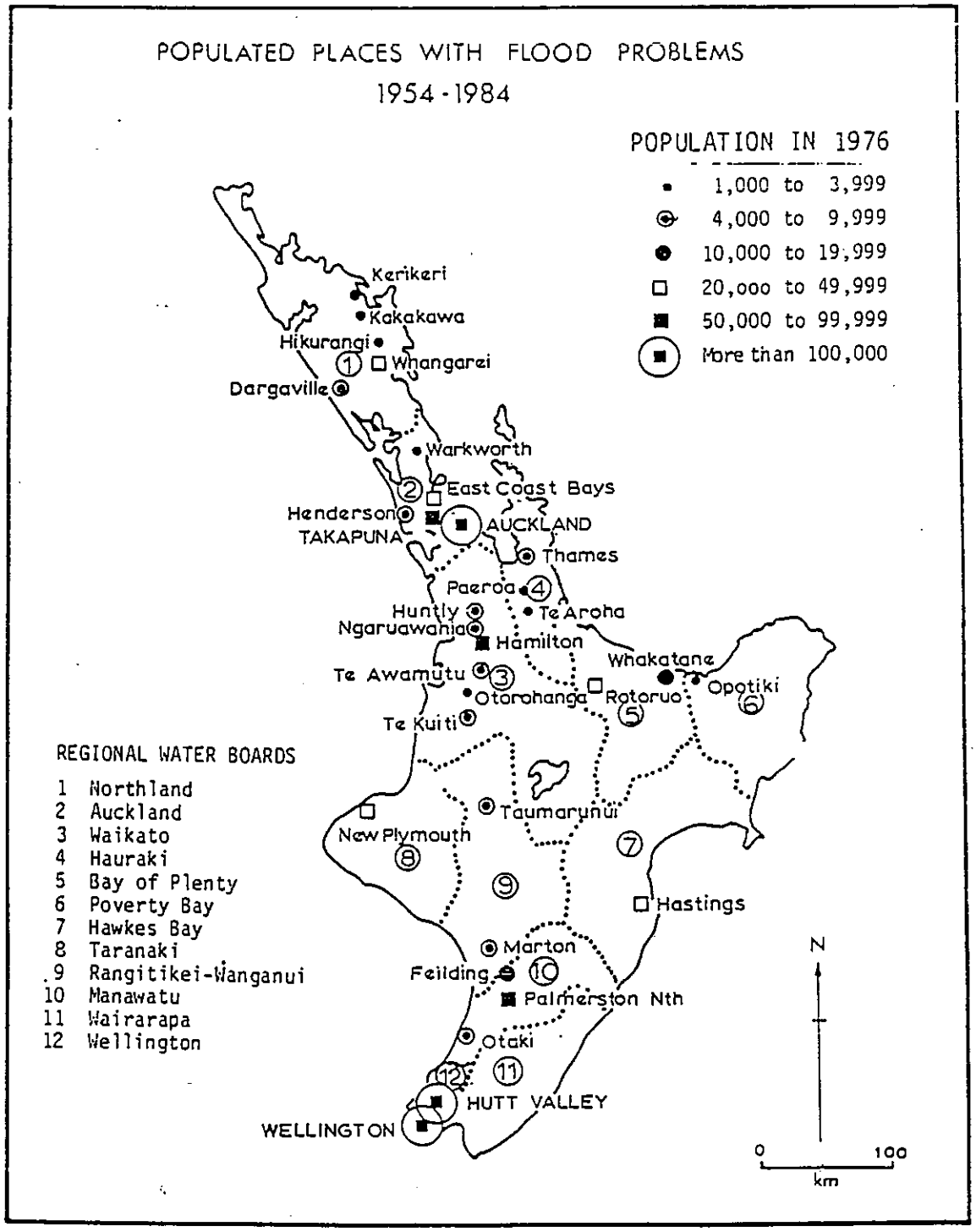


Figure 2. Flood places in the North Island, NZ, 1954-1984: a partial survey. Some boroughs in metropolitan areas are not distinguished on this map. Places with under 1,000 people are not shown. In the year to March 1984, floods affected several communities of this sort in the North Island.

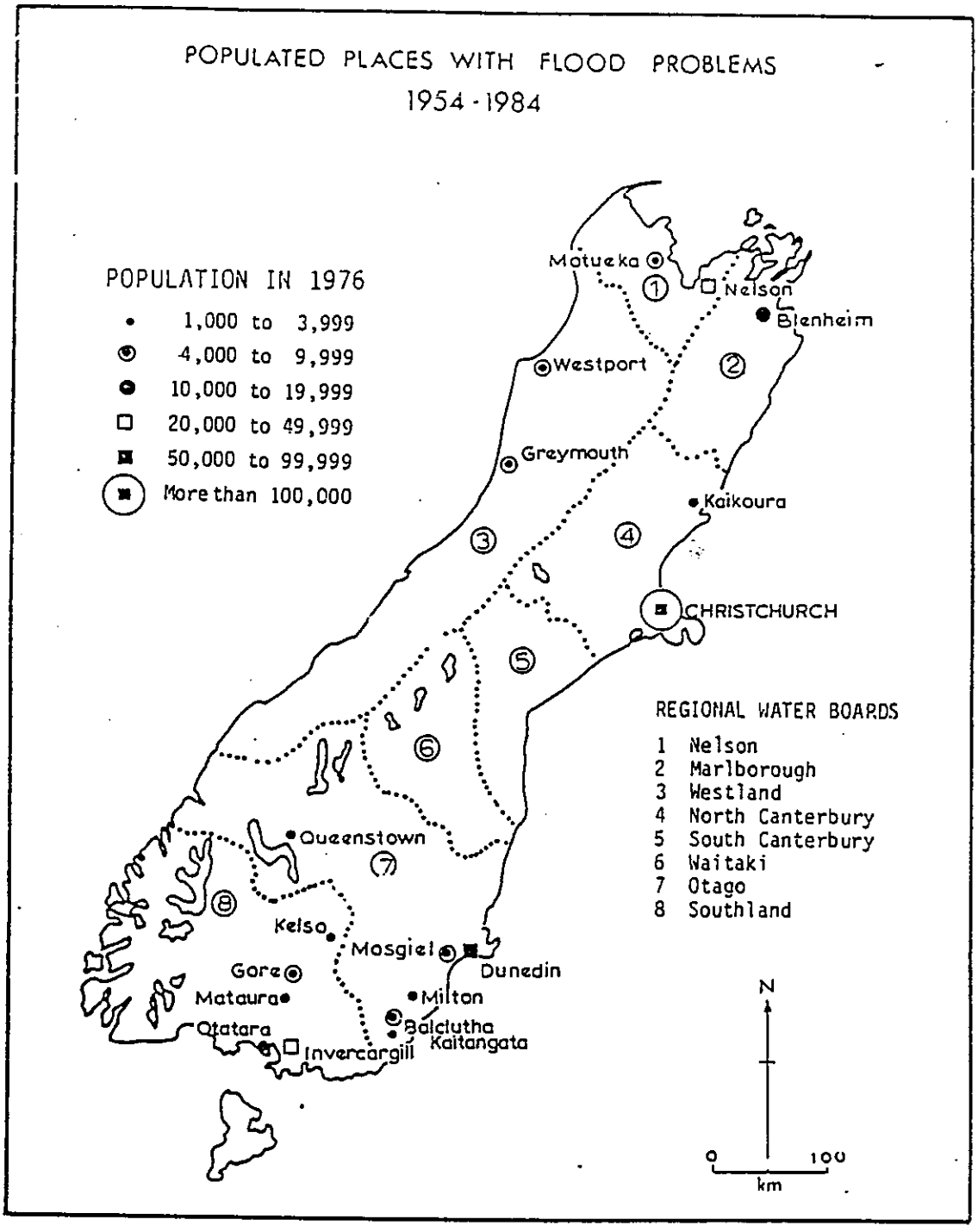


Figure 3. Flood places in the South Island, NZ, 1954-1984: a partial survey. Places with under 1,000 people are not shown on this map. In the year to March 1984, floods affected many communities of this sort, especially in the Nelson, Marlborough, and Southland regions.

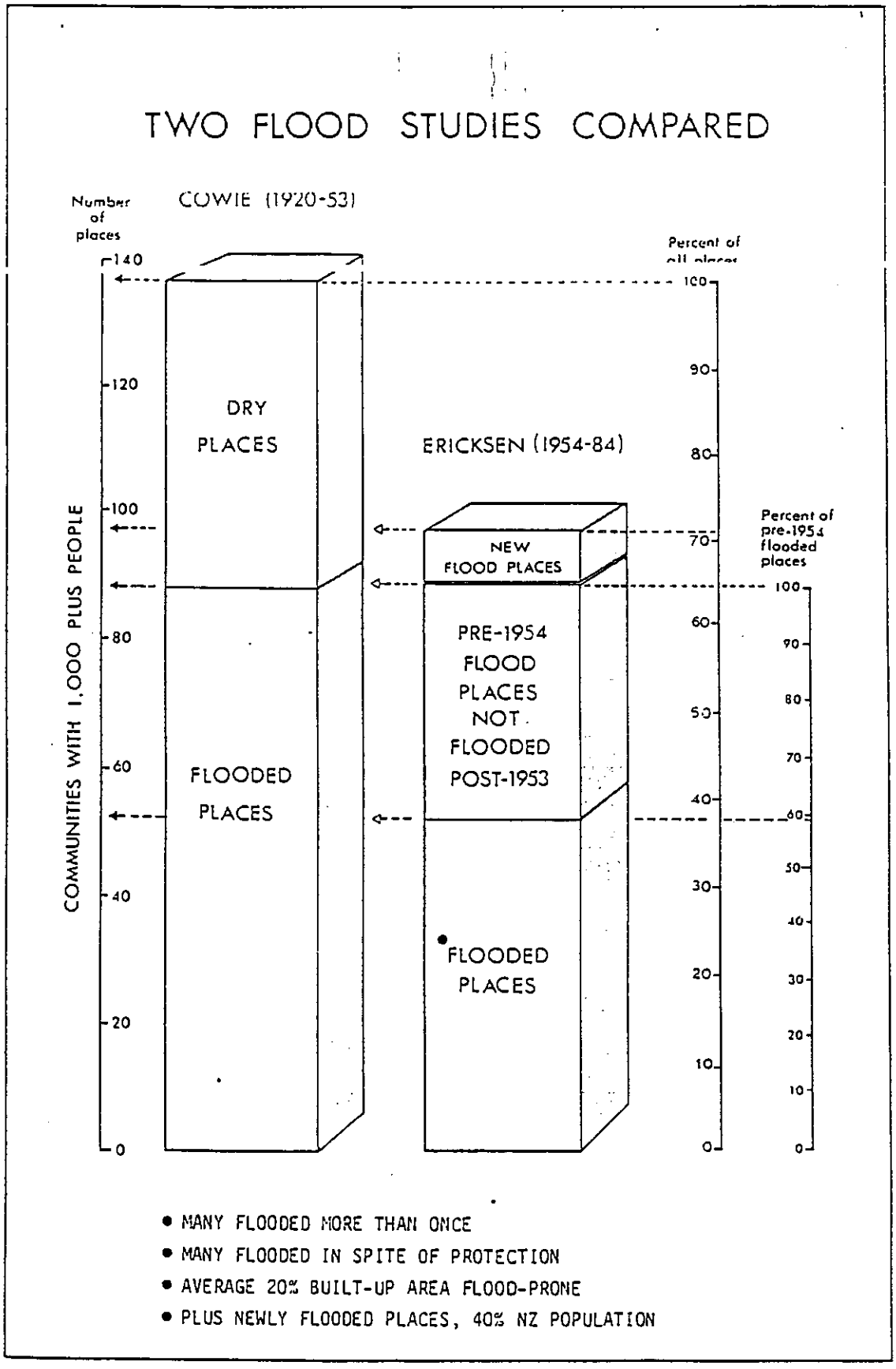


Figure 4. A block diagram comparing the number of urban flood places studied by Cowie in the early 1950's with those studied by Ericksen in the early 1980's.

Table 1: Number and total population of places with flood problems (1920-1953) classified by the 1976 population size

Population Size (1976)	Places with Flood Problems				All New Zealand Places				Number of Flood Places as Percent of N.Z. Places
	Places		Total Populations		Places		Total Populations		
	Number of Places	Percent of Places	Total Population (000's)	Percent of Population	Number of Places	Percent of Places	Total Population (000's)	Percent of Population	
1,000- 3,999	31	35.6	84.5	5.1	62	38.7	127.7	5.2	50
4,000- 9,999	28	32.2	207.4	12.6	48	30.0	288.6	11.8	58
10,000- 19,999	8	9.2	123.9	7.5	21	13.1	303.2	12.4	38
20,000- 49,999	13	14.9	470.8	28.7	19	11.9	629.2	25.7	68
50,000-100,000	4	4.6	293.3	17.9	6	3.8	497.7	20.3	67
Over 100,000	3	3.5	462.3	28.2	4	2.5	601.3	24.6	75
Totals	87	100.0	1,642.2	100.0	160	100.0	2,447.7	100.0	

In some communities, like Opotiki, almost all of the built-up area has been flooded by the largest historical flood (Figure 5b). On the other hand, in cities like New Plymouth it is less than 5 percent (Figure 5c). Nevertheless, of 18 communities examined in detail in 1981, the average built-up area in the historical flood zone was 20 percent. Significantly, many historical floods (largest recorded flood) are not really very rare events being in the 20 to 80 year return period range. This does not augur well for the future, especially since most communities have flood protection design levels of 1:80 or less.

Flood hazard is dynamic: it changes in response both to the size of the flood event and the nature and scale of development on the floodplain. This relationship is illustrated conceptually in Figure 6.

In New Zealand, attempts to identify the flood hazard, as opposed to characteristics of the flood event, such as flood depth and flood spread, are rarely made (Ericksen, in press). Surprisingly-- given the nearly 100 flood-prone places in New Zealand and the heavy expenditure on river control works over many years-- estimates of community flood losses or potential flood losses are also few and far between. Thus, nationally, the aggregate of flood losses is poorly documented. Yet, defining flood losses for past or future floods relative to urban change is an essential first step for evaluating adjustments to floods.

An attempt was made to aggregate losses for the period 1968 to 1984. Based on case studies, the analysis assumed that insured property losses accounted for around 25 percent of direct property losses and 12 percent of losses overall. About $1/4 billion (1984 NZ dollars) was paid out by the insurance industry for 9 major floods, including nearly $50 million from the Disaster Fund of the Earthquake and War Damage Commission. On this basis, the cost to the nation for direct losses may have been over $1 billion, and perhaps $2 billion overall since indirect losses from social disruption and lost production tend to approximate direct losses-- an average annual loss of around $125 million (1984 dollars)(2). The losses seemed to be increasing throughout the 16 year period.

Estimates of loss disbursements show that over four-fifths of direct losses are borne by agencies beyond the flooded community. About

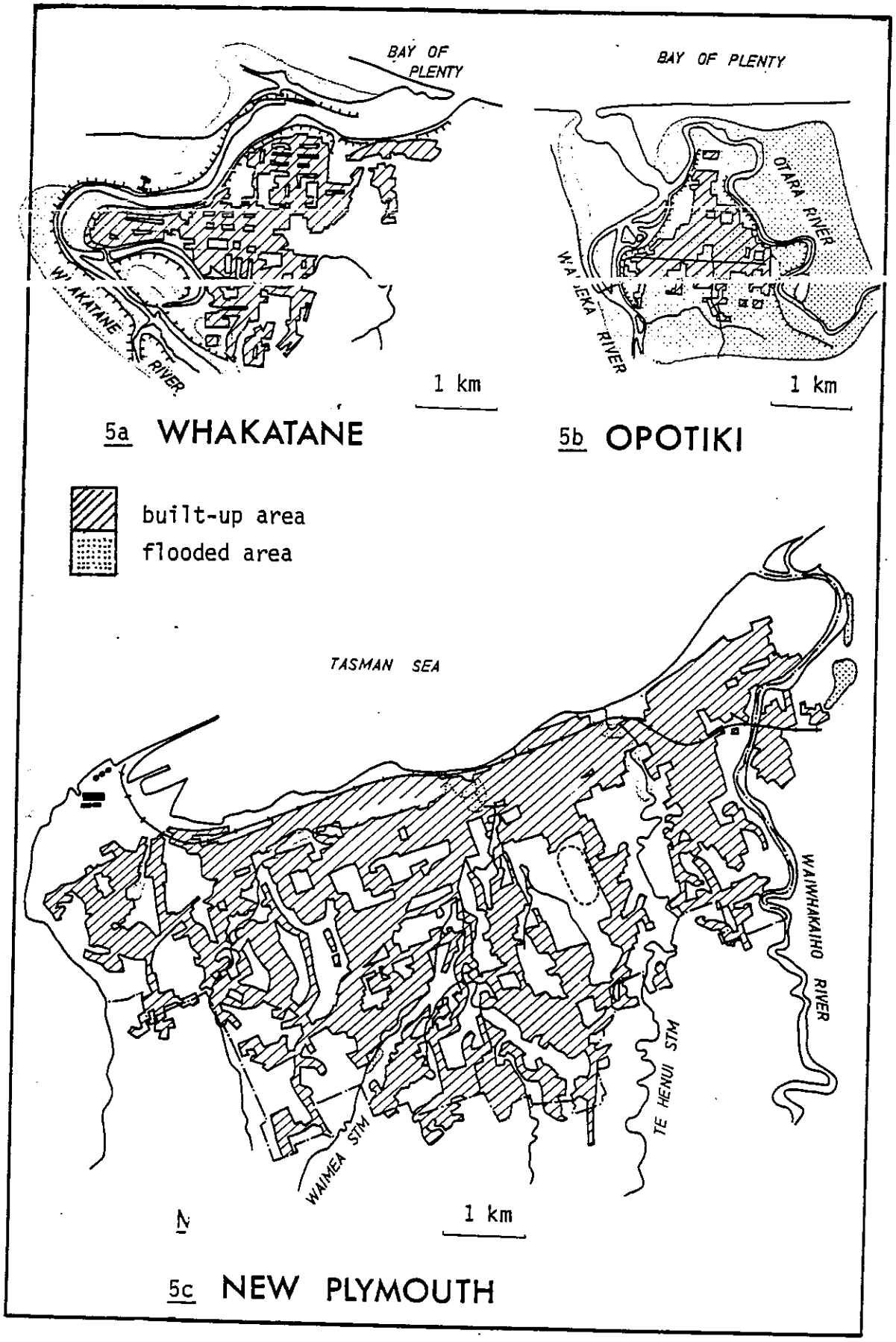


Figure 5. : Whakatane flood 1964: Opotiki flood 1964; and New Plymouth floods of 1971 and 1980.

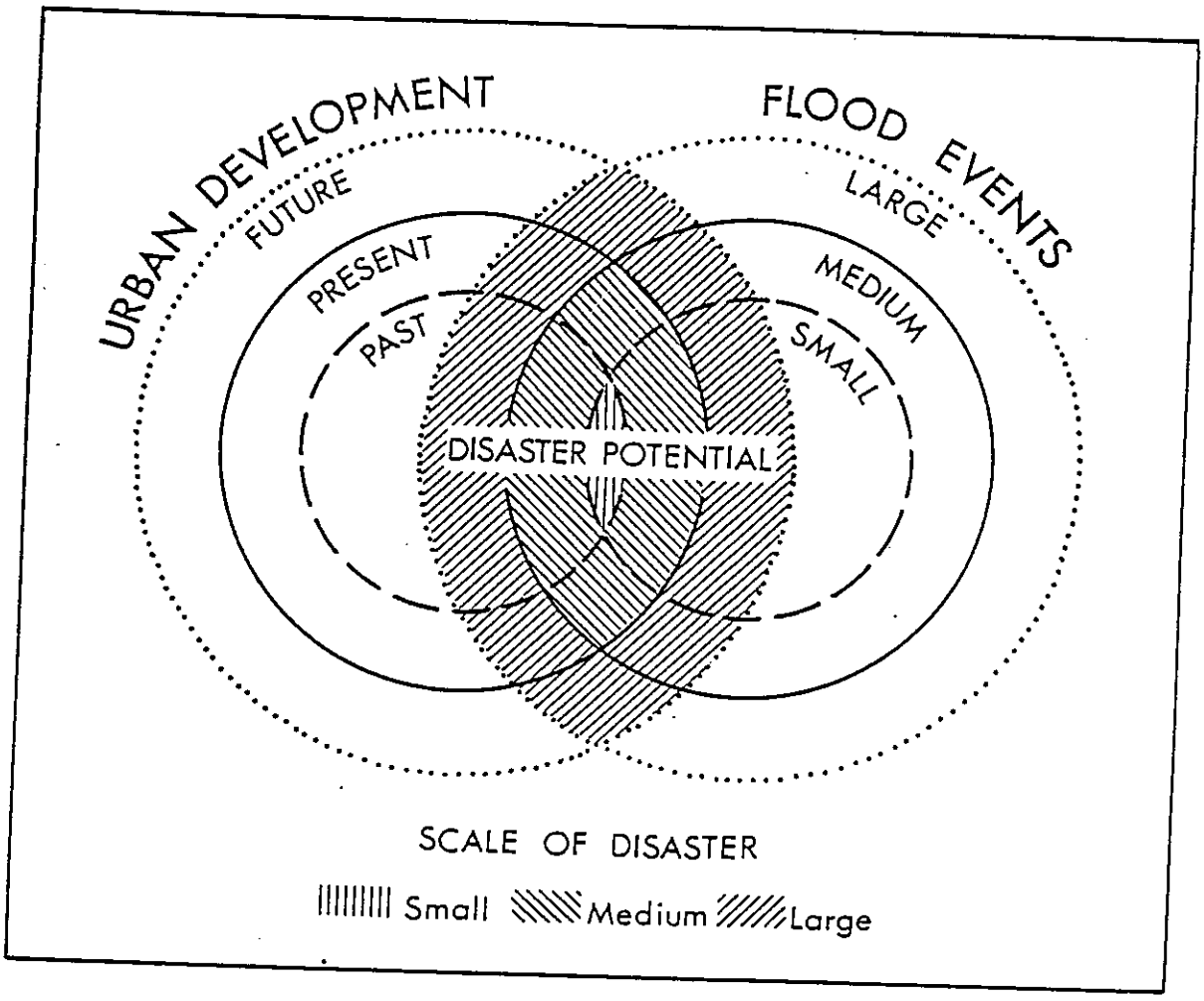


Figure 6. The creation of disaster potential. In this schema the potential disaster (hazard) in a community varies as to the size of flood event and the extent of urban development on the floodplain. It depicts increasing encroachment onto the floodplain so that for any flood of given size, future disasters will be larger than past disasters. This trend may be altered by adopting measures to curb the growth in flood hazard, although some popular measures for reducing flood events worsen it.

half of this is for the restoration of infrastructure created by agencies of central government and for public relief funds (Figure 7). The other half comes from 'insurance', including the Disaster Fund. At most, only about 15 percent of direct property losses are borne by territorial local governments.

Thus, while local communities externalise many of their floodplain development costs, much of the loss within communities is caused by locational decisions of central government agencies; decisions which in turn stimulate local flood hazard developments.

APPROACHES TO THE FLOOD PROBLEM

One approach to the flood problem is to make available an array of options for reducing losses and to allow their piecemeal implementation by flood-prone communities. Another, is to integrate the options into a unified programme tailored to the needs of particular communities. The piecemeal approach tends to lead to a bias towards specific options due to the influence of a range of purposeful and inadvertent incentives and constraints. The integrated approach requires careful analysis of the ways in which options mesh and of the systems of incentives and constraints that might ensure optimal flood-loss reduction programmes get adopted.

In New Zealand, it is the piecemeal approach that has prevailed. Recently, however, the National Water and Soil Conservation Authority (NWASCA) has been developing policies aimed at a more integrated approach. Its success will, however, require co-operation from a wide range of people in other institutions, not the least of which are the local territorial authorities.

Both approaches include within them a range of options or adjustments for reducing flood losses. A popular way to classify these adjustments is by the threefold typology charted in Figure 8. First are measures that adjust floods to people by modifying the flood event through soil conservation and river control works. Second are measures that adjust people to floods by modifying flood-loss susceptibility (or loss potential) through land use management, flood forecasting and warning, and community preparedness. Third are measures that modify flood-loss effects by redistributing the loss through relief and insurance.

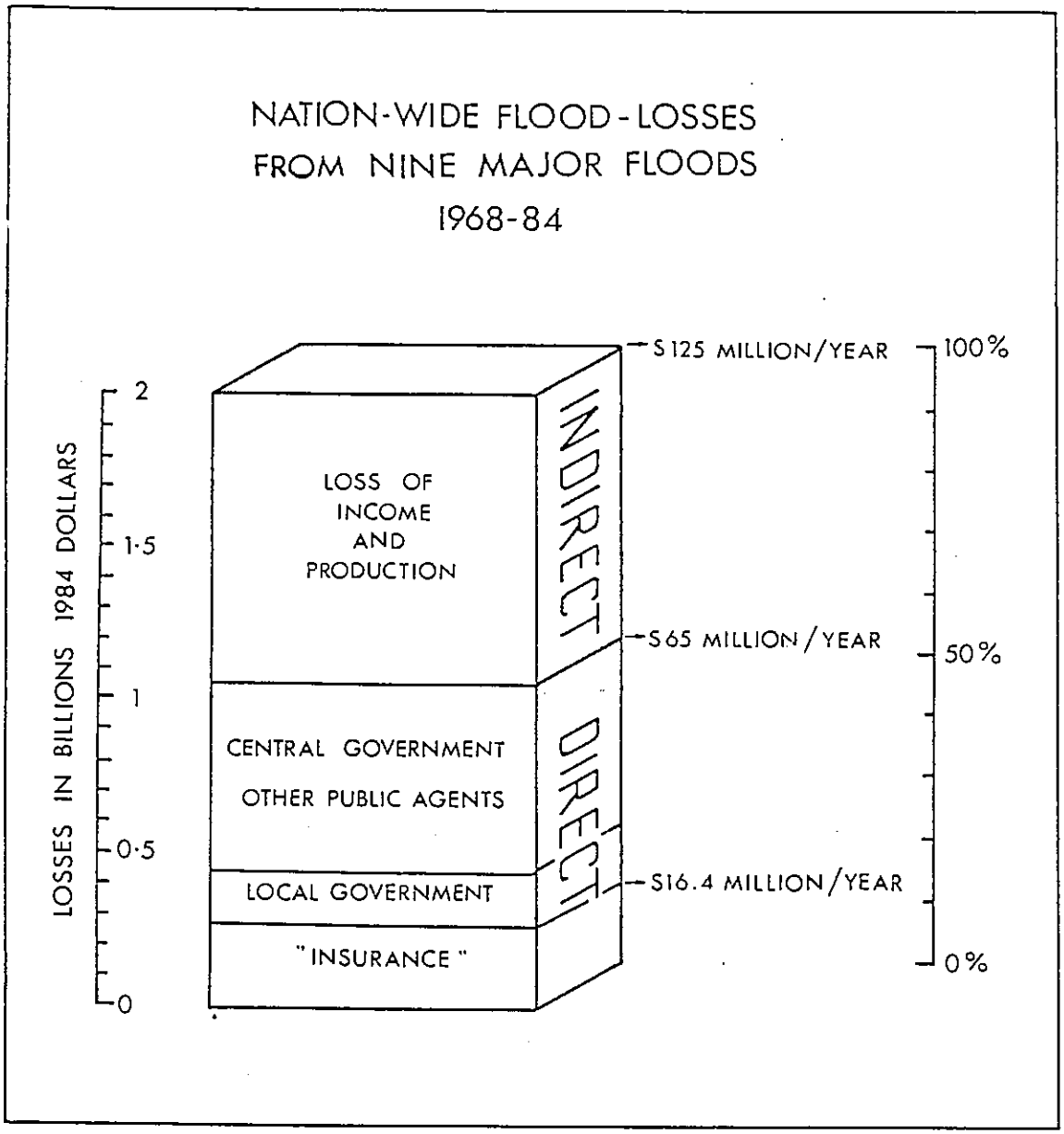


Figure 7. The nation-wide distribution of community flood losses for nine major floods in the period 1968-1984. (Note that each of the nine major floods may have covered more than one region and, therefore, many urban places.)

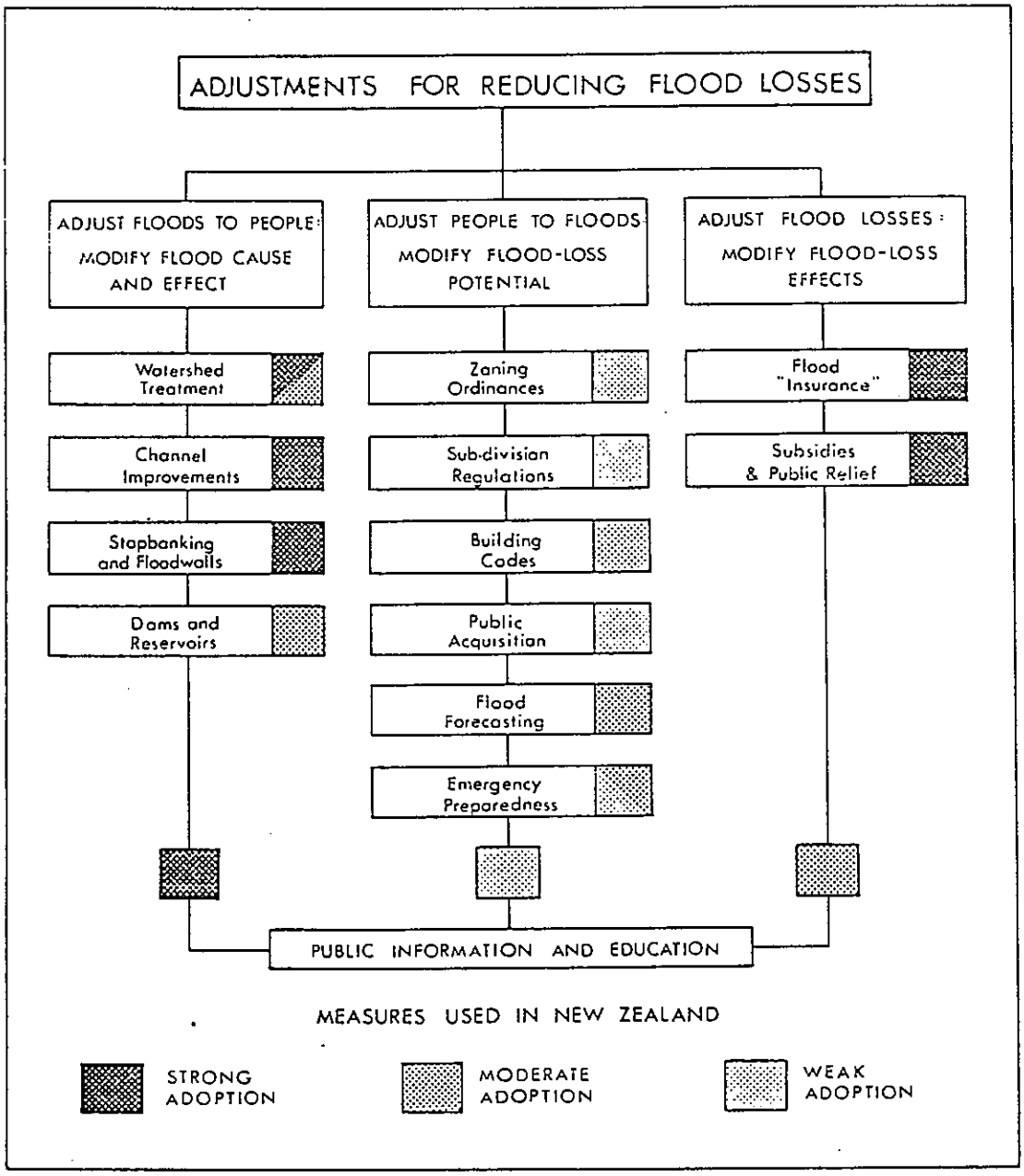


Figure 8. Chart of flood adjustments and the extent adopted in New Zealand. The many measures for modifying loss-potentials are weakly adopted relative to those that modify the flood event and flood losses. (Source: Ericksen, 1971a, 115, Figure 6; 1976a, 16, Figure 4. Updated with permission.)

Theoretically, each adjustment has the capacity to reduce flood losses (Figure 11) (Johnson, 1978; White, 1964). Some, like flood-proofing and elevating buildings and stopbanking (levees or dykes) rivers, effectively stop losses up to their design levels. Ironically, while they reduce losses from less than design floods, they enhance flood hazard and therefore the prospects for future disasters because eventually the 'protection' will fail against larger than planned for floods, as schematised in Figure 9. Other adjustments, like emergency actions, have less capacity than many others for reducing losses and are more reliant upon appropriate individual and community behaviour during the emergency. Still others, like land use management, are highly effective in reducing future flood potentials, but, unlike stopbanking, do not significantly protect existing flood-prone development (Figure 10).

Each adjustment has its own set of advantages. Taken together in an integrated or unified programme that is sensitive to the flood conditions of a given community, they have the capacity to reduce losses to a far greater extent than any one adjustment taken in isolation (Figure 11).

Modifying Flood Events

Modifying flood events through river control works is a highly institutionalised and well funded option for reducing flooding in urban communities in New Zealand. The groundwork was laid by the *Soil Conservation and Rivers Control Act 1941*, which set up regional catchment authorities under a central Soil Conservation and Rivers Control Council (SCRCC). In 1967, the functions of the catchment authorities were extended to include use and control of natural water under the *Water and Soil Conservation Act*. Unlike the 1941 Act, coverage was mandatory for all areas of New Zealand by 1973 and resulted in the creation of 20 Regional Water Boards.

Catchment authorities derive financial support for their operations by striking rates in their own areas for administration and other purposes (such as for river control works) and by project grants (ranging from 40 to 70 percent) from NWASCA.

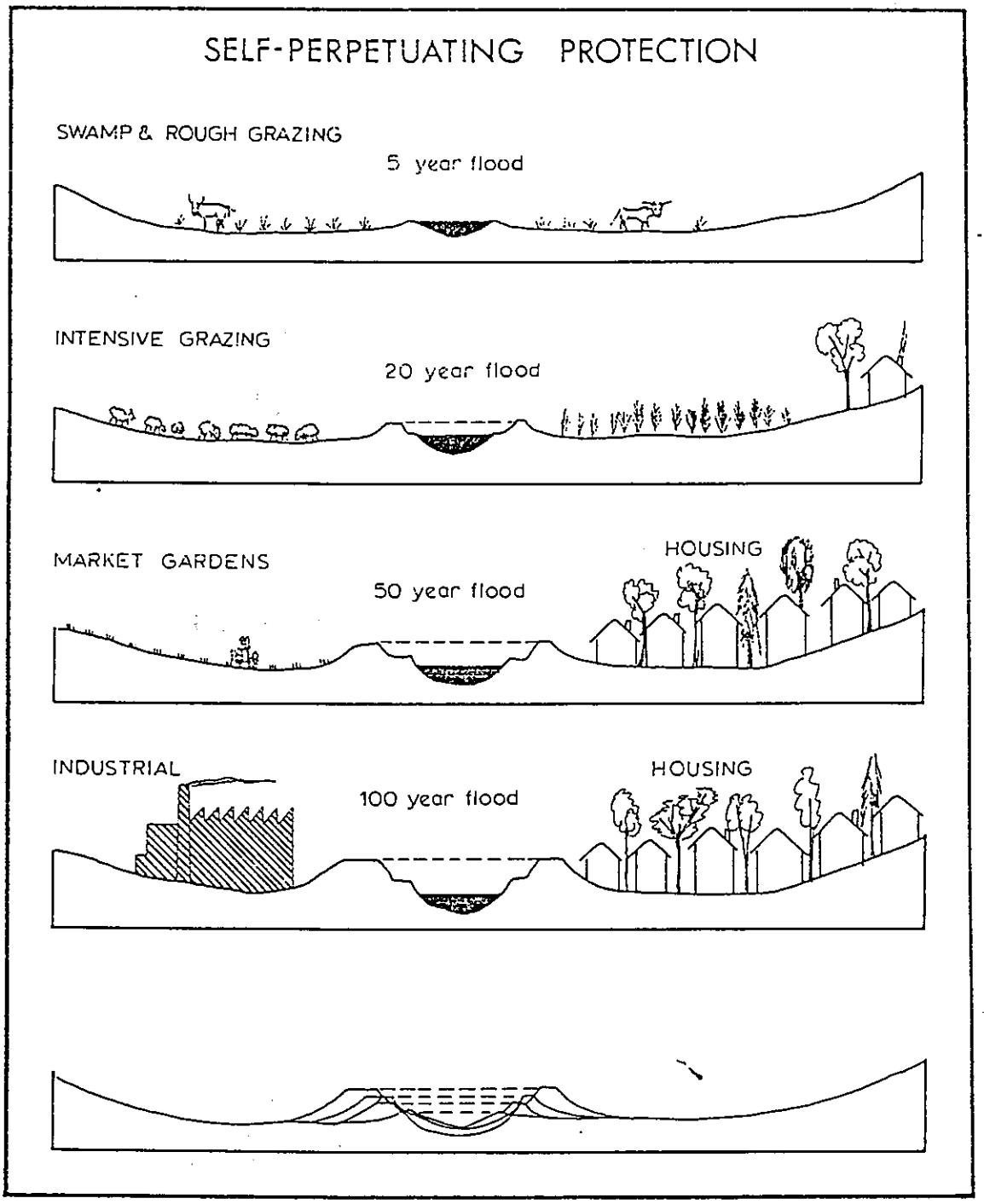


Figure 9. Self-perpetuating protection of floodplain settlement: a) natural conditions supporting rough grazing in swampy land adjacent to a channel with 5 year flood capacity; b) 15 year flood protection of intensive farmlands; c) 50 year protection of urbanising floodplain which when flooded leads to; d) 100 year protection; and e) the composite of cross-sections of enlarged embankments and channel.

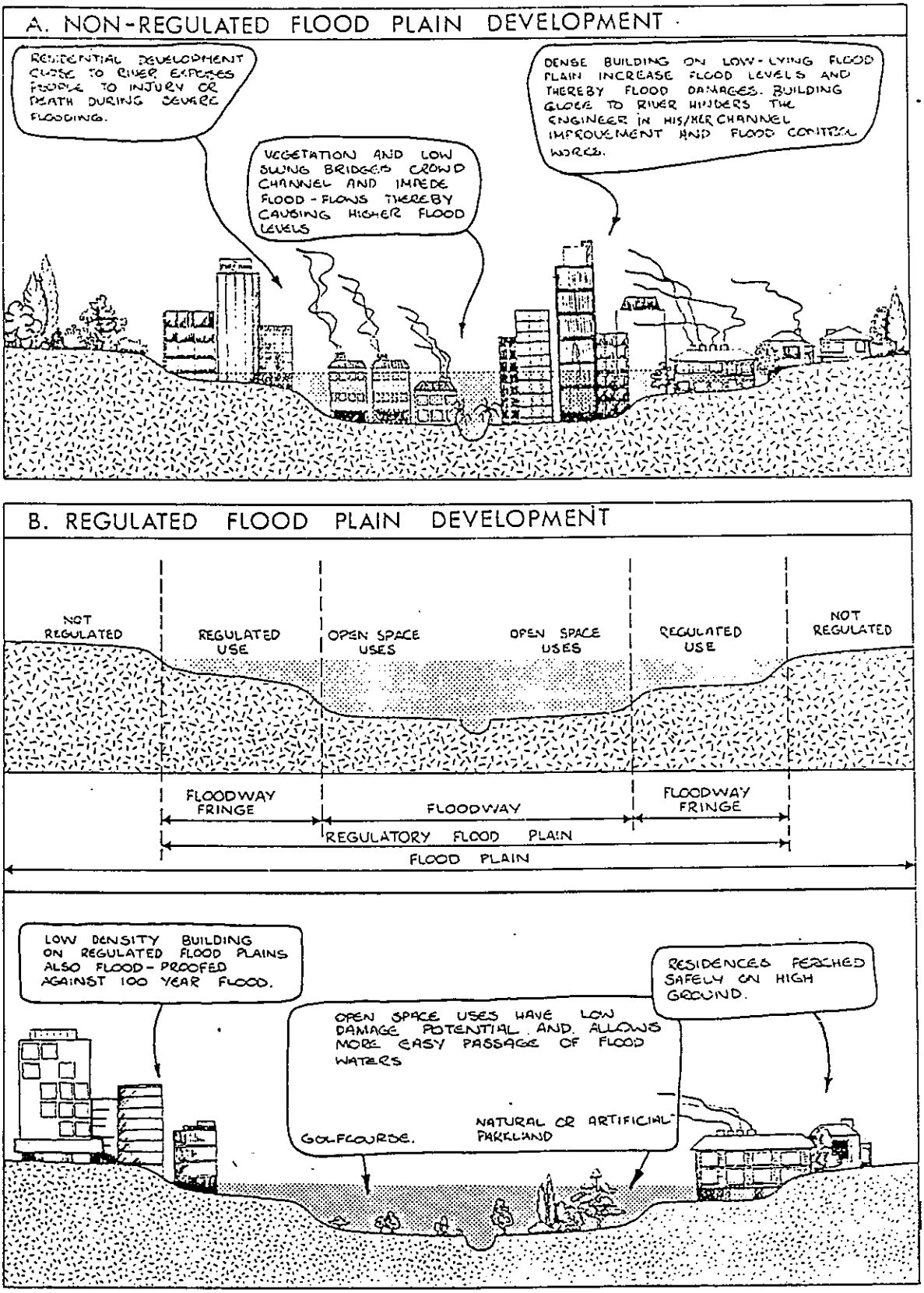
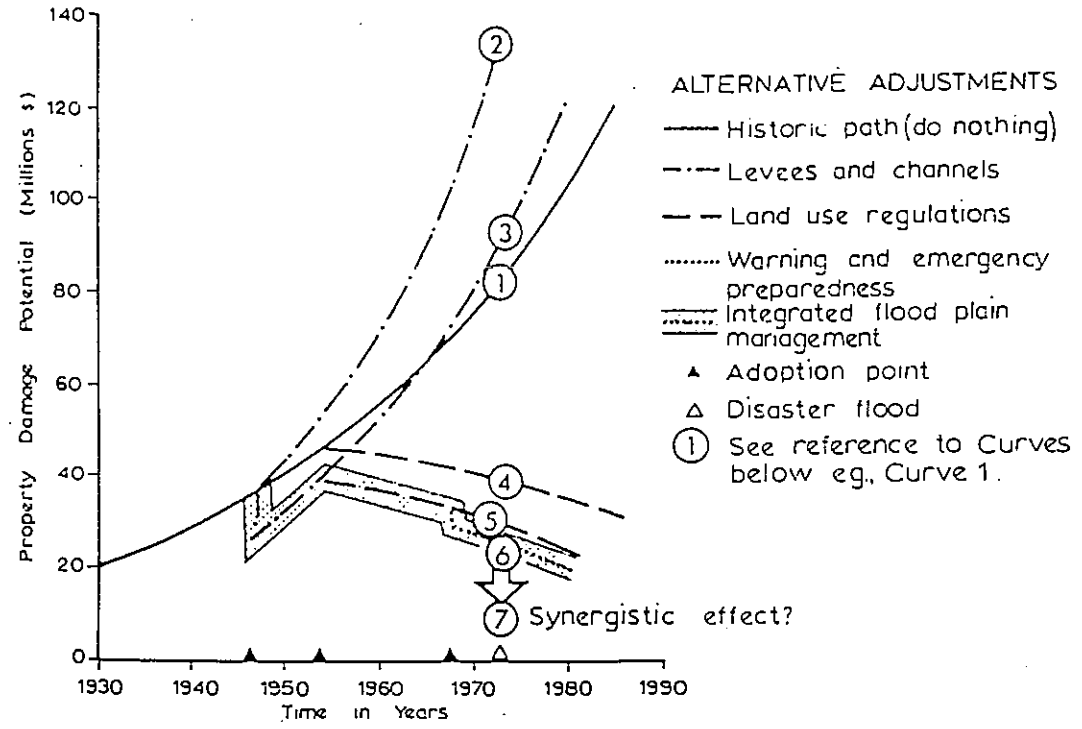


Figure 10. Cross-sections of floodplain development in an urban community (a) and its regulation (b). (Source: Ericksen, 1976a, 18-19, Figure 7. Reproduced with permission.)



LOCAL ASSUMPTION

The flood-loss reducing capacity of adjustments is based on the $80 million property losses of the June 9, 1972 Rapid City flood.

Do Nothing. In effect, this was the historic path. Since 1930, the wealth of development on the flood plain increased by about 3.5 percent per year. In 1930, the 1972 flood would have cost around $20 million (1972) (Curve 1).

Levees. These accelerate natural development from 3.5 to 5 percent per year. Levees adopted in 1947 against a 50-year flood could completely fail in 1972 flood. Damages would exceed the actual amount by $50 million (Curves 1 and 2). Combined with levees, channel works could prevent some of these damages. Even so, a generous reduction potential of 25 percent would still cause losses in excess of the actual $80 million due to levee-induced development (Curves 1 and 3).

Land Use Regulations. These reduce losses by preventing new non-flood-proofed development and by razing and relocating existing buildings. The building decay rate in American cities is near 0.5 percent per year. Planned redevelopment would accelerate this to near 1.0 percent. Regulations adopted in 1954 would reduce losses by more than half by 1972 (Curve 4). Associated with levees and channels, damages reduce a further $8 million to almost $30 million (Curve 5).

Warnings and Emergency Preparedness. These reduce losses by up to 10 percent. Along with regulations and levees they reduce loss potentials to near $26 million (Curve 6).

Integrated Flood Plain Management. While these main adjustments form a system, they do so in a simple additive way. Truly integrated adjustments would be synergistic: the benefits of each would be increased by systemic interactions with all others, and the whole flood-loss reducing effect would be greater than the sum of the component parts.

Figure 11. Rapid City: Potential flood-loss reduction curves for alternative adjustments, 1930 to 1980. (Source: Ericksen, 1975b, 313. Adapted with permission.)

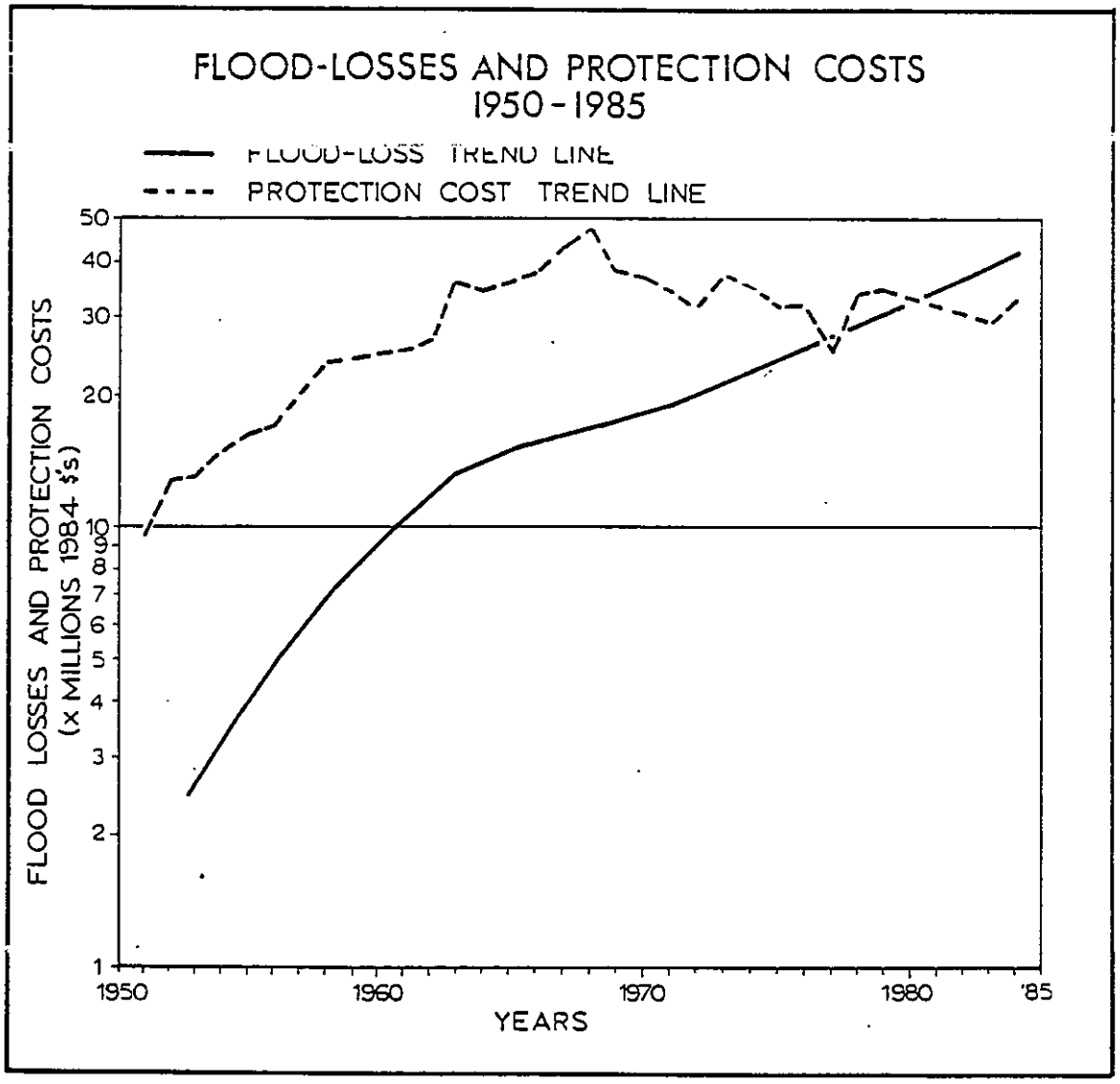


Figure 12. Trends in flood protection costs and insured flood losses, 1953 to 1980.

In 20 years to 1973, the SCRCC had financed, through local catchment authorities, around 85 major schemes (rural and urban) including: 8,800 kms of channel improvements, 480 kms of diversion cuts, 300 kms of river mouth openings, 30,400 kms of channel maintenance, 5,600 kms of bank protection, 3,040 kms of stopbanks, 43 detention dams, 1,500 flood gates, and 139 pumping stations (Ericksen 1976a). Economic and policy reasons caused the rate of works to decline in recent years.

By 1984, over $1 billion (1984 dollars) had been spent by NWASCA on subsidising local catchment treatment and river control works (Figure 12). To this is added the local share of the costs averaging perhaps 25 percent of the total. (In total, about $1.33 billion 1984 dollars or $38 million per year). The overall benefits from these adjustments remain unknown, although since 1971 individual projects costing over $500,000 require benefit-cost analyses to indicate a 10 percent internal rate of return.

Urban protection typically shelters under wider catchment control schemes so that its share of costs and benefits is not really known. As large catchment-wide projects are being completed, the scope for sheltering has reduced. This together with a growing urban flood problem will require better techniques for evaluating the urban flood hazard and adjustments to it than hitherto. Recent policy initiatives of NWASCA are moving in this direction, and a few small urban schemes have recently been subject to more careful evaluation. Nevertheless, methods for project evaluations involving comparisons across several types of adjustments and several criteria, including economic measures, have yet to be developed.

Modifying Flood-Loss Susceptibility

Modifying the flood-loss susceptibility of flood-prone communities is achieved through land use planning and management (including district scheme plans, subdivision and building permit controls, land and building elevation, urban renewal, and acquisition and relocation of property) and emergency actions (including flood forecasting and warning, evacuating people and property, and flood-proofing buildings). (Figures 8 and 10).

Land Use Planning Land use planning and management has had legal support since passage of the *Town Planning Act 1926* and it was a requirement of territorial local authorities in the *Town and Country Planning Act 1953*. By 1970, however, few communities had seriously considered land use planning and management, particularly as an option for reducing flood-loss susceptibility. Consequently, legislation was strengthened in amendments to the *Local Government Act 1974* and the new *Town and Country Planning Act 1977*.

The latter **requires** regional plans to identify areas to be excluded from development because of natural hazards, such as flooding. Regional schemes must include maps and other information considered by a united or regional council as necessary for proper explanation of a scheme. For local territorial authorities, district schemes must identify areas at flood risk and adopt policies to avoid damage or danger by preventing flood areas being zoned for residential, industrial, or commercial use or by ensuring any development is based on sound technical advice. Every district scheme **must** include a code of ordinance and maps illustrating proposals for development of an area. Section 4(3) links the purposes and objectives of the Act to principles of the *Soil Conservation and Rivers Control Act 1941*.

A 1978 amendment to the *Local Government Act 1974* **required** territorial local authorities to refuse approval for any scheme plan where it was satisfied that the land was not suitable for subdivision due to flooding, or where it would aggravate flooding, unless in the view of council adequate protection was or would be provided. Section 274 also linked the Act to the *Town and Country Planning Act 1977* with respect to subdivision development, district scheme plans, and avoidance planning in floodable areas.

An amendment to Section 641 of the *Local Government Act* in 1979 **required councils** to refuse building permits in areas of natural hazards, such as flooding, or where building would aggravate flooding. The amendment was opposed by many councils and interest groups and led to change in 1981. Section 641(2) removed the requirement not to issue permits in areas prone to *riverine* flooding for all buildings *except residential ones*. Under the new Section 641A, however, councils could not issue any building permits in areas where inundation was associated with

erosion, subsidence, or slippage (i.e., non-riverine flooding) unless adequate provisions were made to prevent flood damage or the building was relocatable or the permit was for the alteration, addition, restoration, or resiting of an existing building. In the latter two instances, the council is protected from civil liability for future damage only if the permit has been registered against the certificate of title. The 1981 amendments did not, however, alter Section 274 giving power to councils to refuse subdivision scheme plans in flood-prone areas. Currently, there is pressure from many councils to reduce the restrictions on residential permits in Section 641(2).

Although there are many legal provisions for the acquisition and relocation of flood-prone property there are few examples of its formal application in New Zealand. The same applies to urban renewal programmes. Land and building elevation is, however, becoming increasingly evident and is often given as a policy option in district scheme plans.

In spite of the wide range of options available for reducing flood-loss susceptibility through land use planning and management, territorial local authorities have been slow to adopt them for many reasons. Basic is the belief that it would limit growth, land values, and rateable income. For some, it is due to ignorance of flood risk and measures for reducing it and of their role in creating flood hazard. For others, it is because land use planning and management lack the financial incentives provided for flood control works. Increasingly, however, the role of NWASCA is extending to provide territorial authorities with advice and technical services for land use planning and management.

Emergency Preparedness Pre-event emergency actions have evolved in New Zealand for reducing flood-loss susceptibility. Although somewhat variable in quality historically and geographically, flood-forecasting and warning for urban communities now operates within a well-defined institutional framework involving the New Zealand Meteorological Service, catchment authorities, civil defence organisations of territorial authorities, the Police Department, and the Ministry of Works and Development. Mutual agreements between these agencies should reduce some of the confusion over issuing flood warnings and declarations of civil defence emergencies that has sometimes occurred in the past.

Accurate flood forecasts give longer warning-times and improved capacity for action to protect people and property through emergency actions. NWASCA provides grants to catchment authorities to establish flood-forecasting systems. Territorial authorities are empowered by Section 32(2) of the new *Civil Defence Act 1983* to provide and operate warning systems for their civil defence organisations. Alerts and warnings of flood-producing rains are provided to catchment authorities by the New Zealand Meteorological Office. Catchment authorities are designated the competent authority for issuing flood warnings to other organisations and the public, and they maintain close liaison with organisations involved in a flood emergency. Once a civil defence emergency is declared by the Controller of Civil Defence, all warnings are co-ordinated through that agent.

The focus of flood-forecasting and warning in urban areas has been on civil evacuation with no formal regard for implementation of warning-contingent flood-proofing of buildings and movable property. *Ad hoc* individual actions are, however, prevalent in communities experiencing frequent flooding. Emergency sand-bagging of riverbanks and streets is also common. Between 1968 ad 1984 some 36 flood evacuations under civil defence declarations moved about 16,000 people with only five deaths.

The benefits and costs of measures for reducing flood-loss susceptibility are unknown because, unlike river control works, formal analyses are not required for their adoption. Such analyses can and should be done.

Modifying Flood-Loss Distribution

Modifying the flood-loss burden includes redistribution through post-disaster relief and rehabilitation, and insurance.

Relief and Rehabilitation The *Civil Defence Act* of 1962 required territorial local authorities to develop Civil Defence plans against flood and other hazards. In return, they were given wide ranging arbitrary powers to act in an emergency. By 1967, 90 percent of territorial local authorities had plans approved, but nearly all were generalised, lacking specificity on pertinent local hazards, such as flood. Inability of the system to handle large-scale regional events led

to the inclusion of a regional structure in 1979 based on Regional Authorities and United Councils. Nevertheless, in 1981 the Ministry of Civil Defence reported to Parliament that Civil Defence needed strengthening in almost every respect because regional and local civil defence planning and preparations were for the most part rudimentary. Consequently, efforts to publicly promote civil defence have accelerated and the original Act and its amendments have been consolidated into the *Civil Defence Act 1983*. In addition to making better provision for the performance of territorial regional and local governments in carrying out their functions in a civil defence emergency, the new Act emphasises recovery management by government departments following a serious civil defence emergency. Thus, the Act requires government departments, organisations, local authorities (including catchment authorities) and territorial authorities to: prepare plans to continue functioning during and after a civil defence emergency; undertake civil defence functions and responsibilities; and provide for rescue and relief in their premises. The Act integrates Civil Defence more tightly into the warning system making its operations more anticipatory than before.

To March 1984, there had been 54 flood emergency declarations affecting 75 territorial local authorities-- nearly one third of the New Zealand total of 235. Over half the 75 territorial local authorities were urban (Figure 13). A survey in 1978 revealed that 13 authorities saw no threat from natural hazards. Of 33 authorities that did not respond, nine were flood-prone and a further five were later flooded. In 1984, 13 out of 119 local civil defence organisations had no civil defence plans; 47 organisations employed no civil defence staff; and only 15 employed full-time staff. For regional and united councils, the planning and employment situation was much worse.

The cost of the Civil Defence organisation in New Zealand is thought to have averaged in the vicinity of $500,000 (1984 dollars) per year for administration, salaries, training exercises and promotion. However, the overall social costs and benefits of this method of reducing flood losses is unknown because analyses have never been done. Methods of evaluation need to be developed.

When losses have been sustained by individuals, the most common methods for sharing the burden is through relief funds and various forms

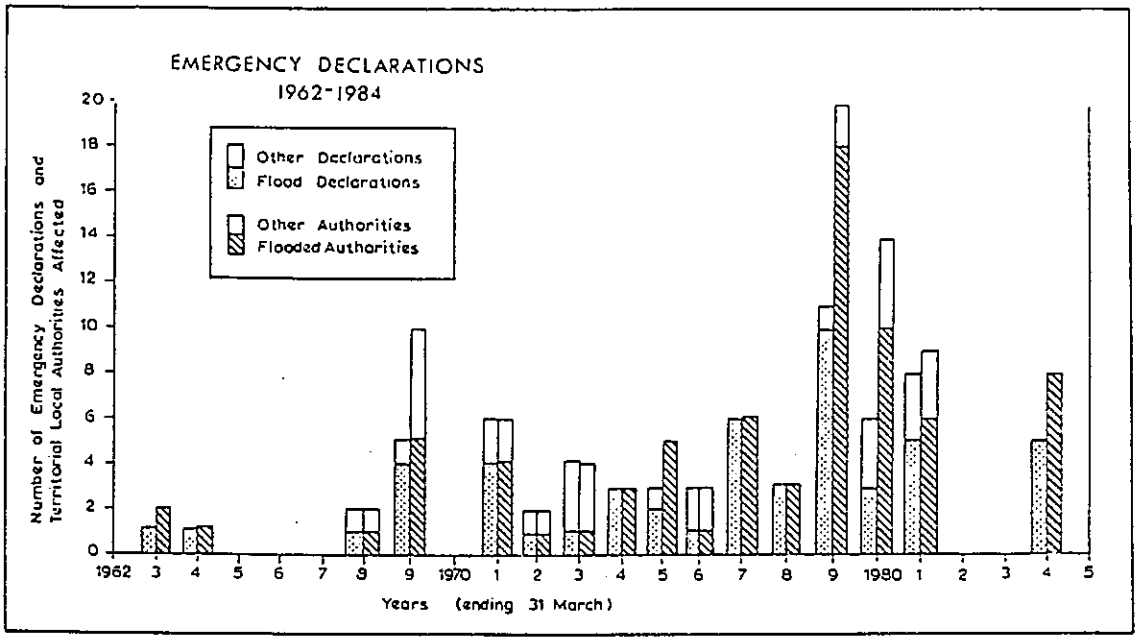


Figure 13. Trends in civil defence emergency declarations and affected territorial local authorities, 1962-1984. The proportions of flood declarations and flood affected authorities to total declarations and total authorities are given for each year. (Source: Compiled from information in Department of Internal Affairs, Annual Reports to Parliament, 1962-1983; Blyth, 1984; and Early 1984; and Holloway, 1982.)

of insurance. Since 1978, the Government has provided a grant relevant to most civil defence disasters, and has called for public donations to match it. The policy is unevenly applied and small communities have failed to receive aid in this form. By 1984 the combined value for floods was over $9 million 1984 constant dollars.

Insurance Residential flood losses can be relieved through a comprehensive policy of the insurance industry and, until 31 July 1985 the Storm and Flood Disaster Fund of the Earthquake and War Damage Commission-- a statutory agency. Access to the latter was through a compulsory levey of 5 cents per $100 of property insured against fire-- an amount unaltered since the scheme's inception in the 1940's. Householders had, however, to exhaust their insurance policy before turning to the Commission for help. In either case (Commission or insurance industry), direct estimates of risk per property are not made.

Because owners of commercial property abused the Disaster Fund (it being cheaper to use their fire policy and the Commission than to take out special cover for floods through the insurance industry), recommendations were made by the Commission to discontinue it. This was adopted in August 1985 and storm and flood cover is now only available through the private insurance industry. In the long-run this is likely to increase the cost of this form of relief to floodplain occupants and make floodable locations with high loss potential less attractive. While ideally this policy change should reduce flood-loss susceptibility, past experience suggests it is likely that other forms of relief and public subsidisation will expand and this will in turn maintain or increase the flood hazard.

CONSEQUENCE OF EXISTING APPROACH

The chart of adjustments in Figure 8 indicates the extent to which each type of adjustment is adopted in New Zealand. It is clear that modifying flood-loss potential is a much less favoured option than either modifying the flood cause and effects and/or modifying the burden of loss.

Incentives and Constraints

A partial explanation for this pattern of adjustments is indicated in Table 2. There, adjustments are reclassified into structural and non-structural options and are related to their mode of implementation and their effect on losses. Structural measures, that is river control works that modify the flood event, are typically supported by central government funds and a strong institutional structure, the regional catchment boards. They are aimed at preventing losses. People see things being done and feel protected by such structures. They are seen as enhancing development, land values, and rateable income. Relative to other measures they are a popular option. On the other hand, non-structural measures that could be adopted by individuals to modify flood-loss potential, like flood-proofing, are rarely adopted because they are not institutionally supported, there is little information about them, and no financial incentives to make them attractive to people. The latter also applies to a range of non-structural options that are supported by local government institutions, such as land use regulations, education, and relocation. (A more detailed pattern of incentives and constraints influencing the pattern of adoption of adjustments in Figure 8 and Table 2 appears in Table 3.)

A Paradox

The consequences of this process of adopting adjustments are considerable. Disaster potential is enhanced by the two types of adjustment most commonly used to ameliorate the flood problem: river control works and post-disaster relief. While it is true that river control works reduce the number and frequency of floods, they do at the same time stimulate development within 'protected' areas. These areas remain at risk from larger than designed for floods. Thus, while net benefits may accrue to the nation as a whole from development in flood-protected areas, it must be recognised that sooner or later these same communities will be flooded again. This is followed by relief and rehabilitation and further river control works. In this way, stopbanking is self-perpetuating as higher levels of 'protection' are sought and floodplain occupance intensifies (Figure 9). There is of course an upper limit to this process due to physical and economic constraints.

Table 2. Classification of flood adjustments: structural/non-structural, mode of implementation, and the theoretical effect on losses(Smith & Handmer, 1984).

	Governmental*		Individual	
	Engineering†	Institutional‡		
Structural	- dams - levees - diversions and channel improvements - retarding basins			Prevent losses
Non-structural		- acquisition - non-regulatory measures: fiscal and financial incentives, infrastructure provisions - regulations: zoning, sub-division and building regulations - information and education - forecasts, warning systems, emergency plans - salvage - state and national emergency services - insurance - relief	- house raising - small levees - other flood proofing - local warning systems - response to warning - salvage	Modify losses Redistribute loss
Do nothing				Accept loss

*Governmental measures are those requiring a central authority to make and enforce regulations, to administer financial incentives/disincentives, and to finance, construct and maintain major works. In the last case involvement may be through an agency regulating private enterprise.

†Engineering refers to the construction of major public works.

‡Institutional measures are those requiring the direct involvement of government authorities through for example land-use regulations, or their indirect involvement as guardians of the public interest, for instance by controlling the insurance industry.

Table 3: Factors influencing community adoption of flood adjustments

INFLUENCING FACTORS + Yes or favourable incentive - No or unfavourable constraint 0 Uncertain influence	ADJUSTMENTS							
	Modify Event		Modify Loss		Modify Damage Susceptibility			
	River Control	Watershed Treatment	Insurance	Relief & Rehabilitation	Landuse Management	Forecast Warnings	Flood Proofing	Community Preparedness
Has information on flood hazard	+	+	-	0	-	-	-	-
Has information on adjustments	+	+	0	+	-	-	-	0
Has operating guidelines and criteria	+	+	+	+	+	0	-	0
Has sound evaluative techniques	+	+	-	-	-	+	-	-
Has strong financial incentives	+	+	+	+	-	0	-	-
Generous Government subsidies available	+	+	-	+	-	0	-	-
Strongly institutionalised	+	+	-	0	-	0	-	+
Strong public lobbying	+	+	-	+	-	0	-	0
Politically attractive	+	+	-	+	-	-	-	0
Perceived fairness to property holders	+	+	-	+	-	+	0	0
Perceived increase in growth & development	+	+	-	+	-	0	0	0
Perceived increase in land values	+	+	0	0	-	-	0	-
Perceived increase in rates	+	+	0	+	-	-	0	-
Perceived short-term benefits	+	+	+	+	-	0	0	0
Recency of flood experience generates demand	+	+	+	+	-	+	0	0

(Source: Adapted from Ericksen, 1975a and field surveys).

This process has led to a paradox whereby flood losses have continued to increase in spite of increasing public expenditure on river control and soil conservation schemes (Figure 12). This situation has been aggravated by the fact that almost all relieved losses are re-invested in the same floodable locations.

Termination of the Disaster Fund will likely increase the number of flood-related policies of the insurance industry. Unless premiums are tied to flood risk, however, much of the social cost of floodplain occupance will continue to be externalised. It is likely, therefore, that the Disaster Fund will simply be replaced by the already expanding public flood relief funds and matching grants of government. This process will be hastened where (as in the past) the insurance industry is unprepared to provide cover.

Catastrophe Potential

The degree to which measures that modify the flood event and flood losses are adopted in New Zealand and their relationship to disaster (catastrophe) potential appears in Figure 14. It contrasts with the pattern for measures that modify flood-loss potentials (susceptibility). It suggests that disaster potential can be reduced in the long-run if measures that modify flood-loss susceptibility are adopted. That is, through land use planning and management and community preparedness.

From a national point of view, the three main approaches to the flood problem can be compared schematically on a graph that relates catastrophe potential with net benefits from occupying floodplains (Figure 15). The comparison suggests that not only do measures which modify flood-loss susceptibility have the greatest potential for averting disasters, but they may at the same time confer benefits on the nation at least as good as for flood control works, although detailed analyses are needed to verify this.

WHAT NEEDS TO BE DONE?

To improve on the existing situation a number of tasks require urgent consideration for action. A few of the more important include: improved information about floods and adjustments to them; standardised

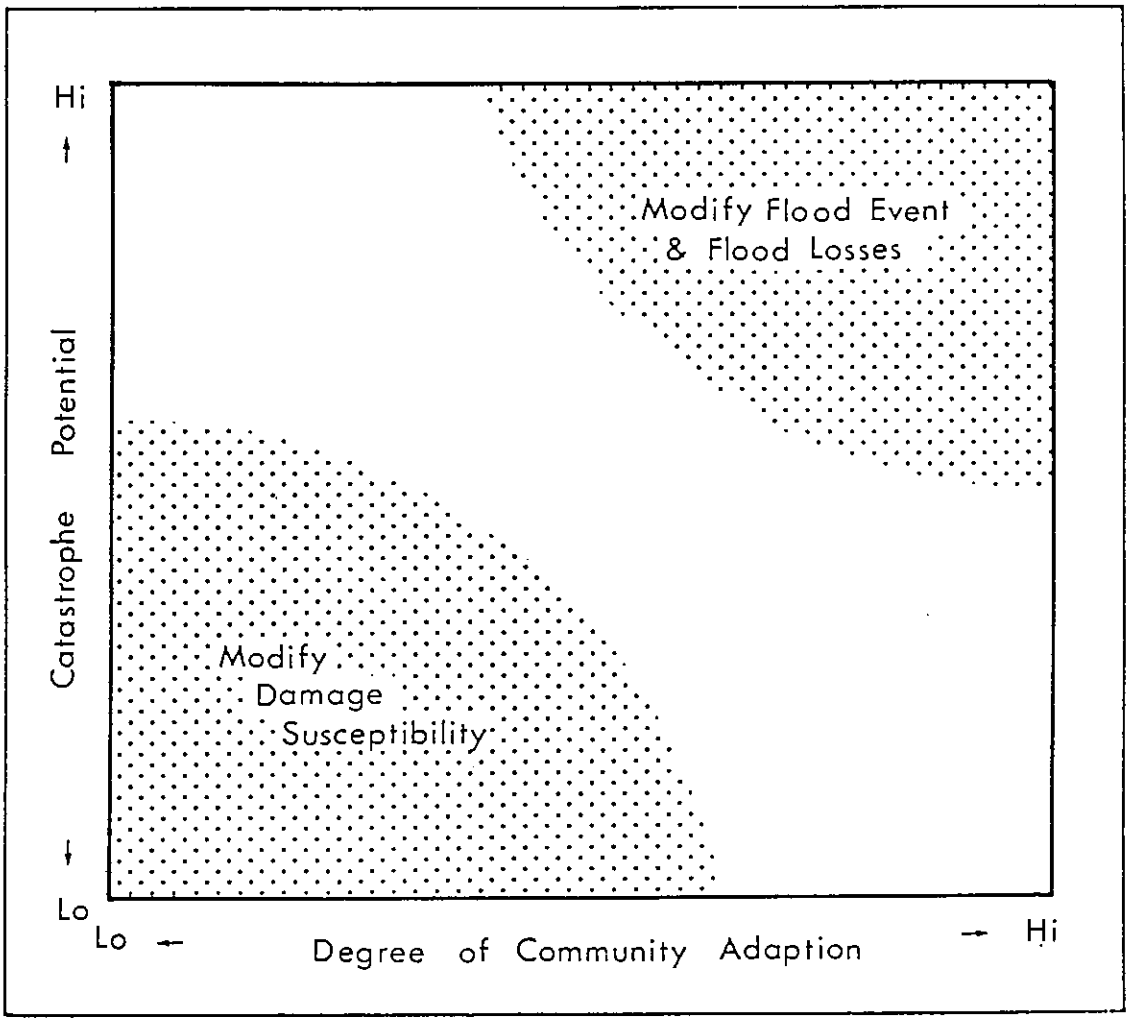


Figure 14. Schematic relationship of catastrophe potential to the degree of adoption of adjustments in New Zealand.

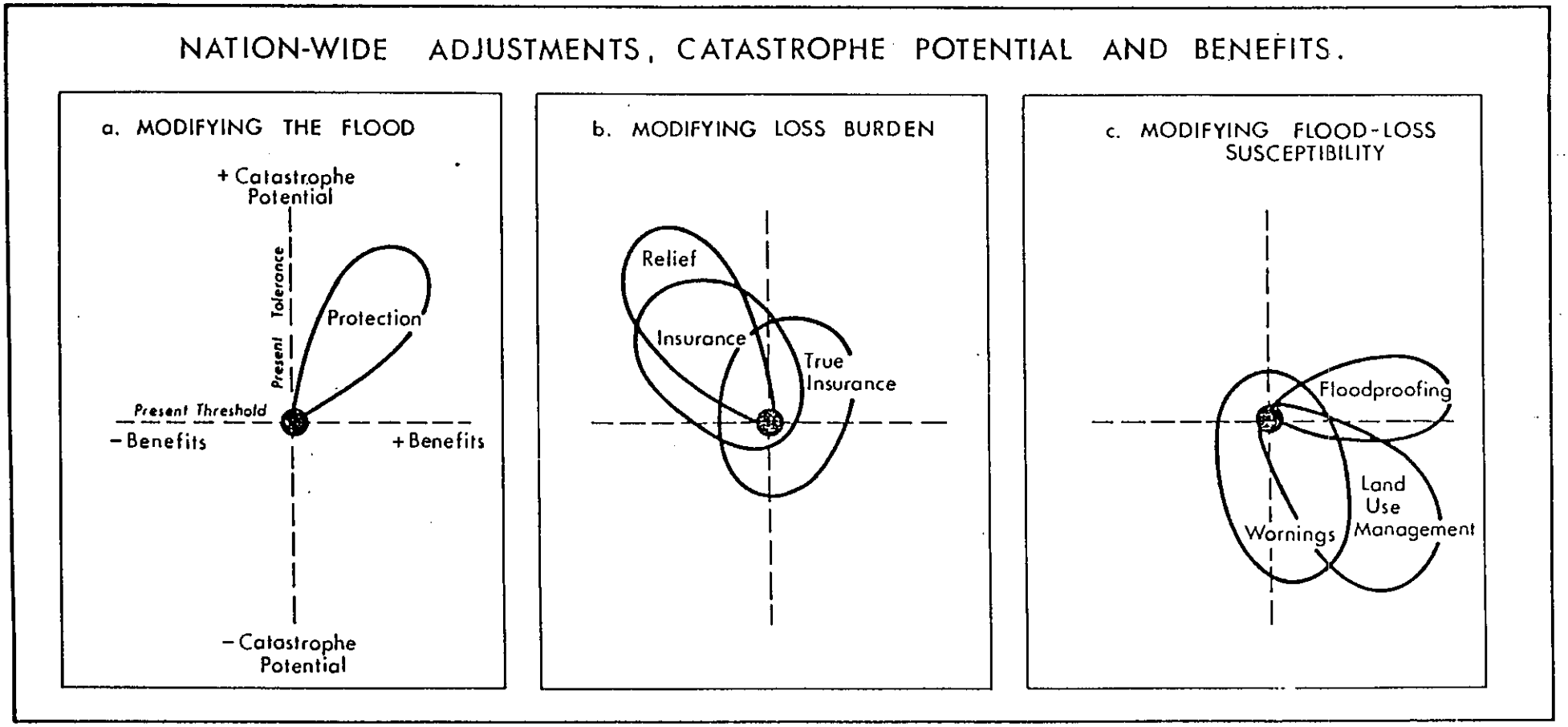


Figure 15. The relative effects of the three main adjustments types in reducing catastrophe potential and providing net benefits to the nation. The centre point represents some ideal threshold of flood-loss tolerance and baiance with respect to benefits from floodplain use. Movement upwards represents an increase in catastrophe potential on the nation's floodplains; downwards a decrease in catastrophe potential. These moves may be accompanied by an increase (right) or decrease (left) in net benefits from using floodplain land. If the nation chose to opt entirely for one type of adjustment (separate from all others) then the possible outcomes are: a) modifying the flood event increases benefits, but increases catastrophe potential; b) modifying the flood-loss burden decreases benefits and increases catastrophe potential; and c) modifying flood-loss susceptiblllity increases benefits and decreases catastrophe potential in the long-run. (Source: White, et al., 1975, 103, Figure, VI-1. Adapted with permission.)

flood hazard mapping; flood loss assessment; research on the interactions between adjustments and their effects on flood hazard; creation of a unified flood-loss reduction programme; and comparing the flood-loss reduction options.

Flood Information

The chart of adjustments in Figure 8 shows that flood information and education relevant to the range of adjustments available in New Zealand are weakly developed. While New Zealand has a wide range of adjustments supported by statute, only soil conservation and rivers control have well developed research and information programmes, and they enjoy considerable financial support of government. It seems self evident that information about flood risk, flood hazard, and ways of coping are essential first steps in developing comprehensive national and community programmes for reducing flood losses. The extent to which this has not been achieved in New Zealand is one measure of what needs to be done.

Because of the rarity of extreme natural events, it is unreasonable to expect individuals to have the information necessary for arriving at flood-wise locational decisions. The planning legislation recognises this and imposes a statutory duty upon territorial local authorities to identify natural hazards and to take actions to avoid dangers and damages from them. Such actions include informing the public of the risks of locating in flood hazard areas.

Flood Hazard Mapping

Identifying flood hazards is the most fundamental step in any floodplain management programme, and is essential for educating the public about the flood risk. The most basic tool for identifying and presenting the flood hazard to the public is a floodplain information map. Territorial local authorities have had a long-standing statutory obligation to identify flood hazards. In 1982, 103 flood-prone urban communities were sent a questionnaire about flood hazard identification and mapping. From 76 replies, only 31 communities acknowledged having mapped their riverine flood hazard. The survey revealed that where maps existed, the public availability of them was very constrained and their quality generally poor (Copinga, 1982). Respondents argued against

mapping flood hazards for one or more of the following reasons: lack of resources; problems in defining the areas at risk, including the methodological means for doing it; balancing community interests against individual rights to develop, including impacts on property values; and perceived legal issues.

In the absence of adequate maps and public information about flood hazards, averting disasters through land use management is likely to remain a weakly adopted alternative, in spite of the legislative requirements for territorial local authorities to avoid flood dangers and damages. It also makes difficult the implementation of emergency actions, civil defence, and insurance programmes. While it is desirable that flood information and education programmes be a community responsibility, the constraints on territorial local authorities are such that it is essential that a nation-wide programme of flood hazard mapping be undertaken by a national agency. NWASCA is currently supporting development of a standardised method for flood hazard mapping.

Estimating Flood Losses

Once the flood hazard is clearly established the way is opened for assessing flood losses. It is essential to have estimates of flood losses before any comparative evaluation of adjustments can take place. While this may seem obvious, it has been shown that information on losses and the means of loss assessment is poorly developed in New Zealand. This shortfall has been recognised recently by NWASCA, and evaluation of the ANUFLOOD integrated computer package for assessing flood losses is an outcome.

Comparing Options

There are several criteria for comparing options including: physical, economic, social, institutional and environmental standards. These are not clearly developed in New Zealand. Nor are the social aims with respect to reducing flood problems. However, existing legislation relevant to the range of adjustments discussed above include social aims like: economic efficiency, social equity, avoidance of social disruption, human health, regional well-being, and environmental protection and enhancement. A discussion of these aims and criteria will not be

attempted here. Suffice it to say that few attempts have been made to compare options or adjustments for any community in New Zealand. For example, while benefit-cost analysis is required for flood protection works, no such analyses are done on other options. Yet, the method of benefit-cost analysis was originally developed with the aim of enabling different projects with similar purposes to be economically compared.

The ANUFLOOD computer model does enable the flood-loss reducing capacity of different options to be compared. In doing so, it should also serve a useful educative function: to encourage its users into thinking about the full range of alternative adjustments to floods and their comparative flood-loss reduction potentials.

Interactions Between Adjustments

The above analysis has shown that the fragmentary approach to flooding currently in use has exacerbated the flood hazard and with it flood losses. This is because the adoption of one adjustment may simply mean that another compatible option is ignored, such as when river control works take precedence over land use management. In this case, the number of flood events are reduced, but the flood hazard and losses rise. The two adjustments are compatible, but convention has lead to the dominance of one over another, when, to reduce flood hazard, both should be used, or land use management should dominate.

The piecemeal approach to flood-loss reduction needs to be replaced with an integrated or unified approach. Creating unified policies that will avert disasters and reduce flood losses will, however, require careful consideration of the linkages that exist between the full range of adjustments to floods and their impacts on the flood hazard. To date, no consideration seems to have been given to the ways in which constraints and incentives have conspired to lead communities into options that in the long-run may reduce the number of floods experienced, but not the flood-loss potential and attendant disasters.

Creating Unified Programmes

A unified flood-loss reduction programme can be created from existing adjustments by forging appropriate links between those

adjustments that analysis shows will reduce flood hazard and thereby losses (Ericksen, 1982). This means that policies that will alter the existing system of incentives and constraints need to be created. For example: instead of withdrawing its support for flood claims, the Earthquake and War Damage Commission could have been given the authority to use its payments as an incentive for communities to adopt sound land use management plans. That is, unless communities could demonstrate sensible programmes for managing flood losses, the Commission would not provide flood cover. This strategy could be supported by another, that the post-disaster relief fund of government be made contingent upon adequate floodplain management. Some of the funds could, for example, be tied to detailed flood hazard mapping. Another mechanism could be the placing of conditions upon a General Authorisation for water rights, issued by Regional Water Boards to territorial local authorities, for the provision of catchment drainage plans that take account of future development of urbanising catchments. In addition, possitive individual and community actions could be given support by the Housing Corporation through various lending arrangements, and so on. NWASCA has already taken a lead in forging links between adjustment types by refusing grants for the 'protection' of post-1971 urban development that does not demonstrate flood-sensitive 'planning'.

CONCLUSIONS

Since there are nearly 100 flood-prone communities in New Zealand, a 200 year flood can be expected to occur in one (or more) of them on average every other year. While these odds may be accpetable for specific communities, it is unlikely that they are acceptable to the nation as a whole, particularly since most of them do not have more than 80 year flood 'protection' levels. Thus, if New Zealand continues with the current piece-meal approach to urban flooding, future disasters will continue to occur-- frequently. A reduction in this expectation seems achievable, however, through the creation of unified flood-loss reduction policies that have practical application at the local level. These policies need to include a system of incentives and constraints that would facilitate a move away from community dependency on relief and rehabilitation and river control towards more widespread adoption of measures that reduce flood-loss susceptibility. This will require action

by government on providing more relevant information on floods, flood hazard, and flood adjustments than hitherto, and on co-ordinating its agencies in order to facilitate a unified flood-loss reduction programme. It will also require development of methods that are appropriate for evaluating the full range of mitigation options, including comparisons between various combinations of adjustments.

NOTE(1) This paper is based on one presented by the author at the 39th Annual Catchment Authorities' Association Conference held in Nelson in April 1985. That paper was in turn drawn from research findings reported in *Creating Flood Disasters* (in press).

NOTE(2) Recent research in the United Kingdom suggests that as a proportion of total flood losses, indirect losses are much smaller than direct losses. See Handmer, Paper A, in ANUFLOOD in New Zealand: Part 2, in this series.

REFERENCES

Copinga, O. 1981: *Mapping Natural Hazards for Land Use Planning in Urban New Zealand.* Hamilton: University of Waikato, Department of Geography, M.Soc.Sc., 16.508 Natural Hazards Research, Graduate Research Paper (unpublished).

Cowie, C.A. 1957: *Floods in New Zealand, 1920-1953.* Wellington: Government Printer (for the Soil Conservation and Rivers Control Council).

Ericksen, N.J. 1971a: Human adjustment to floods in New Zealand, *New Zealand Geographer*, 27(2), 105-129.

Ericksen, N.J. 1975b: A tale of two cities: flood history and the prophetic past of Rapid City, South Dakota, *Economic Geography*, 51(4), 305-320.

Ericksen, N.J. 1976a: The role of the planner in flood plain management: an overview, *Town Planning Quarterly (NZ)*, 43, 13-24.

Ericksen, N.J. 1982: Shaping flood-loss reduction policies in New Zealand, *Geography and Development Policy*, (Proceedings of 11th New Zealand Geographical Society Conference, August 1981). Wellington: New Zealand Geographical Society (Inc.), 123-129.

Ericksen, N.J. 1985: *Urban Flood Hazard and Disaster Creation in New Zealand: A New Unified Flood-Loss Reduction Policy Is Needed*, (Report of the 39th Annual Conference of New Zealand Catchment Authorities' Association (Inc.), 16-19 April 1985). Nelson: New Zealand Catchment Authorities' Association, (Inc.), 44-57.

Ericksen, N.J. in press: *Creating Flood Disastes: New Zealand's Need for A New Approach to Urban Flood Hazard.* Wellington: Government Printer (for NWASCA).

Johnson, W.K. 1978: *Physical and Economic Feasibility of Nonstructural Flood Plain Management Measures.* Fort Belvoir, Virginia: Institute for Water Resources, together with The Hydrologic Engineering Centre (Davis California) and U.S. Army Corps of Engineers.

Smith, D.I. and Handmer, J.W. 1984: Urban flooding in Australia: policy development and implementation, *Disasters*, 8(2), 105-115.

Trebilco, U.M. 1980: *Assessment of the Protection Cost-Flood Loss Paradox in New Zealand*. Hamilton: University of Waikato, Department of Geography, M.Soc.Sc. 16.509 Directed Studies (unpublished).

Ward, R. 1978: *Floods: A Geographical Perspective*. London: The MacMillan Press Ltd.

White, G.F. 1964: *Choice of Adjustment to Floods*. Chicago: University of Chicago, Department of Geography, Research Paper No. 93.

White, G.F. with Brinkmann, W.A.R., Cochrane, H.C., and Ericksen, N.J. 1975: *Flood Hazard in the United States: A Research Assessment*. Boulder, Colorado: University of Colorado, Institute of Behavioral Sciences, Program on Technology, Environment, and Man, Monograph Series, No. 6.

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