AN EXAMINATION OF DECISION MAKING IN ADJUSTMENT TO THE FLOOD HAZARD WITH PARTICULAR REFERENCE TO THE LOWER MANAWATU REGION.

A THESIS PRESENTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF ARTS IN GEOGRAPHY AT MASSEY UNIVERSITY.

BY

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ABSTRACT

The relationship between man and his environment is in a constant state of change. The study of this interrelationship has commanded the attention of many disciplines, yet no one discipline can adequately comment on all essential relationships involved. Geography with a traditional interest in the study of man and his environment is ideally suited to a role as a synthesiser of various interdisciplinary findings. This study is concerned with man-environment interactions in the floodplain and in particular with the varying 'levels' of mans adjustment to the flood hazard.

The primary aim of this research was the identification of the inter-relation of various elements in a decision making model for flood hazard adjustment. The study is based on the analysis of adjustment to the flood hazard in the lower Manawatu region, although it is intended that the research findings and methods be of more general applicability for the study of such adjustment decisions.

The data used in the study was obtained from local Catchment Board files and from floodplain occupants. The variation in attitudes towards flooding and flood protection between these two groups is emphasised and the effect of this on floodplain land use with and without flood protection is outlined.

Floodplain protection has a long history in the lower Manawatu region. The range of adjustment decisions, the reasons for these decisions, and aspects of the impact of these decisions are examined within the analytical framework of Kates model of

adjustment to natural hazards. An examination of the environmental processes and the human use processes are undertaken.

In the examination of the human use processes the role of the decision makers hazard perception, search of alternative adjustments, and evaluation of these adjustments are examined. The factors influencing the Catchment Boards hazard perception, adjustment search, and evaluation are discussed within the constraints of legal and financial limits, as well as the predisposition of this organisation towards conventional "engineered solutions" to flood protection. Variations between this body and the resource users, and the impact of this on post scheme land use is discussed.

The evaluative procedure used in this study then is demonstrated in an analysis of protection measures in the lower Manawatu region. The application of the decision making model is demonstrated and its effectiveness evaluated. It is suggested that floodplain protection should be viewed within a wider planning context and floodplain protection can be seen as a case of inappropriate land use unless viable 'economic' protection can be provided. This implies that post locational errors should not be compounded by automatically providing flood protection. The timescale of environmental processes and the sensitivity of the environmental system should be considered, and a system of land use planned to minimise the social costs of use.

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INTRODUCTION.

The study of man and his environment has long attracted the attention of geographers. For many years however, much geographical analysis was divided between examinations of the physical and the social or economic environment. The recent resurgence of an integrative approach, has resulted in the breakdown of this traditional duality of study and intra-disciplinary conflicts, such as the 'possiblism-probalism' debate, have been cast aside. Largely as a consequence of such a move, there has been a fundamental shift in the research paradigm, from what could be termed regional cataloguing, or place specific studies, to an examination of processes. Attention has focussed on the interaction and interrelationships of the physical and socio-economic environments.

The emphasis has thus largely shifted from systematic differentiation to functional differentiation, and from a concern with events to a concern with processes.

This new research focus views the earth as space in which man lives, including both the physical and the social environments. This in itself is not new. The novelty lies in the focus of attention on the area or zone of interaction between the two environments, that is the systems interface.

The increasing awareness of the importance of understanding the processes that determine the nature or state of this 'systems interface' has led to the emergence of environmental planning as a specific sphere of interest.

One major focus within this sector of planning, is the analysis of management policy of areas in which the operations of environmental processes adversely affect land occupance. There are a number of such situations, including river floodplains, coastal erosion and flooding and earthquake zones, in which land use is subject to the vagaries of nature.

One school of research that has been most active in attempting to promote understanding of the nature of the interaction between man and his environment has been that of natural hazard research (N.H.R.). Burton (1962, p11) identified three major focii in N.H.R. each employing a distinctive approach. These are:

The Attitude Studies

Research in this field has attempted to determine the nature of the relationship between attitudes towards flooding, socio-economic class, education, and levels of flood hazard and protection information. Pioneering work was done by Rodger (1961) in Topeka, Kansas, and Burton (1961) in the Hammond-Munster area of the Little Calumet floodplain in Indiana. Both researchers found there was no correlation between attitudes towards future flooding and socio-economic class, or knowledge of protective structures.

The Disaster Studies

A second approach has been led by the N.A.S. - N.R.C.

Disaster Research Centre at Ohio State University. Here, students of sociology, social psychology, and other behavioural scientists have been concerned with the study of leadership and group interaction. The interest in this research has been stimulated by the hypothesised similarity of human behaviour during an emergency period and under stress, and individual and group behaviour in time of nuclear attack.

The Decision-Making Studies

The third area of research is that initiated by the University of Chicago under the leadership of G.F. White. Research here has been concerned with the long run persistence of settlement in hazardous areas, especially floodplains, and man's associated attempts to reduce the effects of the hazard event.

At the basis of these studies is the concept of a natural hazard. There are two basic elements in the definition of a natural hazard:

(a) the socio-economic system which reflects man's occupance of an area, and

(b) the process of nature.

The interaction of these elements usually can be seen as a process of mutual adjustment; this interaction becomes hazardous in terms of human occupance when the capabilities of the occupants of an area to adjust to the extremes of geophysical events are exceeded and harmful effects ensue. A natural hazard then is the result of the interraction of man and nature "governed by the co-existent state of adjustment in the human use system and the state of nature in the natural events system" (Kates, 1970, p1).

Natural hazards research initially arose from a concern over the paradoxical situation where, despite his technological power and increasing ecological dominance, man's vulnerability to environmental hazards and the damage caused by such events appeared to be increasing. The awareness of the risk of repeated disasters is probably higher in modern man than any of his predecessors, but the pattern of reinvasion of hazardous areas is probably stronger than ever before. The magnitude of impact of 'rare' natural events on society is increasing in terms of real property damage and loss of life, although there may be a verbal reluctance to accept these costs. This may be prompted by the continuing pressures promoting the spread of man and the apparent increase in damages due to improved communication networks which readily bring notice of such events to the attention of people all over the world.

Natural hazards research has been conducted within a human ecological framework in which man is viewed as the ecological dominant. This has led to a specific consideration of the implications of man's actions affecting the physical environment. It has been noted that "it may be helpful to combine an anthropocentric notion of ecological human dominance with a normative concern for understanding the implications of human actions and taking responsibility for them" (Burton _et al_, 1968, p5).

Recognition has been taken of the fact that man's attitude to the natural environment seldom, if ever, involves an optimum response to its conditions. Man tends to aim at satisficing behaviour due to the complexity of natural systems, economics, socio-political constraints and his limited ability to adequately perceive his environment and its inherent hazards.

Attention has focussed on the positive choice exercised by man and the resultant interaction between man and nature. Over the short run this interaction tends to be stable, homeostatic and self regulating but in the long run, dynamic, adaptive and evolutionary in the direction of increasing control of man over his environment. It is worthwhile to take note of the warning that "given the present rapid rates of change, the long run increasingly shortens and it remains to be seen whether that which is extremely adaptive will not prove maladaptive in the future" (Kates, 1970, p2).

Reviewing the different hypotheses and models of natural hazard research, Kates (1970) stated that the basic research paradigm of the various natural hazard papers have attempted to:

1. assess the extent of human occupance in hazard zones.
2. identify the full range of possible human adjustments.
3. study how men perceive and estimate the hazard.
4. describe the process of adaption of damage reducing adjustments in their social context.
5. estimate the optimal set of adjustments in terms of anticipated social consequences.

It has been generally held that to fully understand the natural phenomena gives man the opportunity of avoiding or circumventing the hazard. That is, it was believed that through such studies a more optimal control, preparedness and utilization of the hazard situation would result.

Natural hazards research began with a paper by White, 1945, and the post-war years, particularly the last ten to fifteen years, have seen a greatly increased interest in such studies. Four reasons are tentatively forwarded to explain this:

1. Natural hazards become greater problems in the minds of men as affluence spreads and as recognition grows of a social responsibility to cushion all members of a society against unexpected hazards (Burton, <u>et al</u>, 1968, p4).
2. There is a general feeling that advances in technology will, in the near future, enable some degree of control over presently uncontrollable events. Associated with the increase in technology is an increased intolerance of the vagaries of nature.
3. There is increasing pressure from within and outside government to improve criteria on which public spending decisions are made.
4. The rapidly increasing damages caused by natural hazards

Human occupance of floodplains represents a major theme in the examination of the interaction of bio-physical and socio-economic systems. The perceived benefits of floodplain location and the hazardousness of such locations present an inherent conflict situation. Rather than passive acceptance of flood losses, there has developed a major effort in hydrological engineering through which positive interactions are made in the physical processes.

In spite of an increasingly large investment in flood protection works, the average annual damages caused by floods appear to have been steadily increasing. The most comprehensive data available is that for the U.S.A. Holmes (1961, p11) calculated total U.S.A. flood damages for the period 1903 to 1936 to be U.S.$4.1 billion and U.S.$6.6 billion for the period 1937 to 1958. This was measured in constant 1957 dollars, and suggested flood damages were 2.5 times greater in the latter period. Hines (1970, p322) calculated annual U.S.A. flood damage as U.S.$100 million in 1900 and U.S.$1.7 billion in 1968, despite an increase in expenditure on flood protection from U.S.$270 million a year between 1936 and 1962 to over U.S.$500 million in 1968. The difference in damage estimates by these two sources reflects the basic lack of understanding of the flood hazard situation, but both sets of data indicate increased expenditure on flood protection measures has not prevented increased flood damages. Figures provided by Erickson (1970) indicate a similar situation exists in New Zealand. In 1955 N.Z.$2.458 million was spent on flood protection and this was increased by 171 per cent to N.Z.$6.665 million in 1969. Flood damages in this period however, increased from N.Z.$ 1.232 million a year to N.Z.$2.828 million. Whilst these figures suggest a greater degree of success in flood protection than in the U.S.A., Erickson noted that a closer examination of the distribution of expenditure and flood losses reveals that it is only in the richer catchments where rates can be levied on a large city population that large capital outlays for protection can be supported and damages significantly reduced.

There have been a number of reasons forwarded to account for the increasing flood losses. These include:

1. an increased accuracy and coverage in the collection of damage data.
2. a short run increase in the frequency and magnitude of floods.
3. a general increase in price levels.
4. expanding investment and settlement in areas liable to flooding.

Kates (1962, p4) considered that even after discounting the effects of the first three factors, one must conclude that the failure of flood programs to reduce flood damage is primarily due to the pressure to develop flood plain lands, especially in urban areas. White has on many occasions attributed the increase in flood damages to what he has termed the 'invasion of the floodplain', commenting "the problem is that more and more people are moving into the flood hazard areas, so damage potential keeps going up ... " (White, quoted by Hines, 1971, p323).

The flood control projects themselves are a major cause of this situation, as once flood protection is provided, a false sense of security is often promoted, and more intense settlement of the flood plain then occurs. Flood control programmes, while substantially reducing existing damages, actually encourage an increase in damage potential. Hines (1970, p322) has noted that for every U.S.$6 spent on flood protection by the Federal Government in the U.S.A., U.S.$5 is spent by the general public in expanding into flood plains. This increase in damage potential has been calculated at 1.4 per cent per year by the Corps of Engineers and 2.7 per cent per year by White (1958, p1).

Possible explanations for this rapid increase have been suggested by Hines (1971, p322) and White (1968, p160):

1. ignorance that the area is subject to flooding.
2. the failure of developers to warn prospective buyers that the land may flood.
3. the existence of structures in the floodplains leads others to assume there is no danger.
4. the tendency of people to prefer living and working on level bottom lands.
5. the higher value of floodplains representing a potentially higher source of tax revenue (than hilly areas).
6. the lower costs of floodplain sites for development when neglecting the costs of flood damages or flood protection works.
7. the anticipation of flood damage prevention works through governmental flood control programmes.

The basic problem is compounded by the fact that the traditional adjustment to the flood hazard - engineering works - provide only partial flood protection. Such protection schemes eliminate the damages caused by the smaller, more frequent, floods but not the larger, less frequent floods.

RESEARCH TOPIC AREA

This research examines the decision-making process involved in the choice of adjustment to the flood hazard. The intention of this research exercise in common with other natural hazard decision-making studies, is to increase understanding of the process of floodplain occupation and the nature of man's response to the flood hazard. The primary areas of interest are: the interaction of man, the floodplain and the hydrological system; the range of alternative adjustments to the physical process; and the character of use of natural resources. White (1945) stressed the nature of this relationship as "floodplain settlement represents an interaction between the human system with its economic, social and geographical relationships and a hydrological system, marked by strong elements of uncertainty". The selection of alternative adjustments to the flood hazard and the location decision involves a process of choice and decision. The framework of decision theory provides a useful means of understanding the processes involved.

The model which is outlined here and later employed as the initial analytical frame for the study of the Lower Manawatu Flood Control Scheme is that proposed by Kates (1972).

KATES MODEL.

Kates' model has two major elements:

1. It outlines the structural components of the decision system, and
2. It outlines the actual process of making a decision.

1. Structural Components of the Decision Making System

The structural components of the decision system represent what is perhaps the underlying or basic theme of the model. These are indicated in Figure 1.1. Briefly stated, the model notes that at some point in time and space, man and nature, in the form of a Natural Events System (N.E.S.) and Human Use System (H.U.S.) interact to pose a Natural Hazard. This generates a specific set of hazard effects, which in turn evokes a response in the form of some adjustment to the hazard. This adjustment may modify either the H.U.S. or the N.E.S. or it may be of a temporary or emergency nature.

A. The Human Use System

Under the terms of the model the Human Use System incorporates all human activity in the region under study and includes:

(i) the specific human occupance in terms of numbers, age, sex, diurnal or seasonal occupance;

(ii) activities - economic, social, political; and

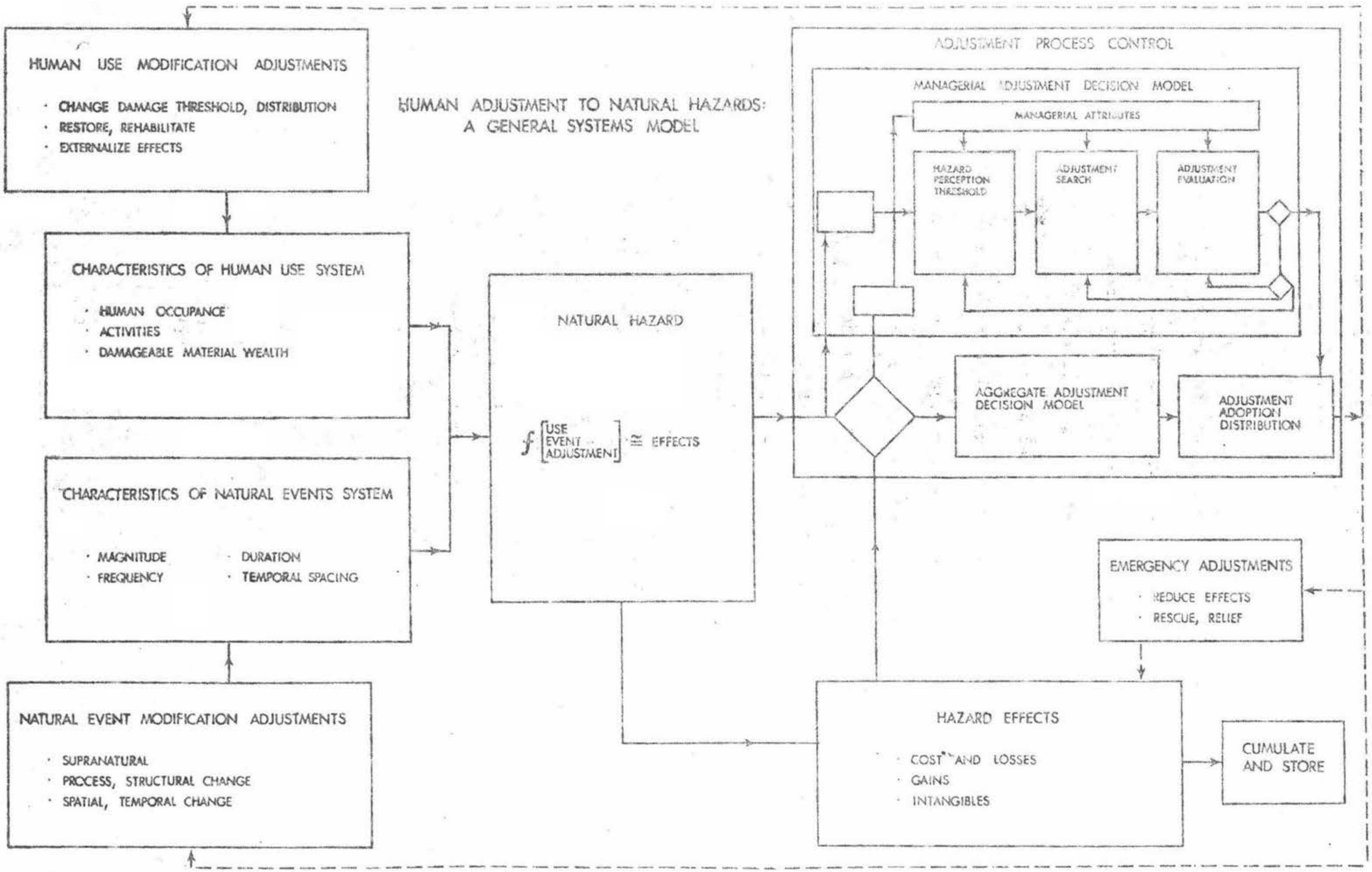
(iii) an inventory of damageable material wealth.

B. The Natural Events System

The N.E.S. includes all those factors resultant of the forces of nature. These are reduced to four major indices for purposes of description in the model.

(i) Magnitude - a dimensional volume or energy expression;

(ii) Duration - a temporal spacing ranging from seconds to years;



Source Kates 1970, P15

(iii) Frequencies - expressed as a probability of occurrence in a given time period or Return Period; and

(iv) Temporal spacing - where the event is described in terms of being random, even (seasonal or regular period) or clustered (serially correlated).

C. The Natural Hazard

A natural event becomes hazardous only if it threatens man or his activities. There are no set physical dimensions to a natural hazard. The volume or magnitude of energy release in one situation that causes damage may not do so in another. What constitutes a hazard for one then, may not necessarily be so for another; for example, snow and ice are hazards in certain environments especially urban areas, but are part of the natural environment for Eskimoes in Alaska. A natural hazard then can only be judged in its particular environmental setting and the level of adjustment in the corresponding social environment.

D. The Hazard Effects

The effect of any hazard event is dependent upon the size of the event and the nature of adjustment in the corresponding H.U.S. The effects of a hazard may be:

(i) indirect, as when social and personal activities are affected or

(ii) direct, as when economic activity is affected, crops lostor damaged, buildings damaged, etc.;

(iii) beneficial, as for those who provide emergency services, or

(iv) harmful, as in the curtailment of economic or social activity;

(v) losses may range from nil to catastrophic and have from short to long term effects.

2. The Adjustment Decision Process

Decision making in its broadest sense may be viewed as the selection of alternative courses of human behaviour. This process is described by the Kates model in the form of a submodel. This submodel The "Adjustment Process Control" includes a "Managerial Adjustment Decision Model" and an "Aggregate Adjustment Decision Model". The actual process of making a decision in the choice of adjustment to a hazard is described by the "Managerial Adjustment Decision Model" which is outlined in greater detail in Figure 1.2.

A. The Managerial Adjustment Decision Model

The model of the decision making process, in common with other decision making schemes, has four underlying assumptions.

(i) The Rationality of Man

Simons' concept of Bounded Rationality forms the basis of the geographers' view of man's ability to choose clearly and consistently those courses of action that are the most appropriate to attaining desired goals. The choice of adjustment is seen as being limited by the ability of the human mind to take account of all the complexities and external effects of factors operating

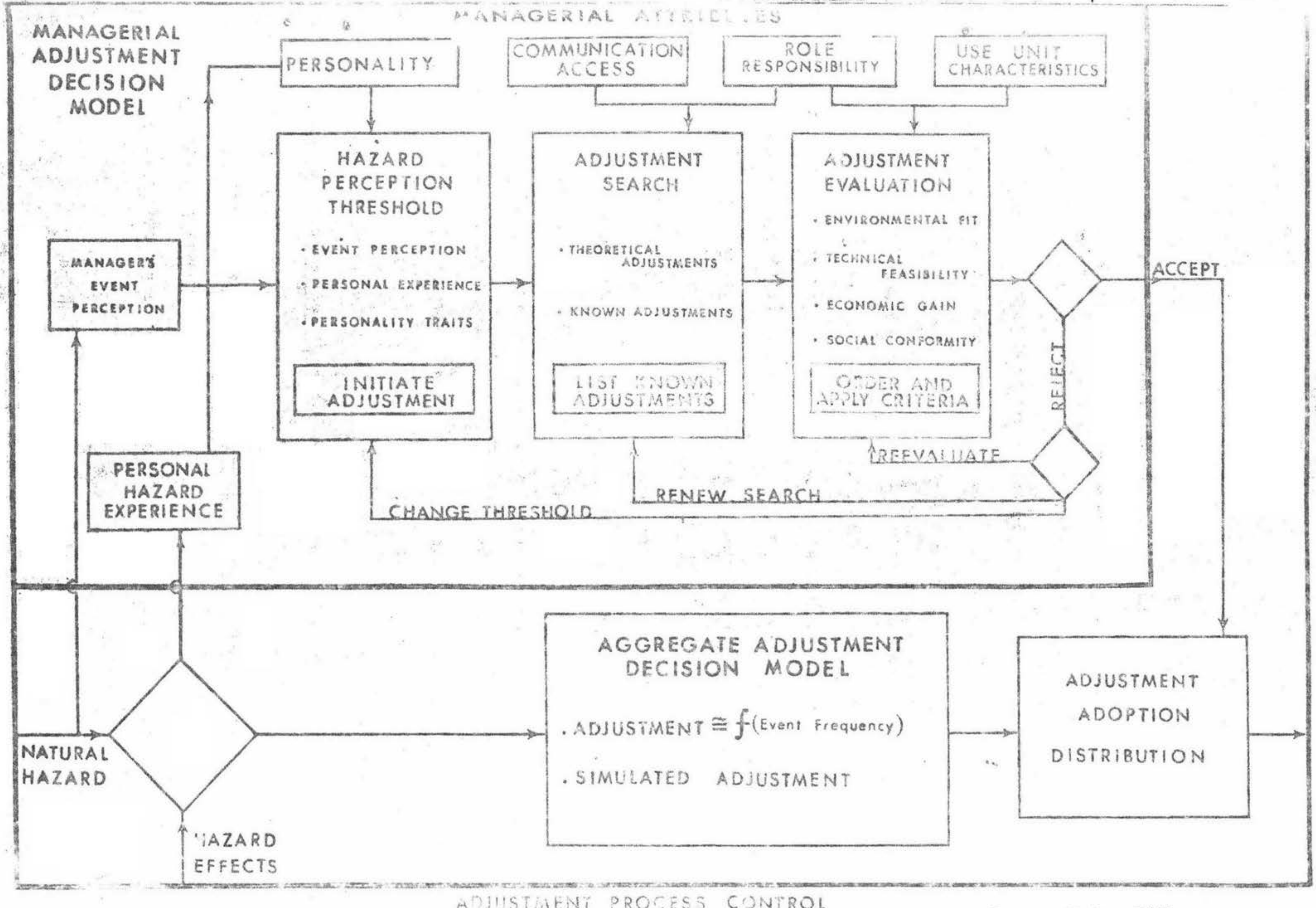


Fig 1.2

Source Kates P17

in the final adjustment choice.

(ii) The Process of Choice

Three types of choice operate in the decision making process. These are: conscious choice, unconscious choice, and habitual choice. All three are recognised as playing a part in the final adjustment decision, but it is believed conscious choice which is limited only by 'restraint' and 'awareness' is the predominant choice process.

(iii) Uncertainty

It is recognised that in the complex real world situation, all knowledge is seldom brought together at one time, and when it is, it is seldom assimilated. It is therefore recognised that conditions under which choice is made involve a considerable degree of uncertainty. Consequently allowance must be made for the varying degress of awareness of choice among resource users.

(iv) Evaluation

Decision making theory allows for a wide variation in the form and effectiveness of evaluation criteria used by resource users.

Kates model of the process of decision making is "the current state of our decision-making theory strung together in an operative sequence" (Kates 1970, p7). The sequence of events in the decision making process as shown in Figure 1.2 is:

I. Perception

For the manager of each unit there is a threshold of perception, below which no response is evoked and no adjustment sought or evaluated. This threshold of hazard perception is most probably a function of the managers' personality traits such as attitude towards fate and tolerance of risk taking and his personal hazard experience.

II. Search of Alternatives

When a hazard event exceeds the managers' perception threshold a search of alternative adjustments is begun. This search is limited by

(a) the managers' access to communication networks, which Kates believes can be approximated by the socio-economic indicators of age, education, income and travel;

(b) the role-responsibility of the decision maker; and

(c) the individual personality of the decision maker.

III. Evaluation of Alternatives

An evaluation of the known adjustments then takes place. Ideally, an evaluation is based on environmental, economic and social considerations, and limited only by technology available to the decision maker, social and legal restraints. These criteria are described in greater detail in Chapter Three. The criteria are not of equal priority and vary according to the role-responsibility of the decision making agency and the use characteristics of the environmental setting. The model allows for this through the attaching of various weights or values to such criteria. Based on the evaluation process a decision to adopt a particular adjustment or not is made. If rejected, provision is made to feed back into the decision making system with provision being made for a change of a manager's perception threshhold of a problem; a renewed search of alternatives; or a modification in the standards of acceptance of a solution.

B. Aggregate Adjustment Decision Model

The distribution of the adoption of adjustments by individual managers is related to hazard frequency. In areas of low hazard frequency few, if any, managers adopt adjustments; in areas of high hazard frequency adoption is widespread. In areas of intermediate frequency there is considerable variation in the adoption of adjustments.

Adjustments to Natural Hazard

Three forms of response or adjustments to a hazard can be made. These are:

(a) those that seek to modify the natural events system.

(b) those that seek to modify the human use system, and

(c) a set of post-event emergency adjustments.

Of those adjustments that seek to modify the natural events system, the most common or widespread adjustment is an appeal to some supernatural power (Kates, 1970, p.18). Other adjustments attempt to effect the natural process or alter the spatial or temporal distribution of the event. A more detailed discussion of these adjustments is given in Chapter Three.

A considerable variety of adjustments that seek to modify the 'Human Use System' exist. These include attempts to raise the damage threshold and the point where damage begins or to change the entire damage potential distribution. Evacuation and other related adjustments as well as bearing the loss are all included in this category, as are those adjustments where hazard effects are externalised through spreading them over a wider time, space or society, through public relief, insurance etc.

Post-Event Emergency adjustments include rescue and relief operations than can save life and reduce the burden of the hazard.

Kates model has two major features that are of importance for this study.

(a) It models the hazard within a human ecological framework.

(b) It focuses on the decision-making process that occurs in response to the hazard.

A major aspect of the decision-making process is the potential for a continuous flow of information regarding the state of the physical and social setting. This approach is adopted because of the importance of the interaction of these two elements or processes in generating the detrimental effects that are the initial stimulus to the problem definition.

The model is sufficiently flexible to allow for periodic refinement in the decision-making process in the light of the new information inputs and increased awareness of the interactions of elements involved. The model recognises that interventions into the 'natural' setting appear to be inevitable, and that this intervention in practice does not have to justify itself, nor does it necessarily have to be in favour of nature. This model, without attempting to impose an environmental dictat, brings to attention the constraints operating in both the physical and social environments, thereby facilitating an effective evaluation of the situation. The model is therefore considered sufficiently comprehensive to make a useful contribution to the reduction of the social costs of interventions into the natural system.

The subject area presented for detailed scrutiny in this study is the Lower Manawatu Flood Control Scheme with specific attention focused on the decision-making process that occurred in response to the flood hazard. The initial consideration of such human intervention into the physical environment must be an examination of the physical setting itself and the existing social system. Once this has been accomplished, an elaboration of, and investigation of the decision-making process can begin.

CHAPTER 2

THE MANAWATU SETTING

I. THE NATURAL EVENTS SYSTEM

A. The Major Physiographic Zones

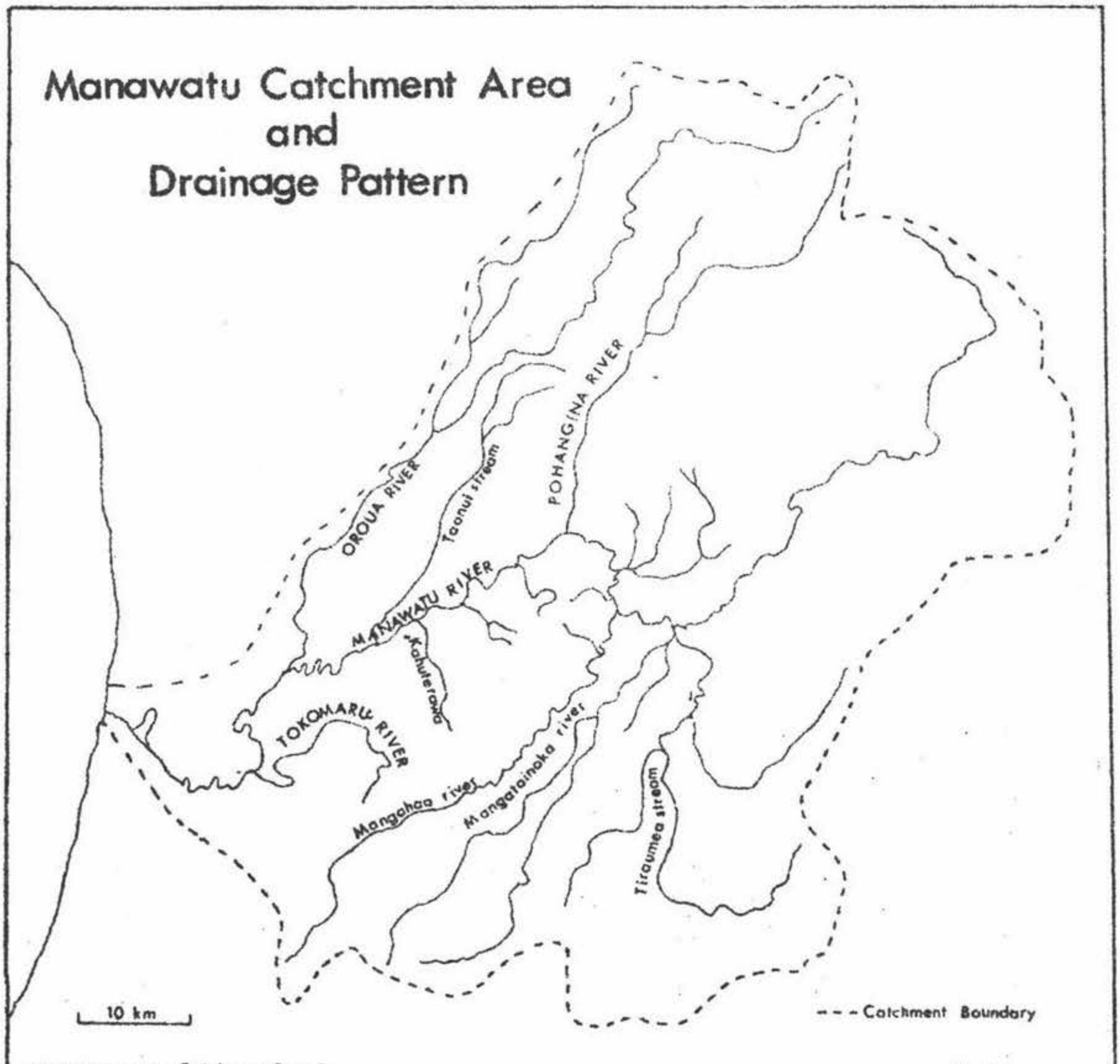
The Manawatu River Catchment shown in Figure 2.1 drains an area of 600,000 hectares. A great diversity of land forms are to be found within this region. To a large extent, these landforms reflect the underlying geologic structure. Two major physiographic zones can be readily identified. These are:

1. The Ranges and Hill Country.
2. The Plains - this includes (a) river terraces,
   (b) alluvial plains,
   (c) coastal sand country.

1. The Ranges and Hill Country

The Tararua and Ruahine ranges dominate the Manawatu River Catchment. They trend in a NNE - SSW direction rising to over 1,800 metres with the main ridges around 1,000 to 1,200 metres above sea level. The ranges are broken at the Manawatu Gorge where they are penetrated by the Manawatu River. The Tararuas here are at an elevation of 400 metres above sea level, and to the north, the Ruahine ranges start.

The ranges are underlain by greywacke with alternating



source: Manawatu Catchment Board

fig 2·1

zones of argillite. Deformation has affected the softer, more easily prodible argillite. This has resulted in the formation of razor-back ridges, spurs and peaks of greywacke with gullies, valleys and small depressions or argillite. The intensity of internal deformation has resulted in the rocks becoming highly shattered and brocciated along the numerous faults.

In the ranges, steep slopes predominate, averaging over 30° on the sides of spurs and ridges and 15° to 25° on the crests. In the northern Tararuas are extensive flattish and rolling areas, remnants of an ancient peneplain. The rugged nature of the ranges can be attributed to the non uniform nature of their uplift, their geologic structure and the processes that have been in operation in the years since their initial formation.

The tertiary hill country that flanks the ranges at an elevation of 75 to 100 metres consists of sandstones, siltstones, conglomerate and limestone laid down during the last fifteen million years, when the land was at a lower level and covered by a sea, which probably extended through the Gorge. The land was later uplifted by and the sediments folded, hardened and subsequently dissected streams. Volcanic eruptions in the central North Island occurred at this time, depositing thick pumicious deposits in the sediments.

2. <u>The Plains</u>

The Plains may be divided into three major physiographic zones; the river terraces, the alluvial plains and the coastal sand country.

(a) The River Terraces

The river terraces were produced by fluctuations in climate, during the waning phase of the Pleistocene, which were of sufficient severity to induce changes in the regime of the river causing periodic aggradation and degradation which produced the terracing.

(b) The Alluvial Plains

An extensive area of alluvium deposited by the rivers which drain the hinterland, lies between the coastal sand country of the coastal lowland. The alluvial plains are characterised by low elevation (less than 20 metres), relatively level topography, their composition of gravels, sands and silt, and recent origin.

Recent alluviation has been aided by several factors. These include:

(i) A rise of over 100 metres in the sea level since the Pleistocene Period. Any rise in the sea level will cause alluvial deposition in the lower channel and downcutting upstream in order that channel flow may be maintained.

(ii) The warming of the climate aided deposition of the coastal plain as rivers in degrading their upstream channels removed detritus that had built up in the earlier cold period.

(iii) The sinking of the main valleys relative to their adjacent anticlinal structures has also aided deposition in the lower courses of the river.

Periodic flooding over the years resulted in broad levees higher than the surrounding land being built up adjacent to the rivers. Away from the river, land in places is lower lying than the river itself.

The gradual subsidence of the Kairanga trough has created very low lying land in the area between Opiki and Shannon. In order to maintain viable flow, the Manawatu River has built up its bed and lengthened its course by meandering, thereby creating a major flood problem in this region.

3. The Sand Country

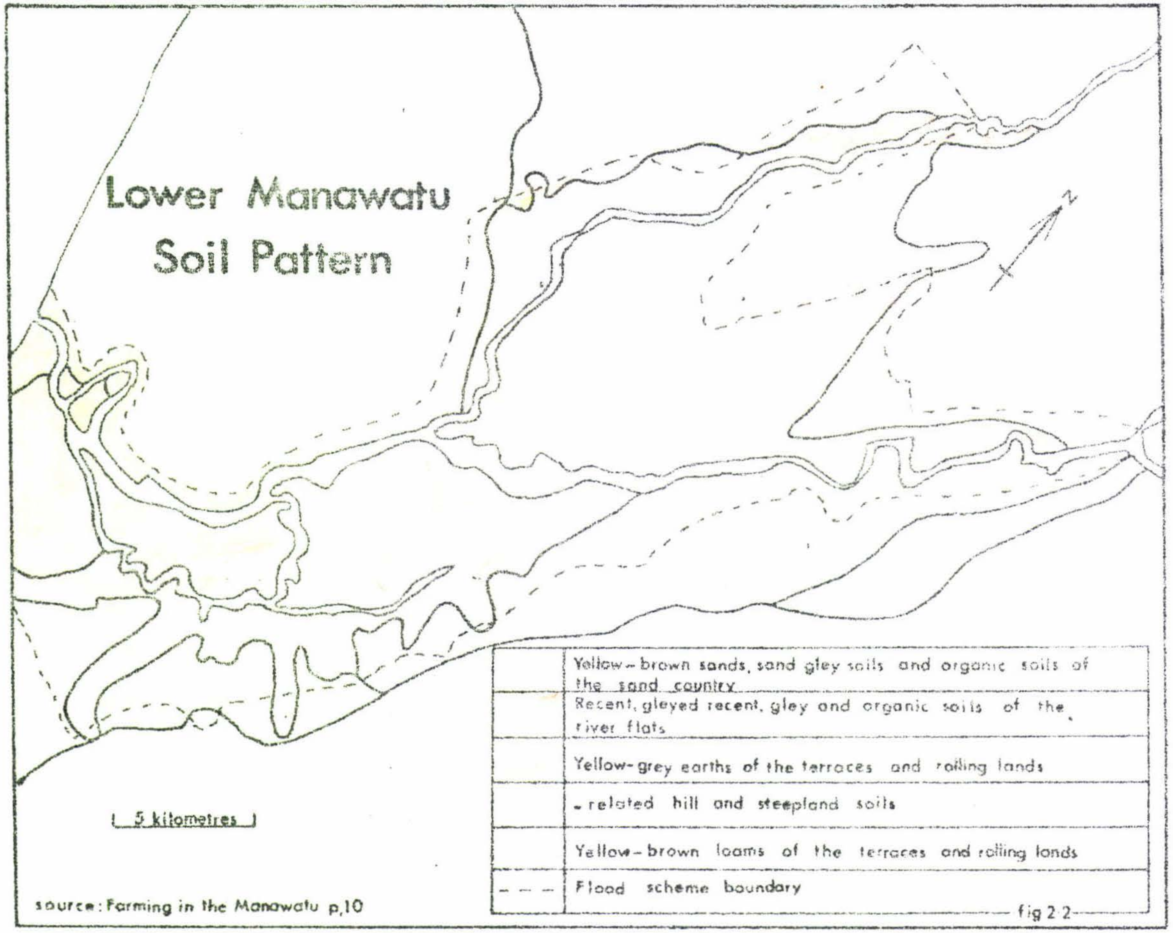
The sand country consists of a belt of sand, sand dunes and sandplains which border the coast extending between one and fifteen kilometres inland. Macro relief is low, with no dunes exceeding 100 metres in height and few exceeding 75 metres. Micro relief, however, is considerable, with dune slopes ranging from 3° to 35°.

B. Soils

The soil pattern of the area shown in Figure 2.2 follows the land form units outlined above. There is a considerable variety in the structure and fertility of the soils.

I. Soils of the Ranges and Hill Country

These soils are mainly formed from greywacke and sandstone. They are generally shallow and stoney. In the areas of high rainfall, much is covered in original forest. Here, soils are of low natural fertility. On the easier slopes soils contain some volcanic ash and silt. On the rolling slopes, soils are deeper, but are heavily


Lower Manawatu
Soil Pattern
N
Yellow-brown sands, sand gley soils and organic soils of the sand country
Recent, gleyed recent, gley and organic soils of the river flats
Yellow-grey earths of the terraces and rolling lands
- related hill and steepland soils
Yellow-brown loams of the terraces and rolling lands
Flood scheme boundary
5 kilometres
source: Farming in the Manawatu p,10
fig 2.2

leached of plant nutrients. Good pastures can be maintained with adequate topdressing. Soils formed from sedimentary rocks are small in area and contain some loose unconsolidated sands causing severe gully erosion.

2. Soils of the Terrace Country

These soils are of two main groups - the yellow grey earths and the yellow brown loams.

The yellow grey earths are found on the rolling country surrounding the alluvial plains. They are characterised by topsoil overlaying a heavy clay loam and clay sub-soils with iron mottling concentrations. These soils are relatively fertile and can sustain cropping provided they are drained.

The yellow brown loams are free draining soils containing some volcanic ash. Natural fertility is not high and phosphate fixation occurs. Potash reserves are also low. Despite this, these soils have many good qualities for farming and with adequate top-dressing, good pastures and high stocking rates can be attained.

3. Soils of the River Flats

These soils are derived from alluvial deposits brought down by the rivers. They are generally of high fertility. Some of the heavier silts, located further away from the river, are fertile but require extensive drainage before pastoral farming and cropping can be practised. In those areas around or below sea level, peaty soils have been formed, consisting of a mixture of alluvium and peat. Dairying and fattening are the major activities on these areas, although cropping of potatoes and onions is practised where the peat is not very deep.

4. Soils of the Sand Country

The sand country soils are formed mainly from wind-blown sand. Near the coast these are very young and raw, with dunes being infertile and unsuited to farming. Inland, these soils are older and more developed containing more organic material enabling good pastures to be maintained. A wide range of nutrient levels are present, but most soils respond to phosphate and potash. Some trace element deficiences occur and copper and selenium treatments are necessary.

C. Climate

The Manawatu Catchment area, because of its size and varying land form types, experiences a wide range of climatic conditions.

1. Rainfall

Rainfall in the region is generally reliable and evenly distributed throughout the year. Rainfall data is shown in Table I and Figure 2.3. On the lowlands rainfall varies between 30" and 50" (900 and 1,250 mm) per year. On the hills and ranges rainfall is greater, averaging between 60" and 150" (1,500 and 3,800 mm) per year in the Ruahine Ranges and 100" and 250" (2,500 and 6,350 mm) per year in the Tararua Ranges. Rain days per year on the lowlands are 150 to 175 which is lower than most North Island districts. In the ranges, however, rainfall is experienced up to 200 days per

TABLE.1.

MEAN MONTHLY AND ANNUAL RAINFALL FIGURES FOR SELECTED STATIONS IN THE MANAWATU RIVER CATCHMENT.

Station	Date	Altitude in feet.	Rainfall in Inches												
			Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	TOTAL
Foxton	1913-54		2.34	2.45	2.09	2.52	3.13	3.45	3.03	3.09	2.50	3.23	2.88	2.69	33.40
Ohakea	1951-66	157	3.10	2.42	2.53	2.80	2.98	3.30	3.34	2.82	2.26	3.11	3.18	3.68	35.52
D.S.I.R.	1928-66	110	3.25	2.96	2.63	3.04	2.94	3.78	3.92	3.40	3.19	2.96	3.09	3.93	39.09
Colyton	1912-63	350	3.10	2.88	2.54	3.28	3.45	3.83	3.33	3.27	3.06	3.96	3.66	3.38	39.74
Apiti	1948-66		3.47	3.46	3.54	3.72	5.13	4.90	5.48	4.65	3.47	4.21	4.17	5.19	51.39
Tiritea	1948-66	428	3.97	3.67	3.95	3.82	4.88	5.02	5.62	4.31	3.75	4.58	3.97	5.20	52.74
L.Mangahao	1948-66	2500	7.46	7.62	7.12	7.44	9.79	9.33	11.00	8.99	7.31	9.91	9.99	9.14	105.10
Wharite	1964-66	3020	3.50	8.67	18.40	5.30	4.50	5.28	9.00	7.94	3.87	4.51	7.20	13.50	91.67
Dannevirke	1948-66	680	3.02	2.41	3.35	3.22	4.13	4.17	4.56	3.71	3.10	3.19	2.90	4.85	42.61
Mangamutu	1948-66	380	3.77	3.29	3.61	3.58	4.47	4.94	5.36	4.17	4.08	4.58	4.00	4.34	50.19
Eketahuna	1948-66	1000	3.84	3.12	4.43	4.72	6.42	6.23	8.84	5.41	4.91	5.27	5.42	4.96	63.57
Putara	1960-66	1400	6.20	3.27	5.38	5.07	9.04	10.10	11.46	7.01	8.81	4.90	11.30	4.73	87.27
Tiraumea	1960-66		4.60	2.09	2.86	3.09	3.13	5.69	6.90	4.94	5.89	2.14	3.84	4.32	49.49

N.Z. Meteorological Service

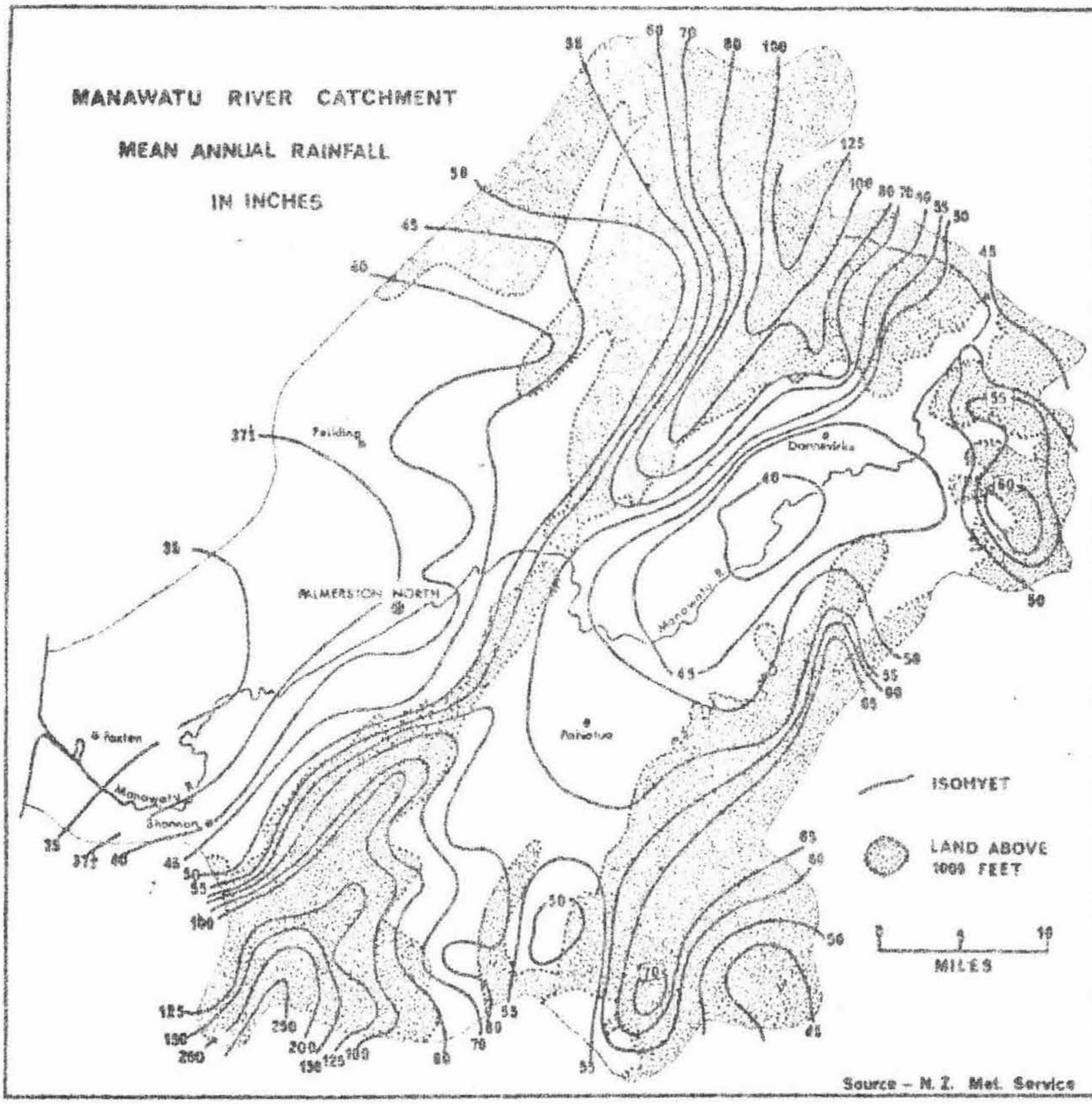

MANAWATU RIVER CATCHMENT
MEAN ANNUAL RAINFALL
IN INCHES
Feilding
PALMERSTON NORTH
Dannevirke
Manawatu R.
Pahiatua
Foxton
Shannon
ISOHYET
LAND ABOVE 1000 FEET
MILES
Source - N. Z. Met. Service

FIG. 2-3

year. There is little variation in the distribution of rainfall over the year, there being only a 25.4 mm difference between the wettest and driest month for Palmerston North. The intensity of the rainfall on the lowlands ranges up to a maximum recorded daily rainfall of 140 mm at Levin and 160 mm at Palmerston North. In the ranges intensities frequently exceed 25 mm and sometimes 50 mm per hour (Holloway, 1943).

Sunshine is plentiful on the coastal regions with Foxton experiencing 2,080 hours per year and Palmerston North 1,814 hours per year, that is, 42 per cent of the possible. This contrasts with the ranges where only 80 days per year experience seven hours clear weather per day.

The high sunshine hours on the lowlands is partly due to the windiness of the region. High winds are a chief characteristic with westerlies prevailing.

Mean temperatures are moderate and only slight differences exist between coastal and inland situations. Ground frosts are not heavy and occur on average 61 days per year in Palmerston North, and are most severe in May and August, while the coastal strip is fairly frost free. The coldest month is July with an average temperature of 8.3°C at sea level and 2.2°C at 1,300 metres above sea level. The warmest months are January and February with an average temperature of 16.5°C at sea level and 10.5°C at 1,300 metres above sea level.

The Manawatu Catchment Board has noted the major storm types which have given rise to major floods experienced in the region in the past. These are outlined below (Table II).

TABLE II - STORM TYPES CAUSING FLOODING IN THE MANAWATU

Type	Meteorlogical Description of Storm	Year and Flow
		(flow in cusecs)
A	Pressure centre from the Tasman sea travels from West to East across the catchment or its path lies somewhat to the North. This type can be subdivided into A_1 and A_2	
A_1	Deep centre with moderate or rapid mut. Rain is generously distributed over the whole catchment with the highest concentrations on the East of the ranges	April 1895 June 1902 - 140,000 June 1936 - 76,000 July 1942 - 76,500 June 1947 - 93,000 May 1948 - 74,000
A_2	Shallow centre usually moving very slowly. In this type rain is usually concentrated in a frontal zone which moves slowly across the catchment.	January 1907 May 1941 - 115,000 October 1945 - 84,750
B	Depressions often of tropical origina which move Southeasterly on a front which lies to the East or North of the catchment. Rainfall in this situation is usually mostly concentrated on the eastward of the Ruahine and Tararua Ranges	May 1907 April 1936 May 1917 June 1917 February 1936 - 93,000
C	Westerly type. Rainfall is heavy in the Oroua catchment, in the ranges and through the Gorge to Woodville and Pahiatua, but is negligible further to the East.	July 1926 - 68,250

Source: M.C.B. Research

D. Vegetation

Zotov (1938) made an early attempt to describe the pre-European vegetation of the Manawatu. His study revealed that little of the original vegetation remains today. Forest, subalpine, scrub-land and alpine grassland types have been described by Holloway et al (1963), and the forest types have been outlined in more detail by Franklin (1967).

The original vegetation on both the hills and the lowland was a dense podocarp forest, bush, with swamps of flax and sand dunes along the low lying coastal belt. Within the bush were small isolated clearings of grassland alongside rivers and streams. Very little remains of this original vegetation today on the lower elevations apart from the Totara Reserve in the Pohangina Valley, at 'Highdale', seven acres near the Awapuni Dairy factory, and at several small locations along the Palmerston North-Shannon highway.

The forsts of totara, rimu and matai have all been either milled or cleared by burning. The timberline today varies in altitude between 600 and 1,200 metres depending upon the dominant species. The once-forested lands have been replaced with high producing exotic pastures in the lowland areas and by lower producing pastures of browntop and danthonia in the foothill and hill country, while much of the sand country is in marram grass and areas of swamp flax still remain. An additional feature of the new vegetation cover is the sparse covering on some of the steeper slopes due in part to the lapse of time between firing and grassing but also because the new vegetation was not able to hold the land in such areas in a steady state as the original vegetation. The result has been a considerable amount of material eroded into the streams and rivers.

E. Erosion

Erosion in the region is due to the altered ecological balance in certain parts of the region, resulting primarily from the removal of the natural vegetation.

In the regions above the treeline, where vegetation cover is sparse, climate is a dominant factor influencing the severity, and the type of erosion. Here peri-glacial erosion occurs at a high rate by the freeze and thaw action of frost, and the tops of the ranges are subject to considerable wind erosion. The susceptibility of areas of argillite to erosion has been mentioned earlier.

Erosion in the hill country is limited mainly to slipping, with the occasional area of gullying where the soil mantle has been partly or completely removed and bedrock exposed. This erosion is due to the formerly high concentrations of noxious animals which, with the exception of the opossum, have since been significantly reduced.

On the foothills where land has been cleared and overstocked and insufficient fertilizer applied, there has been extensive slipping, and damage from sheet and wind erosion.

On the terraces and rock slopes, erosion is minimal being limited to minor slips and stock induced soil erosion (including terracettes) with sheet erosion on terrace scarps. There is some stream bank erosion with the most serious area being near the mouth of the Manawatu River and just downstream of the Whirokino cut. The worst erosion in the region was found in sand country with dune building and topsoil removal.

It is, however, the erosion in the ranges and hill country that contribute to the major amount of sediment in the river system which provides the major flood problems.

F. The Drainage System

The drainage pattern of the Manawatu as shown in Figure 2.1 is unusual in that the Manawatu River flows on both sides of the ranges. As such, the Cathment can be divided into two regions - above the Gorge and below the Gorge. Above the Gorge, the Mangatainoka, Tiraumea and Mangahao Rivers as well as numerous other small s treams, drain an area of 4,830 square kilometres before entering the Manawatu River. Below the Gorge, the Pohangina, Mangaone, Oroua, Tiritea, Kahuterawa, and Tokomaru rivers drain 4,000 square kilometres before entering the Manawatu River. These rivers enter the Manawatu River in a lineal pattern from different directions and have widely scattered watersheds. Consequently, peak flows are staggered according to location and the likelihood of all rivers peaking at once is remote.

At the headwaters of the rivers, gradients are steep, with an average fall of 10 metres per kilometre. Above Palmerston North, the Manawatu River flows between fairly high banks and is readily contained within the river channel. Below Palmerston North, the river crosses the extensive areas of the Manawatu Plains. This has a marked effect on the river gradient and the volume of water the river can carry in its natural state. Between the Manawatu Gorge and Longburn, the average gradient is 2 metres per kilometre. Below this point, it eases to 1 metre per kilometre until the junction of the Oroua River where it eases to 1 metre every three kilometres, which is maintained to the coast.

II. THE HUMAN USE SYSTEM

The basic managerial unit of the human use system is the household. This is especially so in the rural areas, where the predominant activity of farming is based on individually owned enterprises, which are worked by the owner and his family, with the occasional hired hand or seasonal labourer. In the urban areas, the greatest area is privately owned. There are some corporate or company businesses, but these do not form a very large part of the activities located in the floodplain. Publically owned land and services, particularly City Council property and services, do not form a very large part of the survey activities. These latter activities and services, however, are highly capital intensive and innundation can cause costly damage.

Early settlement and development in the area of study was hindered by the dense bush cover and the presence of a Maori population, which prevented early European ownership of land. The area consequently remained relatively isolated and undeveloped until the last quarter of the 19th Century.

The earliest settlement and economic activity was based on milling the forests and on the extensive areas of flax. As more settlers entered the area, the bush was burned, and a subsistence type of agriculture based on crops, animals and revenue from the forest and flax industry arose.

Land was originally leased from the Maori owners for agriculture but was later 'purchased'. Expansion of settlement was slow with Foxton being the only real centre in the whole of the Manawatu in 1870. Inland settlement was begun in Sanson (1870), Palmerston North (1871), Feilding (1874), Rongotea (1878), Ashhurst (1879), although the actual numbers of settlers remained small.

The introduction of refrigeration in 1882 contributed to development of the dairy industry and the rise of fat lamb production in the area. Co-operative dairy schemes also aided the progressive development of the dairy industry in the area in early years.

The transformation of the original landscape was almost completed by 1920. Expansion of grassed areas after this was reflected in increased stock numbers. Between 1920 and World War II, the major changes in livestock composition and production type took place.

In this period, there was a decline in the ratio of dry ewes and wethers to breeding ewes. At the same time, total sheep numbers increased by 50 per cent, but the number of rams increased 100 per cent. The number of store and dairy cattle also increased in this period, but not to the same extent as sheep increases.

The development of the various types of pastoral farming have been described in official statistics by country regions for many years. Such boundaries are not sufficiently accurate for the purposes of this study as they include large and varying amounts of land that are located outside of the area of study. Basing any discussion on such statistics is therefore considered dangerous in that a true picture of the agriculture of the region under study may not be given. To overcome this it was planned to use figures provided by the farmers in association with Valuation Department statistics to outline the nature of economic activity in the area at the time of the flood scheme. Unfortunately the farmers were reluctant to provide such information and Valuation Department data was extremely poor, with accurate and comprehensive data recorded for only twelve per cent of the farms. The temptation to use data aggregated from these files by McNeil-Adams was rejected as there was no guarantee against selection bias in the choice of sample farms used. In addition to this McNeil-Adams data did not take into consideration the effect of changes in farm size and the fact that some farmers run a number of farms (both within and outside the study area) as one unit, with one unit being used for wintering stock off, or summer fattening, etc.

Any discussion of farming enterprise in the area affected by the flood scheme must consider the interdependence of this area with areas outside the flood scheme. This is particularly important as summer grazing, wintering-off stock and the purchasing in of stock for fattening purposes at various times of the year are important economic activities in this region. This interdependence will become more obvious in the discussion of major farming types in the scheme area.

Over the area, there is an intermixing of dairying and sheep farming. Dairying and sheep farming in the region are therefore usually considered to be complementary. Many holdings run both sheep and cattle with few farms carrying only dairy cows. Warr (n.d. p.162), noted that there is a greater emphasis on sheep farming and fat lamb production in the northern part of the lowlands, while dairying and cropping are more important in the southern part of the lowlands.

Information obtained from the Department of Agriculture files suggests that intensity and diversity are the two major features of farming in the area, with livestock densities among the highest in New Zealand. The type of farming enterprises range from highly intensive dairy and fat lamb production to extensive steer-sheep and steer-cattle production.

A. Extensive Sheep Farming

Such enterprises are characteristic of the steeper hill country, the tussock areas west of the Oroua River, and areas of less fertile soils. At the time of the flood scheme, rams, breeding ewes, ewe hoggets, some wethers as well as a number of cattle were run on such farms. These farms supplied store or breeding sheep, fat wethers and fat ewes to the fattening farms in the area of the flood scheme. Cattle numbers around the time of the scheme were subsidiary to sheep. The major function of cattle was related to pasture management in that they grazed off the surplus spring and autumn growth and helped trample down secondary growth. On the margins of the lowlands on less steep hill country fattening was the predominant activity in association with the raising of some breeding and store stock.

B. Intensive Sheep Farming

Intensive sheep farms are found in many areas covered by the flood scheme. Fat lambs, stud stock and dairying are often combined. The emphasis on fat lambs has led to an increase in the proportion of breeding ewes to dry sheep, and an increase in the numbers of store-sheep and breeding ewes supplied to the lowlands by the hill country farms, especially during the summer and autumn months. This has markedly increased the interdependence of the hill country and lowland farming, and has been intensified by the improved transport system that operates between the two systems. The distribution of sheep is influenced not only by topography and soils, but also by the potential dairy cow population. The areas where the lightest numbers of sheep are found are those where there is more intensive dairying, although these are scattered over the entire area.

C. Dairy Farming

There existed a reasonable amount of dairying in the area at the time of the flood scheme. Production of butterfat was reasonably high (128 - 130 kg's). Although herd sizes at the time of the scheme were increasing the number of dairy farms was decreasing. The average sized farm and herd was somewhat below the national average, although it is not possible to give exact figures on this for the study area. It is apparent that there existed a larger number of small herds (less than 30 cows) than in most other areas of New Zealand.

Around the time of the scheme, there was a general trend towards a decreasing concentration on dairying due to:

1. the introduction of sheep onto dairy units upon the sale of the farm.
2. the change to sheep by many farmers nearing retirement.
3. the favourable overseas prices whidh led to a change from dairying to fat lamb farming on many farms.

There was a notable increase in the concentration on butter and casein production and a decreasing emphasis on cheese production at the time of the scheme. A notable concentration was that of town milk supply farms immediately surrounding Palmerston North City, which produced around 3,200 - 3,400 litres per day at the time of the scheme.

III. THE FLOOD HAZARD

The lower Manawatu region has a long history of flooding. The flood hazard involved a combination of river flooding and local flooding due to impeded drainage. In the past, the Manawatu River was the main source of serious flooding, although in most areas local flooding was experienced more often, but was less damaging in its effects.

The main source of flooding from rivers and streams overflowing their banks was the Manawatu River, but extensive areas were also subject to flooding from the Tokomaru and Oroua Rivers. Less extensive areas were innundated from excessive flows in the Mangaone, Kawau Stream, Kiwitea Stream and Whiskey Creek. These different sources of flooding in the main operated independently but, in some cases, such as Whiskey Creek and the Mangaone Stream, the flows in one influenced the effect of flows in the other. A major problem occurred from the backwater effects of the Oroua River, as when flows in the Manawatu River were high, the Oroua River was unable to discharge all of its flow, and consequently land in the Taonui Basin area flooded.

Among other factors complicating the calculation of the problem of such overflows was that the source of the flow for each of these rivers and streams was different, and the recurrence interval, amount and type of land innundated and consequent damages caused by such flows were very different.

The problem of local flooding due to impeded drainage has never been examined in any detail, although it is apparent that lower lying areas experience the most severe local flooding. Local flooding occurs because of the inability of the internal drainage system to remove the water from the land and into the river system at a sufficient rate. The source of such flooding was predominantly local rainfall, compounded by the overflow of spillways and drains.

The interrelationship of local flooding and river flooding and the spatial variation in impact of these events meant that the flood hazard does not necessarily coincide with peak discharges from the Manawatu River. For example, in June and July 1966, the Manawatu River did not rise above three metres, yet there was extensive innundation of land from local flooding especially in the Taonui and Lockwood areas, due to extremely heavy local rainfall.

The only published data on the flood hazard is that by the Manawatu Catchment Board who estimated the likelihood of certain sized river flows and the areas that would be innundated by these flows. These areas and the area of land involved is shown in Figure 4.3. The method of calculation is described in Chapter Four.

CHAPTER 3

THE ADJUSTMENT DECISION PROCESS

A. INTRODUCTION

It has been noted that man continually interferes with his environment, in an attempt to modify it so as to 'maximise' gains and at the same time protect himself from the harmful effects of nature. (Burton, 1962). Any such action involves a conscious or unconscious choice on the part of the decision maker, in selecting from a wide range of alternative adjustments. These adjustments can be implemented by a variety of agencies ranging from individual floodplain managers to collective bodies, such as government agencies, public organisations or ad hoc local bodies. Differences between these decision-making bodies, particularly resources at their disposal, are probably as important as the intensity or severity of the natural hazard, in determining the nature of the adjustment that is made.

In discussing an adjustment decision it is important to make a distinction between essentially private and public adjustment decisions, which despite similarities have essential differences, which Kates (1962, p143) accounts for as being primarily due to the difference between individual and community interests.

1. Spillover effects or social costs and benefits that cannot be allocated or captured by the market may not be reflected in individual decision making.

2. Substantially different probability distributions of risk exist for communities and individuals. The mobility and short planning horizons of individuals provide for the lower probabilities of discrete flood events. An individuals' probability is compounded of the probability of his being on the floodplain and the probability of there being a flood.
3. Communities are subject to political processes that create demands on the community for flood protection on the basis of considerations that individuals making such demands would not employ themselves. Individuals often demand flood protection that they are unwilling to pay for directly or even indirectly through their local community. Such demands are perfectly rational from the individual's point of view as the cheapest means of protecting oneself from flood losses. For the citizens of the national community, they might prove to be a socially costly and uneconomic means of dealing with the problem.

The objective of a flood protection program depends upon the decision making agency. Individual floodplain managers do not follow a policy of optimising their adjustments. Public programmes often have the stated aim of maximising national welfare. Mankind however has many diverse needs and national welfare has many dimensions; (social, economic, cultural etc). It is therefore necessary to deal with each of their elements separately.

Past research has resulted in a good understanding of many aspects of floodplain land use in the U.S.A. Hoyt and Langbein (1955) have shown the major differences in the distribution of flood events; White (1958) has outlined the urban adjustment to floods; Schaeffer (1960) has shown the advantages to be gained from combining emergency and structural measures in the form of 'flood proofing', Murphy (1958) has shown the advantages to be gained from floodplain zoning and, Krutilla (1966) and Lind (1967) have outlined prospects for flood insurance programs. On the practical side of things the Tennessee Valley Authority has made intensive studies of urban centres on floodplain land in the Tennessee Valley; the Corps of Engineers have done the same for numerous other cities and rural areas; the United States Soil Conservation Service has been particularly instrumental in watershed management and have also made intensive studies providing a considerable amount of new information on hazard and use in rural floodplains. Other studies, particularly by the University of Chicago team, have attempted to improve measurement techniques for estimating the damage caused by floods and of savings that can be made from various adjustments. Considerable attention has been given to criteria which should guide public decisions in the design and approval of protection projects.

Until relatively recently, attention was focussed more upon planning the engineering works and judging the economic feasibility of a project, rather than judging the likely impacts of flood protection schemes, or the effects of past schemes. Consequently, man is able to indicate what is economically and physically desirable but, paradoxically, is unable to fully explain why resources are used as they are, let alone suggest how a more rational use of resources could be made in the future.

In studying what people should do about floods, without attempting to increase understanding of the different adjustments that people actually take in living with floods, a widening gap between knowledge and practice in floodplain management has arisen. If this gap is to be closed, it is necessary to know how actual choices are made and how new uses might be better appraised.

Much of the stimulus for the new emphasis in research has come from the realisation that floodplain occupants are not responding to protection schemes as it was originally thought they would. Burton (1962, p144) noted that "a dominant characteristic of agricultural occupance (of floodplains) is that the occupant responds to a variety of conditions among which the flood hazard is often not of primary significance."

In an attempt to determine what factors influence an individual choice of adjustment, or response to adjustments, attention has been focussed on attempting to understand the decision making process, where particular emphasis has been focussed on the relationships between an individual's perception of a hazard, private adjustment to that hazard, or hazard protection scheme, and the prevailing social view of losses suffered.

In most situations there are many obstacles to the free-flow of information from the technical expert to the floodplain occupant. An understanding of the way in which decisions are reached and the way in which floodplain managers react to the adjustment, should increase the level of understanding of that adjustment. The elements in the decision-making process have been outlined above. Each stage of this decision making process influencesthe nature of the adjustment adopted and the floodplain managers response to that adjustment decision.

Early decision-making schema viewed the decision making process as a somewhat mechanistic operation based on the economic and physical factor of land valuation; for example, White's 1945 paper was concerned with the influence of land and water as they affected human adjustment to floods. Such a viewpoint represented a situation where perfect knowledge and competition existed and land was in its 'best' use.

One of the first models developed to explain the decision making process was that by White (1961a). This model (fig 3.1) was applicable to both the choice of resource and adjustment. By a system of nominal notation, the model could be used to explain those factors that were involved in an adjustment decision. Emphasis was given to the range of theoretically possible adjustments, the perception of possible choice and the spatial linkages with activities outside of the floodplains. The model, like all early models of adjustments to natural hazards was of a descriptive nature, and of limited use for analytical purposes or furthering understanding of the decision-making process.

ELEMENTS INVOLVED IN ADJUSTMENTS TO FLOODS

ADJUSTMENT	PERCEPTION BY MANAGER OF:					
	Theoretical choice	Flood Hazard	Technology	Economic Efficiency	Spatial linkage	Practical Choice
Loss Bearing	1	1	1	1	1	1
Flood protection works	1	1	1	1	1	1
Emergency action	1	1	1	0	0	0
Structural change	1	1	0	0	0	0
Insurance	1	1	0	0	0	0
Public relief	0	0	0	0	0	0
Change in land use	0	0	0	0	0	0

0 Not perceived

1 Perceived

Source: White 1961a

FIG. 3.1

Decision-making theory today views the physical environment and behavioural environment as being interrelated, and the adjustment decision as being a consideration of the interaction of both environments. There is the recognition that, in the final analysis, 'it is the attitude of the individual and of society to the natural environment which motivates and controls human environmental intervention' (Chorley and Kennedy 1971).

As shown in Table III, flood hazard research in New Zealand focussed on such factors as the collection of hydrologic data and soil conservation and river control activity - especially channel improvement and levee construction. Some research investigating the range of alternative adjustments (Erickson 1970, Puller 1963, 1967), has been attempted but there is no known work that has examined the effects of a flood protection scheme on floodplain activity or examined the decision making process leading to the choice of adjustment.

TABLE III

FLOOD DAMAGE REDUCTION MEASURES DISCUSSED IN PAPERS
PUBLISHED IN N.Z. PERIODICALS 1957 - 67

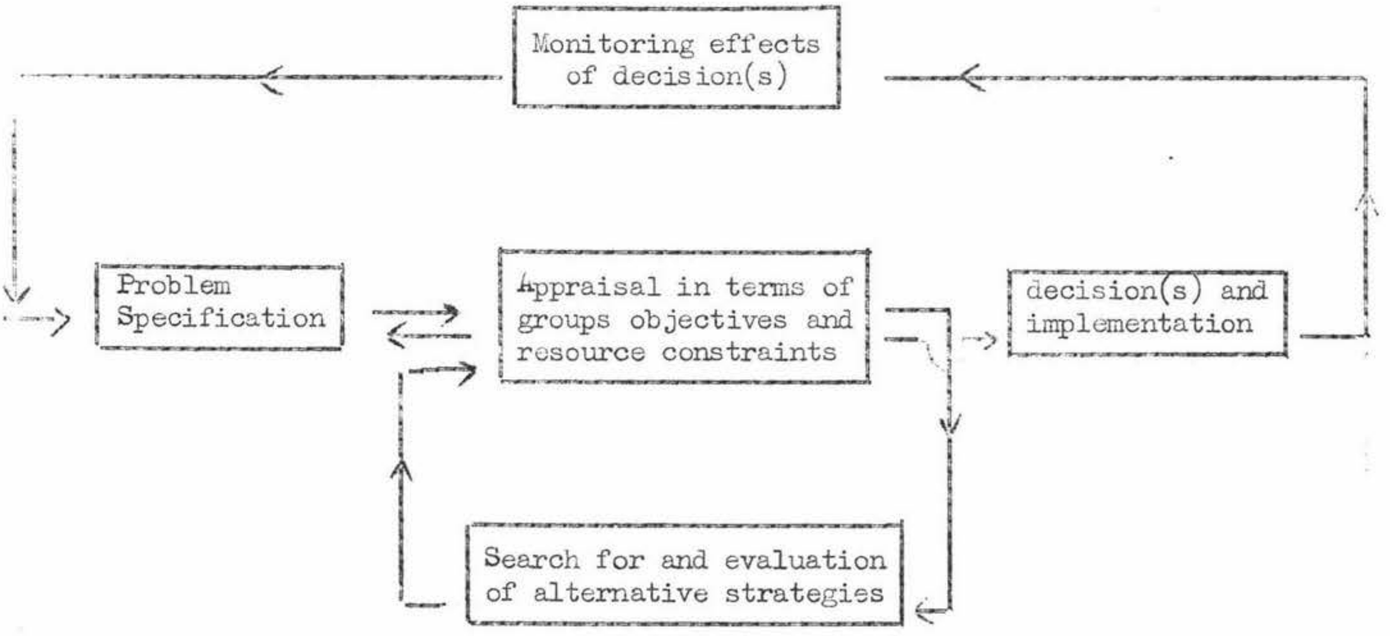
Adjustment To Floods	No. of Articles
1. Flood Control	47
i) stopbanking and channel improvement	(41)
ii) detention dams	(3)
iii) other land treatment works	(3)
2. Flood Forecasting	3
3. Emergency Action	5
i) temporary evacuation	(0)
ii) flood fighting	(2)
iii) emergency relief	(3)
4. Structural Changes to Buildings	0
5. Land Elevation	0
6. Landuse Change	1
7. Landuse Regulation	2
8. Insurance	0

Source; Erickson (1971, p109)

The decision-making process involved in the choice of adjustment involves a number of basic steps which were identified in Chapter One. The actual process of making a decision in flood protection may be described as in fig 3.2 which illustrates the basic elements of the planning process from problem specification through problem appraisal to the evaluation of alternative strategies and their analysis, and the decision and implementation phases. An essential facet of the processes are the feedback interactions, which, either as a result of the appraisal or through monitoring the effects of the implementation of the decision(s) may result in a restatement of the nature of the problem.

Fig. 3.2

THE PROCESS OF MAKING AN ADJUSTMENT DECISION



This modelling procedure can be translated into the terms of reference adopted by Kates, as outlined earlier. Kates identified the three major steps in the actual process of making a decision as being

1. the perception of the hazard
2. the search of alternative adjustments
3. the evaluation of alternative adjustments

An elaboration of the role of each of these elements is essential to an appreciation of the complexity of the decision making process, and so will be attempted below.

B. THE ROLE OF PERCEPTION

Social scientists have observed that the same person or group in a number of different naturally-occurring settings, invariably react to the immediate socio-physical environment in different ways. Available evidence suggests that both overt behaviour and pyschological state is affected by the socio-physical environment. Geographers have for some time realised that the different elements of the environment have different meaning for different populations. These differences in meaning result from perceived utility differences, in which the same environmental element is seen as having different functions, or else they result from perceived quality differences, in which the environmental element is seen as having the same function but as being of different value for this function.

It is possible to make a tripartite division of the process of perception. The elements are not rigid in content and individual factors may be incorporated into one or all of the elements. Essentially the process flows from left to right, but there may be feedback between elements so the process is by no means uni-directional.

Receipt of Signal ⇄ Appraisal ⇄ Behaviour

In discussing perception of the environment, interest is not in the neurological and physical aspects but rather the impression on individual receives when viewing the stimulus of interest. Appraisal of the signal received is the second step in perception. Many complex factors outlined below influence this process. The resultant behaviour, which may include inaction, is the physical expression of the persons perception of the hazard. This involves a high degree of abstraction and generalisation of a complex reality, (Saarinen 1966, p83). Geographic research on perception of natural hazards has been summarised by Craik, (1970). Perhaps the most significant finding is that considerable variation in the perceived existence and severity of a natural hazard is known to exist, both among users of the same resource and among the technical experts, but more significant is the difference in perception's held by resource users and technical experts.

1. <u>The Technical Experts Hazard Perception</u>

The technical expert attempts to predict the spatial and temporal occurrence and magnitude of a natural hazard. In the case of flooding, the spatial occurrence is set.

Estimates of the temporal spacing and magnitude are made within a probalistic framework expressed in Return Period and associated streamflow in cusecs (one cubic foot of water passing a given point in one second). The need for a technical perception of the 'problem' arises from the uncertainty of the event and the demands of a technical society for scientific judgements and decisions.

Burton et al (1968, p.16), noted that the estimates of frequency and magnitude are often not as good as the non-professional assumes them to be. It is suggested that this unreliability is due to the infrequency of the events themselves and the short period of actual records from which judgements are extrapolated. This situation is demonstrated by Burton and Kates, (1964) when they noted that by using the three major methods of calculating the Return Period for the maximum flood on the Lehigh Valley, one arrived at a Return Period of 27, 45 or 75 years.

2. <u>The Floodplain Managers Hazard Perception</u>

Research by Burton (1961), Kates (1962), Rodger (1961), White (1961 and 1964), Burton, Kates and White (1968), Burton and Kates (1964 a and b), has attempted to discover what factors influence an individual's perception of the flood hazard. Results have not proven very conclusive although it has been discovered that perception is not a function of age, education or socio-economic status. A correlation between the recency of the last flood, frequency of flood events, damages or losses suffered and perception of the hazard does appear to exist. Kates' study of La Follette and five other communities indicated perception was a function of direct flood experience and outlook towards nature and that the mere supply of technical and scientific information as to the extent and magnitude of previous floods did not necessarily give rise to a more precise recognition of the flood hazard.

Burton and Kates (1964,b) showed that perception among users of the same resource varied considerably. They suggested three reasons to account for this;

(a) Relationship of hazard to dominant resource use. For example, in an agricultural area this would include such factors as the ratio between the total farm size and area on the floodplain.

(b) The frequency of occurence of the flooding influences perception. Where this is very frequent or very rare, little variation in the adoption of adjustments amongst resource users is expected, but in the areas of intermediate frequency, considerable variation in the adoption of damage reducing adjustments can be expected.

(c) Variation in the degree of personal flood experience.

It has been discovered that considerable variation in the perception of a hazard is to be found between different resource users. Burton and Kates, (1964,b), showed a wide variation in hazard perception between the managers of river floodplains and coastal zone hazard areas existed and Burton (1962) indicated that agricultural floodplain managers were more aware of the hazard than urban dwellers as discussed by White (1958), and that rural floodplain managers made a more accurate estimate of the danger of the hazard, especially where flooding was frequent, than did urban dwellers.

3. Variation in Perception between the Technical Expert and the Floodplain Manager

A wide variation in the perceived existence or severity of a hazard by the technical expert compared to the floodplain manager has been noted. It is possible that this variation could be due to a number of factors such as; the difference in outlook towards nature, - (the technical expert has what could be termed a 'neutral' outlook towards nature, whereas the floodplain manager is very involved with nature) - a basic difference in the tolerance of uncertainty; the effect a flood event will have on the floodplain managers and technical experts vary; the technical expert views the likelihood of the occurrencein the long term whereas the farmer views it by the length of time he intends to spend on the farm.

It is possible that the estimate made by the resource user may be no more divergent from reality than that made by the technical expert. Nevertheless, the variation does have serious implications as to the efficiency of an adjustment decision, especially where the technical agency is responsible for the calculation of the severity of the hazard and the construction of the protection scheme.

C. THE THEORETICAL RANGE OF ADJUSTMENTS

The traditional choice of adjustment to the flood hazard in the U.S.A. has been to either bear the loss from occasional overflow or to press for the construction of engineering works financed by public agencies, (White 1964a, p1). This trend has also been observed in New Zealand by Erickson (1970). There are however many other theoretically possible adjustments. The most common alternatives - all of which have been used at some time, were outlined by White (1942) as follows:

land elevation	flood protection
flood abatement	emergency measures
structural adjustment	land use change - crops
public relief	- urban, rural
insurance	- public

from White 1966, p 257.

This typology was misleading for two major reasons.

1. It included social adjustments as though they were adjustments in themselves. For example, land use regulation was listed as an alternative public measure whereas today it is recognised as a possible guide to any adjustment or use.
2. Land use change was shown as an alternative adjustment. While this is true for any one land use at one point in time, the original classification suggested that such a change excluded other adjustments.

Consequently, the typology was revised in 1965 showing seven different adjustments for all possible land uses and consideration of the effect of various social actions which may affect choice were omitted.

Land Use A - bear the loss
- protection
- emergency measures
- structural including land elevation
- flood abatement
- insurance
- public relief

Land Use B - bear the loss
- protection etc,

White 1966, p 257.

Different adjustments act upon the effects of the flood hazard in significantly different ways. For example it is possible to;

1. affect the cause of the flood through watershed treatment,
2. modify the hazard by controlling the flow with reservoirs, levees or channels,
3. modify the loss potential with warning systems, emergency evacuation and preparation, floodproofing of buildings,
4. adjust the losses by spreading them amongst the population in the form of public relief and subsidised insurance,

5. plan for losses with insurance and reserve funds, or
6. the individual may bear the loss.

These measures cover a wide range of techniques; they prevent water from damaging property or remove property from the reach of water; they cover measures that are wholly organisational and those that are completely structural; they include direct adjustments which involve a conscious assessment of flood effects and indirect adjustments, such as occur when renovating a building; they include both public and private measures and those methods that seek to alter the Human Use System and those that seek to alter the Natural Events System. Further distinctions can be made, for example, between those measures that seek to alter the Natural Events System there are those measures that affect

1. peak magnitude and duration of floods, for example, reservoirs.
2. stage-discharge relationships, for example, channel improvements levees, floodings
3. individual structure stage damage relationships, for example, floodproofing, evacuation and floodplain zoning.

One of the most common distinctions that is made is that between corrective measures and preventative measures, as made by the Tennessee Valley Authority and shown in Fig 3.3.

Another common distinction is that between individual and public adjustments as shown in Fig 3.4.

FIG 3.3

FLOOD DAMAGE PREVENTION MEASURES

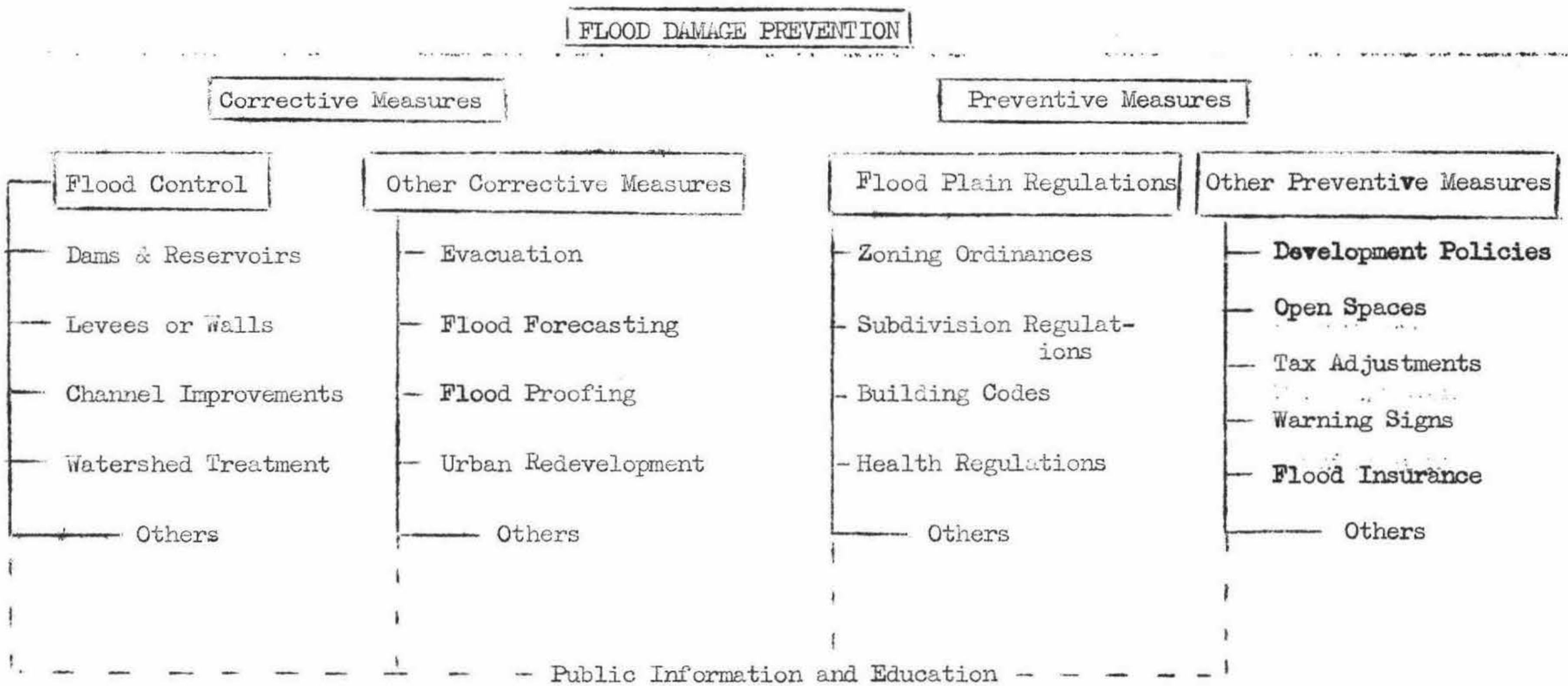
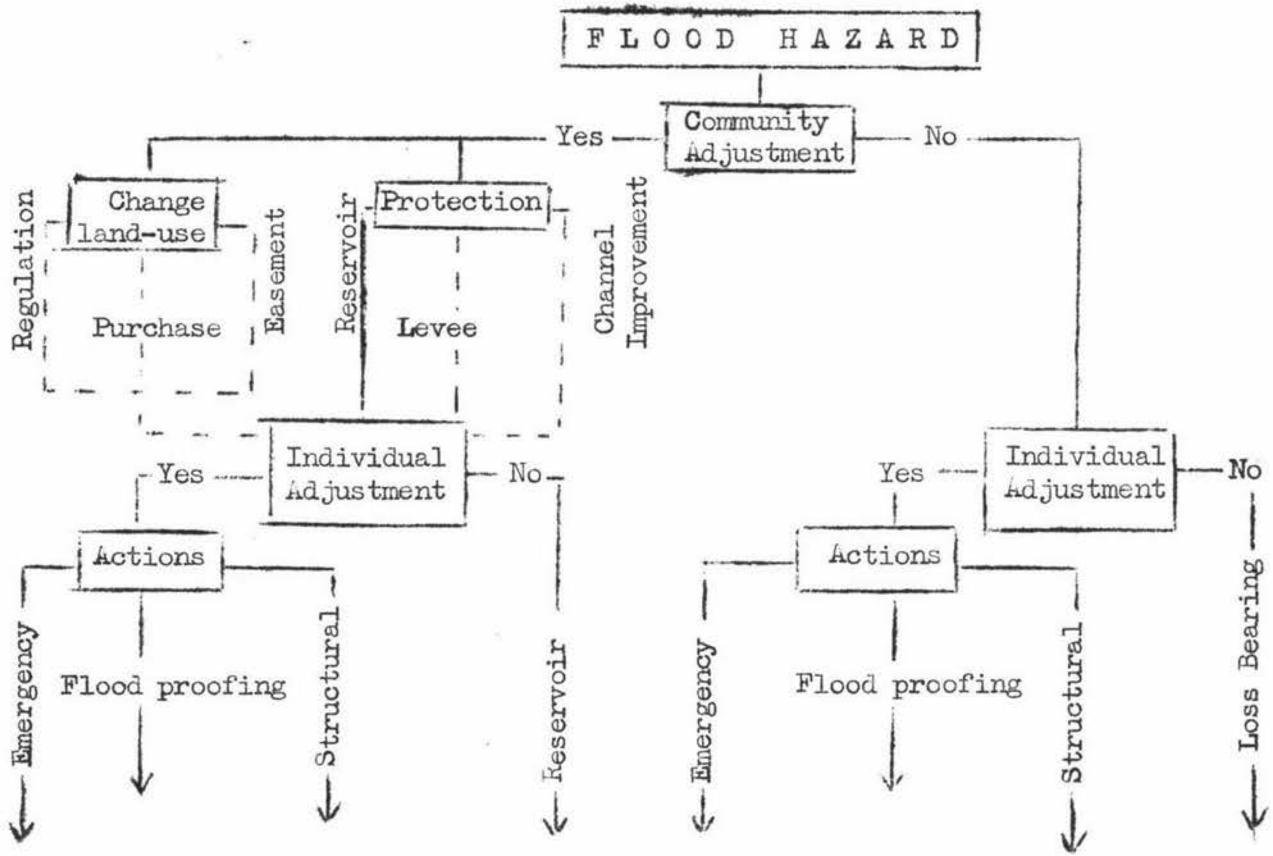


FIG 3.4



An abridged schema of human adjustment to flood hazard

It is only relatively recently, that engineers have begun to realise that structural flood control measures are not the only answer to the flood problem. A number of researchers have pointed to the use of nonstructural measures for flood control, and the advantages and disadvantages of such measures, (Weber and Sutton 1955, Whipple 1969, White 1967, Krutilla 1966, Lind 1967, James 1970). A unified flood control program can be conceptualised in terms of four basic components.

1. Structural measures.
2. Land use management in deciding what types of development should be restricted or permitted on the floodplain.
3. Deciding how to arrange, use and maintain those activities that locate on the floodplain so as to minimise flood losses.
4. Savings that can be made by the provision of emergency services.

Each of these components can be used in varying combinations, depending upon local circumstances. The ideal combination varies by locality and by individual locations over time. For this reason, it is necessary to remember that planning is never complete and a plan should be continually reviewed to make sure it remains optimal in the light of unfolding developments. It should be flexible enough to allow alterations when unanticipated developments occur.

D. THE EVALUATION OF ALTERNATIVE ADJUSTMENTS

In that a number of alternative adjustments are usually possible for any one hazard situation, it is desirable that some design criteria be employed, that selects the one or combination that performs most favourably in terms of stated objectives.

Considerable attention in the literature has been devoted to criticism as to what should guide public decisions in the design and approval of flood protection projects. This criticism has focussed on "the need for a test which could be applied to planning, to guide decisions as to which design would be best for a given situation, and to make the best use of limited funds". (James 1970, p308). For this reason, decisions based solely on a political decision process, and the suggestion that flood programs should be implemented no matter what the cost, cannot be accepted as there is no guarantee such decisions would yield the most desirable adjustment.

There is a need to employ some evaluation criteria, any evaluation process there must therefore include some realistic means of objectively measuring the costs and benefits of a project, rejecting the poorer alternatives and accepting or modifying the better ones.

The earliest and most crude method of evaluating the worth of a project was to simply compute the estimated benefits and estimated costs. If the estimated benefits exceeded the estimated costs, then the project would proceed.

The first guidelines to objectively evaluating the costs and benefits of a project was contained in the United States Flood Control Act of 1936. This Act stated that a project could proceed if "the benefits to whomsoever they may accrue are in excess of the estimated costs and if lives and social security of the people are not otherwise adversely affected" (U.S. Code 1940 quoted James 1965, p9). The Act, however, gave no effective guideline as to the nature or direction benefits should take. What was determined was that Congress had declared the primary objective of flood control to be economic efficiency. Social Security was also considered. This had important implications as this objective requires a higher level of protection than warranted by economic efficiency alone. Since economic efficiency specifies a level of protection, social security can be viewed as the objective used to justify the preselected minimum level of protection largely used in practice.

The use of economic criteria alone in the evaluation process must be rejected on three grounds;

1. There is no substantial agreement about which theory is to be used. There are a number of theories, and there are considerable disagreements about assumptions, subtheories, procedures, etc. used.
2. To be fully operational for making decisions about resources and the environment, any economic theory would require that all aspects of the problem be quantifiable, which they are not.

3. All economic theories make general assumptions about the economic behaviour of individuals, firms, and governments. These assumptions are seldom realistic. There is no consideration of intangibles such as demands for security, beauty, good health, freedom from stress, etc.

There has been a fairly rigorous investigation of what factors should be included in the evaluation process since the 1936 Act. Procedures for field personnel have been specified by the U.S. Soil Conservation Service, Army and National Government, and these have been subject to critical review by various scholars, noteably Eckstein (1958), Hirshleifer et al. (1960), McKean (1958), Maass et al. (1962), Hufschmidt et al. (1961) and Sewell et al. (1962). This research and associated works, particularly that of the University of Chicago team, has led to the identification of a number of important factors that should operate in the evaluation process. Kates (1970, p18) summarised these findings and noted that ideally an evaluation of alternative adjustments should be made with reference to four basic questions, or criteria.

1. Is it suitable for the environmental setting?
2. Is it technically efficacious and feasible, given the available tools, skills, materials and the indivisibility of activity?
3. Is it economically gainful in the context of the managerial unit's time horizon, reserve - loss ratio, and constraints on choice?

4. Does it conform to social guides of law, tradition or expected norms of behaviour?

Each of these criteria are of differing importance, depending upon the particular environmental, social and economic setting in which the adjustment is to be made, as well as the nature of the decision-making agency, and in particular resources at its disposal. For example, engineers in the Western World use the criterion of technical efficiency (will it work?), as their prime criterion and considerations such as cost and social conformity act as constraints on the adjustment adoption. Similarly, in other areas, social conformity, (do as my father did), is the basic constraint. In a specific area, the order of criteria is most likely a function of the human use characteristics of that area. Based on the evaluation process, a decision to adopt or reject a particular adjustment is made. If rejected, there is then a feedback process, in which a re-evlauation of the problem is undertaken, new alternatives are sought, or standards of acceptance of a solution are modified.

CHAPTER 4

THE DECISION-MAKING PROCESS IN THE LOWER MANAWATU REGION

Introduction

The task of the decision maker and the importance of understanding the decision-making process has been described in earlier Chapters. It is proposed in this chapter to examine the decision-making process in the lower Manawatu region. Emphasis will be placed on the importance and the effects of various elements of the decision-making process, as defined in Kates model shown in Figure 1.2.

The choice of adjustment to the flood hazard is dynamic rather than static, "to think of there being a decision only when a major project is under consideration is to ignore the variety of paths along which adjustments move", (Whie 1964b, p4). In the past, research has often ignored the fact that adjustments are continually being made to the flood hazard. The following discussion will therefore be divided into two sections: (a) Pre-scheme adjustment decisions; and (b) The adjustment decision process involved in the Lower Manawatu Flood Control Scheme. Emphasis will be placed on the Manawatu Catchment Board's decision-making process that led to the Lower Manawatu Flood Control Scheme. This weighting is justified because (a) this scheme theoretically negated the effectiveness of any pre-scheme adjustment decisions, and (b) the very size and complexity of the economic, social and environmental ramifications and considerations of such an adjustment decision, provide an excellent case study to illustrate the processes involved in the decision-making process.

I. PRE-SCHEME DECISIONS

In the years preceding the Lower Manawatu Flood Control Scheme, adjustments were made in response to the flood hazard. The exercising of choice in these years was of two principal types:

(a) individual floodplain managers.

(b) collective action by official bodies, notably the River Boards and Drainage Boards, and in later years the Catchment Board.

A. Individual Floodplain Managers Adjustment

In the lower Manawatu region, there is evidence of conscious adjustments to the flood hazard by individual floodplain managers in pre-scheme years, especially in rural areas of the floodplain. There is evidence of buildings being constructed on elevated areas and on man-made mounds where such elevated land was not present, while in other cases buildings were constructed off the floodplain. In the Tokomaru area, houses have been constructed on platforms rather than piles in response to the mobile nature of the ground caused by a very high water table. In other areas, buildings have been elevated six to nine metres by using high piles. Perhaps the most conscious adjustment to hazard has been the building of private stopbanks around a number of houses, and in some cases, around a large portion of individual properties. Changes in land usage in post-scheme years suggests some regulation of economic activity in response to the flood hazard in earlier years. It must be recognised that some changes in land use are the result of changing markets and technology and not necessarily changing hazard intensities. There is, nevertheless, some suggestion that land use in the more frequently inundated areas was of an extensive nature (sheep, steers and bullocks) as these activities could be readily moved in a hazardous situation.

In urban areas, there is little evidence of structural alterations to buildings on the floodplain. It appears that the only common reaction to the flood hazard was to build off the floodplain. In Palmerston North city, for example, the oldest buildings are to be found on the higher terraces and off the floodplain, and as one moves further onto the floodplain, the buildings and houses are progressively newer. A similar situation exists in Feilding, Shannon and Awahuri, although to a lesser degree, possibly because the flood hazard in these areas was seen as being far less threatening, and the general level of development was considerably lower.

B. Collective Action Adjustment

There is a long history of river control and drainage work in the lower Manawatu region. Initial thoughts on flood protection focused on stopbanks, and it was originally considered that stopbanks should be erected by whoever could afford to do so. The drawbacks to this were quickly recognised, in that the stopbanking of an individual property would place more water on farmlands downstream, and if one farmer stopbanked, but the farmer upstream of him did not, then the land "protected" by the stopbanks could still be flooded. It was therefore realised at an early stage that it was necessary to group together to protect properties.

Collective action on flood protection received an early stimulus with the phasing out of the Provincial Government system in 1876, and the organisation of local government in it's present form. This led to the 1884 Rivers Board Act and 1893 Land Drainage Act. These Acts recognised the need for better planning and co-ordination of work and assured a means of raising finance. These Acts were consolidated in the 1908 Rivers Board Act and 1908 Land Drainage Act, which brought together pre-existing legislation providing the basis of River and Drainage Board work up to the present day.

Under the terms of these Acts, Boards were established as fully corporate bodies to carry out flood and erosion prevention works, and the general maintenance and improvement of rivers, streams and watercourses. Boards were given the power to levy a rate for work done. This was not to exceed an average of one and a half pence in the pound of the capital value of all rateable property. Where works were of a major nature and of national as well as local interest, government subsidies were available at the rate of two to one.

The 1908 Acts led to the creation of a number of new local drainage boards. Prior to the Act, there was only the Manawatu Rivers Board formed in 1894 to develop the Kairanga and Taonui Basin areas, and the Makerua Drainage Board formed in 1906 to protect and develop the area on the southern bank of the Manawatu River between Longburn and Shannon. Soon after the passing of the Acts the Moutoa Board was formed (1908) to cover the area from the junction of the

Manawatu and Oroua Rivers down to Foxton. The next Board formed was the Sluggish River Drainage Board (1912) to cover the area on the western side of the Oroua River. The Buckley Drainage Board (1913) was responsible for the area between Shannon and Whirokino and the Manawatu Drainage Board (1922) was responsible for the area between the Oroua and Manawatu Rivers.

These early Boards did much to develop the land from a wet flax and bush covered state. Most of the early work consisted of drainage, stopbanking and river channel dredging. The first mechanised drainage was the excavation of the Moutoa Main Drain, but the most significant work was in the Makerua Drainage Board area, where, in 1919, Messrs Jickell and Gilmour, planned and completed the development of 54,500 hectares of swampland for the Makerua Drainage Board. This included over 65 km of stopbanking along the Manawatu River, up to the level of the 1902 flood, and along the Tokomaru River. Canals and drains were also constructed throughout the whole area, and the Tokomaru River was cleared. This work was completed by 1925. The initial expenditure of £136,000 was met entirely by ratepayers of the area as it was not until 1941 that government finance was officially available for drainage work.

Each of the drainage boards operated independently and within their own boundaries. The lack of co-ordination between the different drainage boards negated many of the benefits of their work. The stopbanking of the Manawatu River on the Makerua Drainage Board side of the river only may be cited as one instance. This resulted in much more water flowing onto the land on the opposite side of the river in times of flood. It was not until the formation of the Manwatu Catchment Board in 1944 that an overall flood control policy could be introduced. The Catchment Board covered nine times the area covered by the Drainage Boards. Their earliest work was in co-ordinating the work of the Drainage Boards and in the construction of stopbanks to protect Palmerston North city.

C. Emergency Action Adjustments

A third area of adjustment that needs to be discussed in flood hazard adjustment in pre-scheme years is that of emergency action to reduce losses to property and life in time of actual flooding. Much of the data presented below is drawn from newspaper reports of the 28th and 31st January 1953, which was the time of the largest flood in the region since detailed records have been kept.

Emergency action involved the co-operation of official bodies and individual floodplain managers. The Catchment Board had an official emergency warning system, based on river level recorders and a telephone network, to warn farmers of the impending danger of flooding. This warning system served only to alert those farmers whose land was normally inundated in time of flood and in the 1953 flood, the biggest since the formation of the Catchment Board, farmers outside of these areas were not aware of the impending danger to their land and consequently were caught by surprise. The reliability of the warning system is also brought into question by the Catchment Board's prediction, on January 28th when the river level at the Fitzherbert Bridge was at 15 feet, that the flood would peak at 16 feet 6 inches - a level reached four times in the preceding 22 years

- and the banks would be overtopped only in the Taonui and Moutua areas which were natural ponding areas. The flood actually peaked at 21 feet 3 inches and a much greater area than that predicted by the Catchment Board, including parts of Palmerston North city, was flooded.

There was little in the way of planned emergency action in time of flooding and the organisation of such activity appears to have been led and co-ordinated by the Police and Army, supplemented by civilian volunteers. Police and Army volunteers rescued or evacuated over 500 people in Palmerston North city including all but two in the Hokowhitu transit camp. In Palmerston North twenty trucks were despatched by civic groups to help in the evacuation of people and personal goods. Many local carriers also volunteered their services and an entire fleet of trucks from Linton was made available. Billets were provided for evacuees, the Red Cross provided food for victims and the Boy Scouts helped lift carpets and move furniture (according to some flood victims, they caused more damage than good), and assistance was offered by the Feilding Borough Council.

In rural areas Catchment Board staff, Army personnel and a party of 30 from Massey University as well as other civilian volunteers sandbagged stopbanks on the Manawatu and Tokomaru Rivers that were threatened to be overtopped, especially those in the Makarua area where the risk was greatest. Three bulldozers were also used in this operation. Powerboats and rowboats owned by private individuals, the Catchment Board, and the Army were requisitioned by the Police and used in evacuating people. Cooksley transport and Reid transport companies provided their entire fleets of lorries to farmers to help shift stock.

In the majority of cases, people waited until the flood waters were several feet deep in their houses before evacuating them. In a similar manner, few farmers shifted stock sufficiently early to prevent losses. Stock took refuge on stopbanks and areas of high ground. After the floodwaters had receded, stock was shifted to higher ground and grazed on the roadsides. Only one farmer had a ready plan in case of flood and his stock was trucked out before his land was flooded.

Other emergency measures were post event, with the Manawatu Oroua Electric Power Board removing and servicing all farm and factory equipment inundated in the flood. Mechanical trenching machines were used to ensure rapid burial of the dead carcases.

II. THE MANAWATU CATCHMENT BOARD DECISION MAKING PROCESS

The Lower Manawatu Flood Control Scheme represented the end product of the Manawatu Catchment Board's decision-making process. In this way it can be viewed as the Catchment Board's response to the flood hazard and the perceived disruption to economic and social activities of the area that would result. The actual protection scheme decided upon reflected the nature and operational procedure of the Manawatu Catchment Board, the institutional and legal framework within which the Catchment Board operated, and the land use characteristics of the lower Manawatu region.

Planning for water resource use theoretically requires the assembly and analysis of all information relative to the social, economic, legal and physical aspects of the area under study, and the examination of long and short-term ways to meet these needs. It involves the comparative evaluation of alternative solutions and their social, economic, environmental and technical merits. Wise exploitation of natural resources then, calls for careful and articulate planning, which involves making rational choices among feasible courses of investment and other development possibilities on the basis of social, economic and environmental considerations.

It is thought that past and present flood protection policy in New Zealand may be producing adjustment schemes that are less than satisfactory in their economic, social and environmental effects. Discussions with Evans (the chief engineer in charge of the Lower Manawatu Flood Control Scheme), revealed that few of the theoretically possible adjustments were considered. An examination of the Economic Report on the Scheme presented by the Catchment Board revealed the use of analytical techniques and methods that are not very rigorous in their application.

It is therefore possible that an examination of the various elements or factors involved in the adjustment decisions of the Catchment Board may give insight into the merits and deficiencies involved in flood hazard adjustments being made in New Zealand and in the Manawatu in particular.

The major factors influencing the nature of the adjustment decision were the Catchment Board's:

1. role responsibility as defined by the 1941 Soil Conservation and Rivers Control Act.

2. perception of the flood hazard,
3. awareness and consideration of alternative adjustments,
4. resources at their disposal to enable a particular adjustment to be implemented, and
5. evaluation of the benefits of a particular flood control project.

A. Role Responsibility of the Manawatu Catchment Board

It has long been recognised in New Zealand that government has a major role to play in flood protection - (witness 1884 Rivers Board Act and 1908 Land Drainage Act). The regulatory and financial provisions of governmental legislation determine the boundaries within which decisions may be made.

The Manawatu Catchment Board derives its powers and functions regarding river and flood control and soil conservation from the 1941 Soil Conservation and Rivers Control Act. Subsequent Acts, particularly the 1967 Act, greatly extended the powers of the Catchment Board. The flood control scheme under study however, was instigated, designed and constructed under the legislative provisions of the 1941 Act. A closer examination of this Act will help to identify the role, powers and functions of the Catchment Board as part of the total official approach to flood control in New Zealand.

Soil Conservation and Rivers Control Act, 1941

Government Inquiries and Reports were commissioned in 1919, 1937 and 1938 to investigate the inability of Rivers Boards and Drainage Boards to cope successfully with river deterioration, flooding, problems of erosion and provisions of adequate drainage facilities. These enquiries noted increasing occupance of the flood-plain and increasing deterioration of the above mentioned problems. Their findings and reports culminated in the 1941 Act.

This Act was one of the most advanced of its kind in the world at the time as it recognised the general condition of the catchment, affected the lower reaches of the river, and stressed the interrelationship of soil conservation, river control and drainage problems. It brought these problems under unified control at the national and local level.

Objectives of the Act

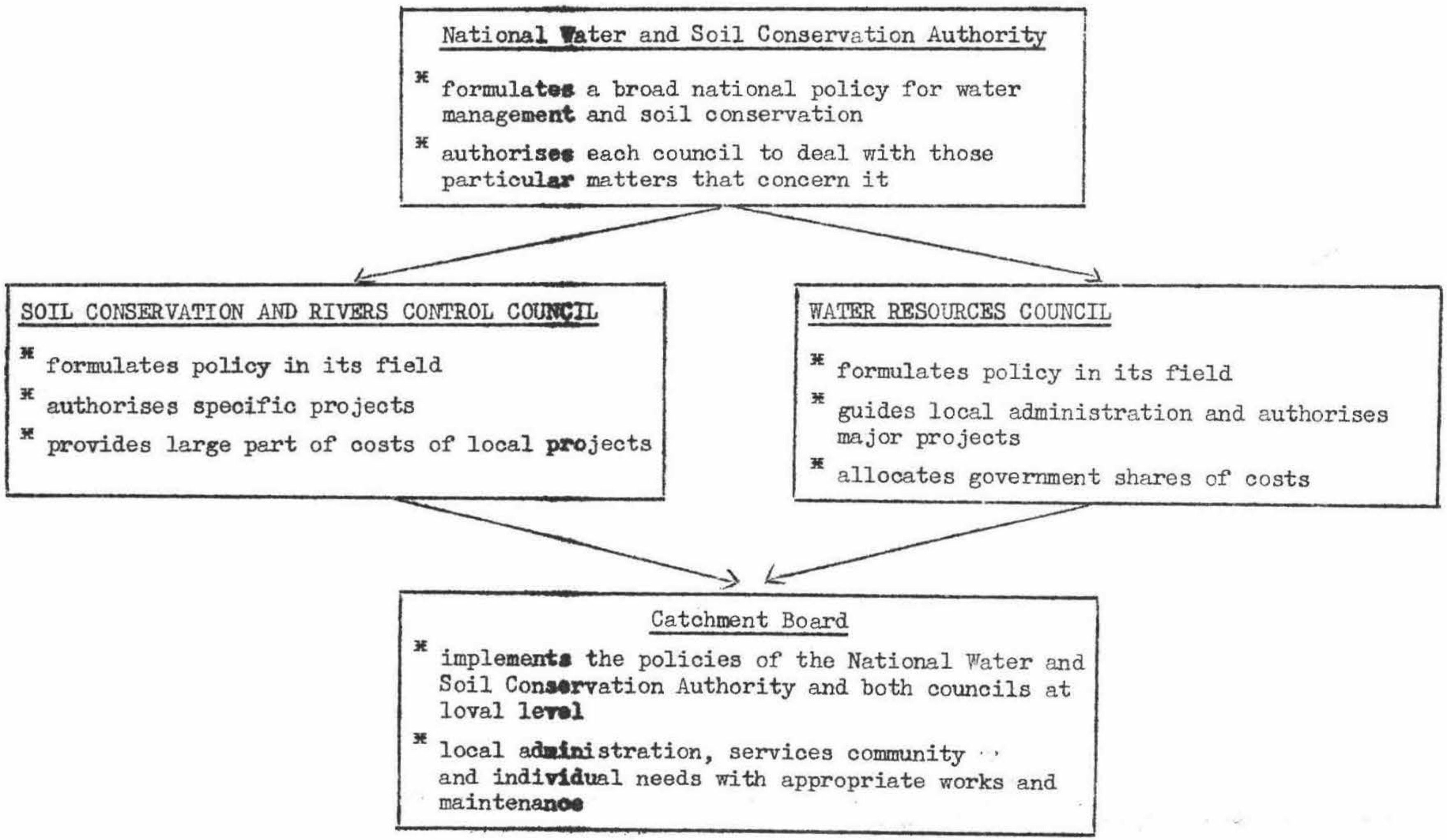
The Act had four major objectives:

1. The promotion of soil conservation.
2. The prevention and mitigation of soil erosion.
3. The prevention of damage by floods.
4. The utilisation of land in a way that is in accordance with the above objectives.

Legislative Provisions

The Act, which is outlined in diagramatic form in Figure 4.1, provided for the establishing of a Soil Conservation and Rivers Control Council (The Council), and Catchment Boards. The Council was to consist of representatives of the Ministry of Works, Department of Lands, Department of Agriculture, Department of Forestry, the Treasury, two representatives from areas that lay outside Catchment Board boundaries and seven representatives from municipalities-County

The Distribution of Authority for Soil Conservation and River Control Works



Councils (2), Catchment Boards (2), River and Drainage Boards and agricultural and pastoral interests.

The Council was given wide-ranging functions covering the formulation of policy, authorisation of specific projects, it was also given financial assistance and backing for local projects, research, data collection, investigations and demonstrations which covered the prevention of erosion, river control and drainage. The powers of Council included the carrying out of surveys, the taking of land in critical areas or regulating land use, the carrying out of demonstrations and research work, the construction of soil conservation measures, river and drainage works and their maintenance.

The constitution of the Catchment Boards was established in the Act. They were to be the executive authority for soil conservation and river control within their districts. A Catchment Board was to be set up to cover one or more complete adjacent catchments with a community of interest, where river control, drainage and soil conservation were of sufficient magnitude to justidy the setting up of such a Catchment Board.

Catchment Boards are fully corporate bodies with elected and non-elected members. Elected members have to exceed the non-elected members, and can represent one or more constituent local authorities within the district. Representatives are apportioned according to the number and relative importance of the constituent authorities within the district. Non-elected members are appointed by the Governor General and include nominees from the Ministry of

Works and Departments of Lands and Survey, Forestry and Scientific and Industrial Research.

Boards are empowered to have their own administrative and technical staff for construction and maintenance work needed to bring catchments, rivers and drainage areas under a reasonable degree of control. The Catchment Boards may also contract with the internal constituent authorities, or with the Council, plan and carry out works on their behalf.

Catchment Boards must consult with internal local authorities such as River Boards, Drainage Boards and County Councils about work proposed for the district, and if objections cannot be resolved they are then referred to the Council for their decision.

With the establishment of the Catchment Boards, River Boards with similar but more restricted functions and powers, became largely redundant in Catchment Districts. In general, local opinion has favoured the retention of internal Drainage Boards, particularly in regard to drainage work, with any river control functions being taken over by Catchment Boards, which exercise general supervision of River and Drainage Board work concerned with watercourses, drainage and flood prevention, with their engineer often being a consultant to the Drainage Board.

The main functions of Catchment Boards are to minimise and prevent damage from floods and erosion and to promote soil conservation. This includes the regulation and control of water towards, into, in and from watercourses; the prevention, as far possible, of the likelihood of watercourses breaking their banks and the damage caused when such events do occur; prevention or reduction of the likelihood of erosion and the promotion of soil conservation activities in the area.

The Catchment Boards are empowered to make by-laws to cover the construction, alteration or maintenance of watercourses, drainage, channels and the construction of defences against water, land utilisation changes and prevention of erosion, but require the sanction of the Governor General before carrying out any work on tidal waters. Their powers and functions include those in the 1928 Public Works Act. Before commencing any project, however, details of the project have to be forwarded to the Council for their approval.

Financial Provisions of the Legislation

The economics of flood protection are determined to a large extent by the availability of funds. Under the terms of the 1941 Act a state subsidy for flood protection works was provided, in addition to a fixed annual grant to the Catchment Board.

Moneys are appropriated annually by Parliament under the vote Public Works and Services, Subdivision number IV - Soil Conservation, River Control and Drainage - to meet estimated government expenditure by way of loans, grants and subsidies, for the purposes of carrying out the objectives of the Act. This money covers subsidies, grants and loans for capital works and maintenance, repairing of flood damage, surveys, investigations and research, publicity and administration.

Under the terms of the Act, Catchment Boards are empowered to strike rates for various purposes. These include a general administrative rate, to cover administrative costs, costs of surveys, investigations and supervision of works which may be levied over the entire catchment for the purpose of carrying out the Act, and a special rate which can be struck for specific protection schemes.

B. The Manawatu Catchment Board's Hazard Perception

The first step in any adjustment decision is the perception or identification of the severity of the hazard. The Catchment Board's hazard perception was based on the estimated likelihood of river flows of certain magnitudes being exceeded and the corresponding area it was considered such flows would inundate. This was expressed in terms of cusec flows, return periods and flood frequency areas. A cusec is one cubic foot of water passing a given point in one second. A return period is the theoretical probability of a certain cusec flow being exceeded. For example it was calculated a flow of 150,000 cusecs in the Manawatu River had a return period of 100 years, that is, there was a 0.01 likelihood of this flow being exceeded in any one year. A flood frequency area is that area the Catchment Board considered would be inundated by flows of different magnitudes and were given the same value as the return period expression for that sized flow. Using the above example, the area that would be inundated by a 150,000 cusec flow would be the 100 year flood frequency area.

Flood frequency areas of 0 - 11 months, 1 - 4 years, 5 - 19 years, 20 - 100 years were identified as shown in figure 4.3 in which it was assumed flood damages would be constant. By multiplying these estimated potential flood damages with the possibility of the occurrence of flooding for that area, the estimated flood damage potential for the entire region was identified.

The Manawatu River was considered to be the most important source of flooding. The Catchment Board's first objective was to identify the distribution of flows and the flood frequency areas of these various flows. The distribution of flows was determined from an analysis of the record of river flows which have been taken every day at the Fitzherbert Bridge, Palmerston North since the installation of a river level guage in 1929. The river level is recorded in feet and then converted to a cusec flow. It was considered that "flows at this point are practically the same as those for the whole scheme, as the only main tributory below this point, the Oroua River, generally has little effect on the main flow values" (Appendix A of the Economic Report, p.1).

The records of flow in the Manawatu River, which are shown in Table V and Figure 4.2 were then analysed in two ways:

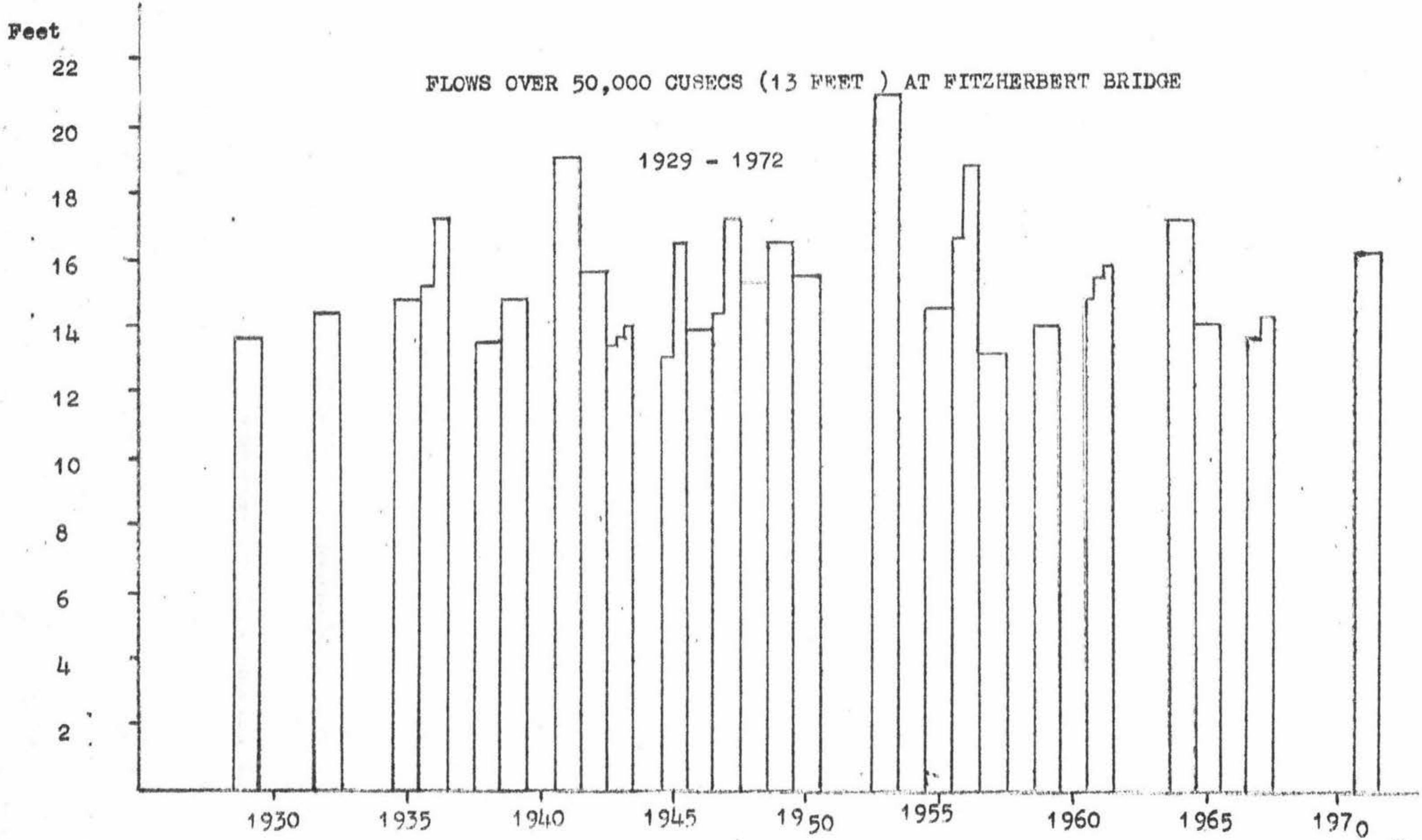
(a) The maximum flow which occurred each year was obtained and plotted on a graph by Gumbel's formula. From this graph, the average frequency of recurrence of different-sized floods was obtained.

(b) The number of floods at each six inches of gauge

TABLE IV - MANAWATU RIVER FLOWS OVER 13 FEET (50,000 CUSECS) AT FITZHERBERT BRIDGE 1929-1972

Year	Height at Fitzherbert Bridge							
	13'to 13'11"	14'to 14'11"	15'to 15'11"	16'to 16'11"	17'to 17'11"	18'to 18'11"	19'to 19'11"	+ 20'
1929	13'8"							
1930								
1931								
1932		14'5"						
1933								
1934								
1935		14'8"						
1936			15'2"		17'3"			
1937								
1938	13'6"							
1939		14'8"						
1940								
1941							19'0"	
1942			15'8"					
1943	13'6" 13'3"	14'0"						
1944								
1945	13'0"			16'6"				
1946	13'11"							
1947		14'5"			17'3"			
1948			15'4"					
1949				16'6"				
1950			15'6"					
1951								
1952								
1953								21'3"
1954								
1955		14'6"						
1956				16'6"		18'10"		
1957	13'2"							
1958								
1959		14'0"						
1960								
1961		14'6"	15'0" 15'9"					
1962								
1963								
1964					17'3"			
1965		14'0"						
1966								
1967	13'9"	14'3"						
1968								
1969								
1970								
1971				16'3"				
1972								

Source: Manawatu Catchment Board Records



source: Manawatu Catchment Board Records

height, nine feet or over, was counted and tabulated chronologically, and using Schumann's formula then analysed statistically and the average frequency of recurrence again obtained.

These two results were plotted on one graph, and it was considered that the Schumann method was probably the more accurate for the lower readings, while Gumbel's analysis was probably more accurate for the higher readings.

Using Gumbel's formula return periods for the Manawatu River were calculated as shown in Table V.

TABLE V - THEORETICAL MANAWATU RIVER FLOWS

Return Period (Years)	Cusec Flow	Height at Fitz-herbert Bridge (feet)
1	50,000	13' 0"
5	85,000	16' 6"
10	100,000	18' 0"
25	120,000	19' 0"
50	135,000	20' 0"
100	150,000	21' 0"
250	170,000	22' 0"

Source: Manawatu Catchment Board Records

As can be seen from Table VI the distribution of flows over 13 feet in the Manawatu River appears to be random, there being no cyclic spacing to their occurrence, although Evans was quoted as commenting of the 1953 flood, "there was a possibility of a major flood at any time, and that on the flood cycle, Manawatu was due for one", (The Times, January 31st, 1953).

TABLE VI - MONTHLY DISTRIBUTION OF FLOWS OVER 13 FEET AT FITZHERBERT BRIDGE 1929-1972

Month	13'-14'	14'-15'	15'-16'	16'-17'	17'-18'	18'-19'	19'-20'	+ 20'	Total
Jan	1							1	2
Feb		1			1				2
March									-
April	1								1
May	1	2	1	1			1		6
June	2		1		1				4
July		2	2			1			5
Aug	2	4		1					7
Sept	1	1	2						4
Oct				2	1				3
Nov									-
Dec									-
Total	8	10	6	4	3	1	1	1	34

Source: Manawatu Catchment Board Records

An attempt to estimate the maximum probable flood was made by analysing the major floods that had occurred since detailed records had been kept, that is since 1929. This was done using "The Precise Rationale" (Time of Concentration of Storm) method. From this, the Cathment Board concluded that "rough figures for a probable maximum flood appeared to be:

Time of concentration of storm = 24 hours

Maximum probable 24 hour rainfall = 5 inches

Runoff factor = 80 per cent

Maximum probable flood = 165,000 cusecs

(Appendix A to Economic Report p.1)

The calculating of the maximum probable flood served as a general check against the accuracy of the calculations described earlier, and other than this was not considered in the design of the flood control scheme.

Flows in other rivers were also considered and return periods for these were calculated as shown in Table VII, although the method of calculation was not given by the Catchment Board.

TABLE VII - RETURN PERIODS FOR TRIBUTARY RIVERS

Return Period (years)	Cusec Flows			
	Upper Oroua	Lower Oroua	Kiwitea	Makino
1	7,000	10,000	2,500	1,000
10	13,000	20,000	5,000	2,000
25	17,000	25,000	6,500	2,500
50	20,000	30,000	7,500	3,000
100	23,000	35,000	8,000	3,500

Source: Evans (1964, p.413)

Other factors that affected the Catchment Board's hazard perception were the area near the source of the Tokomaru River which was prone to flooding and the area to the north of Palmerston North which was flooded almost annually from the Mangaone and Kawau Streams and Whiskey Creek.

Comments on Catchment Board Perception

The statistical analysis of flood events is necessitated by the absence of any physical law to account for the irregularities of flood distribution. In order to determine the most effective flood design one needs to consider the flood distribution rather than rely solely on a consideration of the maximum probable flood.

The best guide to the shape of the distribution of floods and predicting the composition of future floods, are records of the past. At the time of construction of the scheme there were only 30 years of continuous flow records. It is likely that extrapolation based on such a small sample is open to a considerable degree of error. Benson (1952, p.64) showed that it would take at least a 39 year record to define a magnatude of a 50 year return period (probable occurrence in any one year, .02 per cent), with an accuracy of plus or minus 25 per cent, 95 per cent of the time. To increase such accuracy to within a plus or minus 10 per cent accuracy 95 per cent of the time would require a 110 year record.

The Gumbel method for estimating flow distribution, as used by the Catchment Board is one of the most widely used methods. Benson (1962, p.9), however, considers there are four reasons why the Gumbel theory cannot be expected to provide an exact distribution for flood peaks.

1. It is assumed that the treatment derived for daily discharges can also be applied to flood peaks.
2. The daily discharges are not independent events.

3. The 365 daily discharges in a year do not constitute a large number, as predicted by the theory.
4. An assumption underlying the theory that all events are part of the same statistical population is not necessarily accurate as the annual peaks under consideration may not be of the same population.

Benson believed that Gumbel's work simply presented three basic asymptotic distributions of events for which the one with the best fit was to be applied and "this statistical method, (then), is merely an empirical process of curve fitting" (Benson 1962, p.9).

The above would suggest the Return Periods as estimated by the Catchment Board may not be very reliable. The flows over 50,000 cusecs (1 year Return Period) since 1929 are shown in Table VIII. These flows are grouped by 1, 5, 10, 25, 50 and 100 year Return Periods in Table VIII where the actual and theoretical flows and the difference between these are shown. From this Table, it can be seen that in the 42 year period (1929 to 1971) a flow of 50,000 cusecs (1 year Return Period) has been exceeded 34 times. Of these flows, one has been of a 100 year Return Period, two have exceeded the estimated 25 year Return Period, but one of these was the 100 year Return Period flow; three have exceeded the 10 year Return Period, but one was the 100 year Return Period flow, and one, the 25 year Return Period flow referred to above. Nine flows have exceeded the 5 year Return Period, but one of these was the 100 year Return Period flow, one the 25 year Return Period flow, and one the 10 year Return Period flow.

Table VIII - MANAWATU RIVER FLOWS OVER 50,000 CUSECS AT FITZHERBERT BRIDGE (Actual and Theoretical) 1929-1972

Return Period (years)	Actual Number of Flows	Theoretical Number of Flows	Difference Between Theoretical and Actual Flows
1	25	34	-9
5	6	4	+2
10	1	3	-2
25	1	1	0
50	0	0	0
100	1	0	+1

Source: Compiled from Manawatu Catchment Board Records

It must be realised that a Return Period is an estimation of the probability of a flow. For example, in the Manawatu River a flow of 150,000 cusecs has a Return Period of 100 years. This means the chance of a 150,000 cusec flow occuring in any one year is one in 100 or 0.01 per cent. Therefore, while it appears as though there is some variation between the expected and actual distribution of flows, (especially when one considers flows of around 150,000 cusecs were experienced in 1880 and 1897), this may be due to the short time span of the data used, and the fact that the data used represents a selected time span.

It is likely that the method the Catchment Board used in calculating the maximum probable flow is not very accurate. In the same Report in which the method was outlined, it was noted that the method was "inapplicable to the catchment as no suitable average rate of rainfall records are available because of an absence of data on rainfall intensities" (Appendix 'A', to Economic Report 1). It is therefore impossible to determine the relationship between rainfall and runoff rates that are necessary for the calculation. Other calculations of runoff rates for the catchment have not produced very conclusive results with a wide variation (45 to 100 per cent) being noted.

Even though the Precise Rationale Method suggested a Maximum Probable flood of 165,000 cusecs and Gumbel Analysis suggested a 500 year Return Period of 185,000 cusecs, the scheme was designed to take a flow of 150,000 cusecs which was a 100 year Return Period. The selection of the 100 year Return Period as the sized flow to protect against, did not guarantee against overtopping at some future date. There are no justifications for the selection of the 100 year Return Period as the system design in any of the reports on the Scheme and discussions with Evans the Chief Engineer of the scheme revealed that there was no consideration given to the economic, social or environmental effects of providing protection at a different level. This suggests that the selection of the 100 year Return Period was virtually an arbitary selection figure.

In calculating the impact of various flood events, the Catchment Board ignored a number of basic considerations. It was assumed that river channels would remain unaltered, yet it has often been pointed out that aggradation or degradation of a river such as the Manawatu is occurring most of the time, especially in a situation where stopbanks have been constructed and a considerable amount of material is entering the river from the tributaries. As a result of such processes, the stopbanks on the Oroua River have already had to be raised several feet and there is no reason to expect that the same situation may not occur in the Manawatu River. It is also possible that the conditions under which a maximum flood occurred in the past no longer apply. The nature of the river bed and the nature of the bed load and sediment load, for example, may be very different today than when the original estimates were made.

In the Catchment Board's explanation for taking the river level reading at Fitzherbert Bridge, it was claimed that the Oroua was the only tributary below this point and that it had little effect on flooding in the area. This is a debateable point as the Oroua River has overtopped its banks on a number of occasions and the volume of flow in the Oroua significantly affects the backing up of water in the Manawatu River. This has particularly significant implications for flooding in the Taonui Basin area.

A final criticism of the Catchment Board's perception of the flood hazard is the way in which the Flood Frequency Area's were identified. Discussions with Evans determined that they were based on topographic details, and personal and local knowledge of the extent of past floods. There are, however, no detailed topographic maps of the area, therefore major emphasis must have been on personal and local knowledge. Valuation Department staff who have been responsible for determining the value of land in such scheme areas have expressed concern at Catchment Board methods of defining Flood Frequency Areas.

No recorded data exists on areas covered by different-sized flows in the past. Ideally, a technical expert's perception of a hazard would be based on a knowledge of local economic activity, and the extent of areas covered, the duration and depth of innundation, the velocity of flows in different areas, as well as the sediment load carried and deposited in such flows. As this information was not available, the Catchment Board perception could not be expected to reflect the real damage potential for flooding in the area.

C. Alternative Adjustments and the Adjustment Search by the Manawatu Catchment Board

All of the alternative adjustments outlined in Chapter 3 could have been incorporated in the Lower Manawatu Flood Control Scheme. Most of these adjustments provide for collective benefit, although floodproofing and structural alteration of buildings can be performed by individual floodplain managers. It is proposed to examine those adjustments that provide a collective benefit as, by its very foundation and function, the Manawatu Catchment Board was duty-bound to provide such protection.

Alternative adjustments would have had different impacts on activity in the floodplain. It is not the intention here to present a case for or against any one adjustment, but rather to outline what the possible implications of that adjustment, had it been adopted, may have been.

The Catchment Board focused its attention almost completely on traditional engineering methods of flood protection. The actual scheme decided upon drew heavily on previously proposed schemes, especially those by Grant (1937), Hay (1925), Halley (1944) and Fulton (1890).

The idea of ponding areas and dams was rejected by Evans on the grounds that Grant, an earlier engineer, had concluded such means of control to be unsatisfactory. Evans quoted Grant as noting "It is considered that the enquiries are complete enough to conclude that there are no major schemes for flood retention basins in the Manawatu that are worthy of development", and Evans himself added "Mr Grant prepared a number of schemes and considered proposals for holding back the water by dams in the upper reaches would be unsatisfactory", (Evans 1950, p.3).

The actual scheme adopted included levees, channel improvement and stabilization, cutoffs and floodways, all of which had the aim of getting water to the sea as fast as possible. There are no records or evidence of consideration of the benefits that could have been achieved through watershed management, floodplain zoning, structural alterations to buildings, the introduction of flood insurance schemes or land use changes. Discussions with Evans revealed that at no stage were any of these alternatives considered, either as independent adjustments or as part of an adjustment program that included a combination of alternative measures.

Structural Protection Works

Structural protection work such as dams, levees, reservoirs and channel improvement that were considered by the Catchment Board alter streamflow, producing a change in the distribution of flood losses. System designs are formulated so as to prevent all floods up to a certain magnitude. In a strict hydrological sense, however, there are few, if any, structures that are not liable to be overtopped, for no matter how big the historically largest flood, there is still a larger one to come. Nevertheless, "structural protection by eliminating the smaller more frequent floods, that account for a large part of the total losses, thereby reduces the expected value of losses", (Lind, 1967, p.346). The elimination of the possibility of flooding also eliminates the risk involved in the floodplain settlement, but as pointed out above, there is always the possibility of floodwaters overtopping the structural protection measure. The rapid inundation of the floodplain that would follow such an action, coupled with the increased invasion of the floodplain due to the false sense of security fostered by such measures, may offset the benefits of the protection itself.

The levee bank is perhaps the most widely used flood protection measure used by official bodies in the western world. They do, however, have certain drawbacks, of which two have been described above. In addition to the increased danger to floodplain occupants and damage to floodplain properties if overtopped, levees also force flood levels upwards, and decrease the natural valley storage thus transferring a higher damage potential to downstream locations. Other evidence suggests levees cause a rise in the level of the river bed and may accentuate aggradation in aggrading reaches of the river (Finer 1944, p.23). Levees also serve to create a less favourable natural drainage situation and deprive floodplain land of fertilizing water and silt. These disadvantages must be considered along with the benefits when judging the effectiveness or value of levee banks.

The levee has an advantage over reservoirs as protection is clearly distinguishable. Reservoirs have disadvantages in that they are prone to silting up and consequently, in extreme cases, may have a life expectancy of only 30 to 50 years. In addition to this, they are usually kept nearly full for fishing and recreation, or town water supply, leaving little capacity for floodwater. They also present a greater danger downstream if overtopped than if they did not exist at all.

River channel improvement consists of measures designed to increase velocities and thereby lower flood stages. This is usually done by straightening, widening, dredging, shortening the channel and/or decreasing its roughness. These measures will always be at least partially effective in reducing even the largest flood. The difference in hydraulic conditions can be calculated by Mannings formula, and some idea of benefits can then be gained. Against this, however, is the tendency for increased velocities and the cutting of meanders which promotes uncontrolled erosion, thereby developing new bends and damaging embankments etc. This problem was partly overcome in the Manawatu by the placement of stone on potential erosion spots.

Watershed Management

This general term includes a number of measures aimed at the control of erosion, conservation of water and flood control. All erosion control measures have the tendency of reducing runoff and thereby reducing flows in downstream channels. In the same way, the amount of detrius washed down from the hills is also reduced, thereby helping to reduce streamflows. The reduction percentage is greatest for floods of moderate magnitude, and least for floods produced by excessively heavy rain.

Studies undertaken in the United States have demonstrated the effectiveness of watershed protection. Sears in Peterson (1954) noted that land converted to ordinary agricultural usage lost one half to two thirds its initial capacity to absorb. Peterson (1954, p.23) noted that it was possible to control a cloudburst of 13 inches in 24 hours with good watershed management. (This may be compared with the estimated maximum probable fall of 5 inches in 24 hours for the Manawatu.) Perhaps the most persuasive case for watershed management is drawn from U.S. Agricultural Department findings that 75 to 85 per cent of all agricultural flood damage occurs on tributary watersheds, leaving only 15 to 25 per cent for the floodplain. Whilst it is agreed that not all situations are comparable, it must be recognised that watershed management does have a significant contribution to make to flood protection.

Watershed management is extremely important for future river conditions and therefore flood control in the Manawatu region. The erosion problem is serious in the ranges, particularly the eastern Ruahine ranges and Pohanginga Valley. Around one million dollars is scheduled for erosion control in the eastern Ruahines. The entire catchment condition is thus recognised as being of major importance in determining flood conditions.

Flood Insurance

Although provision for the introduction of a flood insurance scheme as an adjustment to the flood hazard was not directly incorporated in the 1941 Soil Conservation and Rivers Control Act, the Act did state that new laws could be formulated if it was considered they would prove beneficial to controlling flood losses.

A compulsory flood insurance scheme is the only adjustment that completely removes the uncertainty of future costs of flood damage. Such a scheme has been advocated by Krutilla (1966) and Lind (1967). The premiums would be equal to the estimated future social and private flood damages, and would be proportional to the risk of each floodplain occupant.

An insurance policy that covered all economic loss by a premium equal to the expected loss would serve to add the cost of the premium to operating costs. The expected cost of floodplain location would therefore be the same with or without flood insurance, but with an insurance policy, these costs would be known with certainty and risk therefore eliminated.

The major problem with such a policy is that transaction costs would need to be added to the premium, which would consequently exceed the expected losses. Thus, whilst a flood insurance scheme could serve as a rationing device in floodplain land use by the elimination of economically unwarranted uses of floodplain land, at the same time some activities that would have found it profitable to locate in the floodplain could now find it unprofitable.

The major benefit of the scheme would come from the elimination of the risk of floodplain location. If the amount by which the premium exceeded expected losses was less than the cost of risk bearing, then the net benefit would be the difference between the cost of risk bearing and the cost of the policy.

Flood insurance is being seriously considered in the U.S.A. "Recent proposals for a national scheme of floodplain insurance are apparently being taken seriously by Congress," (Whipple 1968, p.68).

In fairness to the Manawatu Catchment Board, it must be pointed out that developments in this field have occurred mainly since construction of the flood scheme, although the issue was the subject of scholarly discussion by 1953 (Langbein 1953). The virtual certainty of loss and its catastrophic nature were considered to be formidable obstacles. It is suggested, however, that some investigation of the feasibility of such a scheme was possibly warranted.

Floodplain Regulations

Floodplain Regulations, which were first suggested in 1960 by Vogel, cover a wide range of codes, ordinances and regulations designed to control land use and construction within the floodplain. Floodplain regulations or zoning can be a major factor in flood damage reduction, by ensuring floodplains are used for purposes not subject to flood damage and by maintaining the necessary floodway capacity so that flood flows are not obstructed.

The formation of floodplain regulations involves the selection of the type and degree of control to be exercised. This varies with the hazard and the need for various uses in the floodplain. The degree of control by floodplain zoning should be based on a definition of alternatives and the selection of the one that maximises the excess of benefits over costs.

Floodplain zoning in excluding some activities that could have profitably located in the floodplain suggests that where the attitude towards risk differs between the individual and society, and where society is forced to accept some responsibility for catastrophic losses, then society is justified in imposing its preference for risk bearing on the individual.

Floodplain regulations do not mean that floodplains cannot be used advantageously even though it has been stated that floodplain zoning consists of a loss to the community of being unable to use land in the productive manner in which it could otherwise be used (James 1970). Floodplain zoning, because it is uniform in cost value per acre and independent of design flood depth, is advantageous for deeper and rarer floods. The management of floodplains through floodplain regulations has increased as the importance of environmental control measures has been recognised, but deserves more attention for economic reasons. Such regulations could have been introduced in the Manawatu after the scheme to reduce damage potential.

Emergency Action

Emergency action in time of flooding consists primarily of flood warning and evacuation services. In order that property and stock can be removed from the threat of floodwaters a reliable warning system giving sufficient warning of an impending flood, and a system for disseminating the information, as well as public and private plans for action, and equipment and personnel to do the job are required. Three different estimates of the savings that can be made if a reliable warning system is provided have been outlined by White (1964, p.68). These three estimates suggest a saving in flood damage of five to ten per cent can be obtained. These estimates are those by:

1. White and Morill (1935) who used Weather Bureau date and field surveys and concluded a five per cent saving could be made.
2. The Corps of Engineers who also estimate a saving of five per cent if adequate warning is provided and
3. The Weather Bureau who used their own weather data plus mail posted questionnaires and estimated a ten per cent saving if warning services were provided.

D. Manawatu Catchment Board Evaluation Process

An examination of a proposed scheme should theoretically involve an assessment of the various alternative adjustments and the selection of the one or combination that perform most favourably in terms of stated objectives. The evaluation process ideally involves a consideration of economic, social and environmental implications.

The Manawatu Catchment Board's evaluation process did not include consideration of alternative adjustments, or the possibility of different levels of flood protection other than that provided in the scheme. The only evaluation criteria referred to were economic. Social and environmental factors were not evaluated. These criticisms are both valid and very real (they were arrived at after discussions with Evans, the chief engineer in charge of the scheme). It is apparent that the Catchment Board's evaluation process was very limited in its considerations.

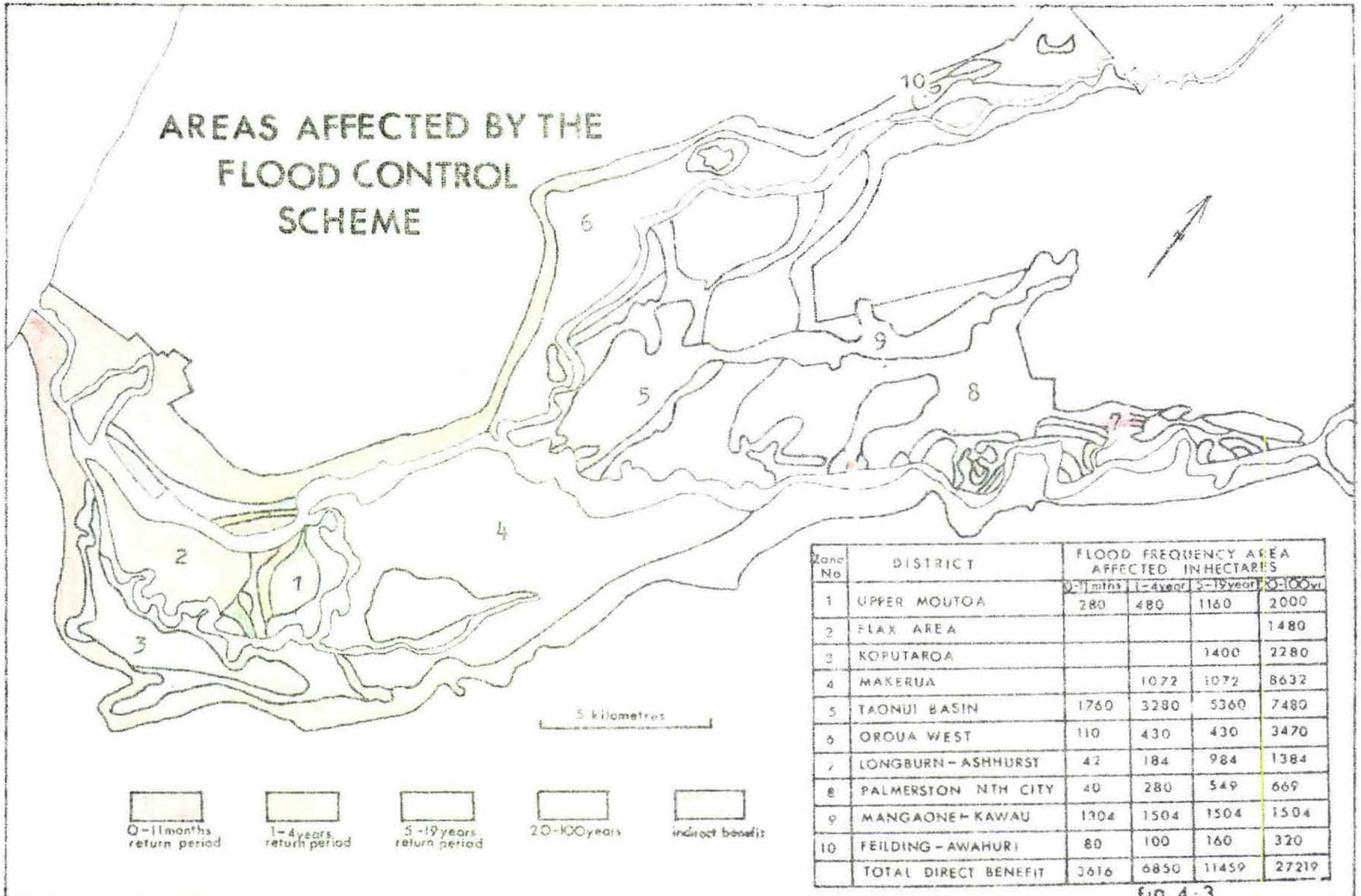
An economic evaluation of the scheme was demanded by the 1941 Soil Conservation and Rivers Control Act. Before a flood protection scheme can begin, a Catchment Board has to provide an Economic Report to the Soil Conservation and Rivers Control Council showing that the anticipated economic benefits of a flood scheme exceed the anticipated economic costs. The details of the Economic Report presented by the Manawatu Catchment Board and the implications of various elements in the evaluation process are outlined below.

The Economic Report Submitted to the Council

For the purposes of analysis, the region the Catchment Board considered to be affected by the scheme was divided into the flood frequency areas and zones shown in Figure 4.3.

In all it was estimated that 71,475 acres (176,686 hectares) of rural land would directly benefit from the flood protection scheme, and 43,860 acres (108,422 hectares) would indirectly benefit. A further 1,672 acres (4,133 hectares) of

AREAS AFFECTED BY THE FLOOD CONTROL SCHEME



Zone No	DISTRICT	FLOOD FREQUENCY AREA AFFECTED IN HECTARES			
		0-11 mths	1-4year	5-19year	20-100yr
1	UPPER MOUTOA	280	480	1160	2000
2	FLAX AREA				1480
3	KOPUTAROA			1400	2280
4	MAKERUA		1072	1072	8632
5	TAONUI BASIN	1760	3280	5360	7480
6	OROUA WEST	110	430	430	3470
7	LONGBURN - ASHHURST	42	184	984	1384
8	PALMERSTON NTH CITY	40	280	549	669
9	MANGAONE - KAWAU	1304	1504	1504	1504
10	FEILDING - AWAHURI	80	100	160	320
	TOTAL DIRECT BENEFIT	3616	6850	11459	27219

fig 4·3

Palmerston North stood to benefit from the scheme. In all it was considered some 127,007 acres (308,229 hectares) would benefit either directly or indirectly from the prevention of floods up to a 100 year Return Period.

The Capital Value of this land was calculated as shown below (the year on which land values were based was not given):

Urban (actual prices)	
Palmerston North City	£14,881,555
Feilding Borough	£ 2,307,810
Foxton Borough	£ 673,106
Shannon Borough	£ 258,890
	£18,121,361
Rural (estimated prices)	
Direct benefit	£ 3,379,285
Indirect benefit	£ 1,500,000
	£ 4,879,285
Total £23,000,646	

The actual Economic Report submitted to the Council was divided into three main sections covering:

1. Estimated flood damage.
2. Estimated increase in market value of the land.
3. Estimated increase in the production with improved land use.

1. Estimated Flood Damage

The estimated flood damage from all causes shown in Table IX was compiled from information obtained from landowners,

TABLE IX - SUMMARY OF ESTIMATED FLOOD DAMAGES (in £'s)

		Damage within Flood Frequency Areas			
		0-11 Months	1-4 Years	5-19 Years	20-100 Years
1	Moutoa	190	314	635	12,035
2	Flax area				
3	Koputaroa		41,623	1,522	4,402
4	Makerua			41,623	477,955
5	Taonui	1,535	3,690	6,807	61,342
6	Oroua West	100	1,067	1,067	30,562
7	Longburn Ashhurst	67	683	3,374	12,359
8	Palmerston North City			21,500	235,000
9	Mangaone Kawaua	530	630	1,185	2,302
	Palmerston North City				19,000
10	Feilding Awahuri	144	417	1,579	6,525
	Stopbanks	1,000	3,000	5,000	10,000
	Drains	100	200	500	10,000
	Highways and Roads	660	1,100	1,600	4,760
	New Zealand Railways	300	700	1,400	2,000
	Totals	4,626	53,433	87,801	888,242

Estimated Flood Damage over 100 year period

Flood Frequency Area					
0 - 11 Months	£4,626	x	80	=	£ 370,080
1 - 4 Years	£53,433	x	15	=	£ 801,495
5 - 19 Years	£87,801	x	4	=	£ 351,204
20 - 100 Years	£888,242	x	1	=	£ 888,242
	Grand Total				£2,411,021

Source: Manawatu Catchment Board Records

Dairy Factories, Produce Merchants, Newspaper files, Local Bodies and data collected by the Manawatu Catchment Board between 1950 and 1956.

Wherever possible actual figures of losses were used. Where this was not possible estimates were made. In the case of loss of revenue from butterfat production, where figures for all areas were not available, actual known losses were used to strike an average loss per cow over comparable areas. Revenue losses were based on the estimated increase in value over the 1942 figures. (The Report was filed in 1950.) The values used by the Catchment Board in estimating flood losses were as follows:

Butterfat yield	- Average 250 to 275 lbs per cow
Butterfat	- 18 pence per lb.
Dairy cows	- £10 per cow.
Sheep	- Average £1 per head.
Beef cattle	- £10 per head.
Grazing out cattle	- One shilling per head per week.
Grazing out sheep	- Three pence per head per week.
Repair fences	- Minor floods 18 pence per chain.
	- 100 year floods £1 per chain.
Pasture damage	- £3 to £5 per acre.
Crop damage	- £5 per care.
Onions	- £200 per acre.
Potatoes	- £70 per acre.
Market garden	- £150 to £200 per acre.
Hay losses and purchased	- £5 per ton

Buildings	- Depreciation, loss of personal effects etc. £100 per dwelling.
Plant and Implements	- Depreciation and reconditioning $33\frac{1}{3}$ per cent.

Estimated losses under stopbanks were based on the actual cost in 1949 of moving back and repairing stopbanks, necessitated by the erosion of the land on which the stopbanks were built. The annual value placed on this was $1,000 for the 0 - 11 month flood frequency area, £3,000 for the 1 - 4 year flood frequency area, £5,000 for the 5 - 19 year flood frequency area and £10,000 for the 20 - 100 year flood frequency area.

The damage to drains was based on the estimated cost of removing silt, rubbish, etc. and restoring the drains to good conditions after the flood. This was valued at an annual value of £100 for the 0 - 11 months flood frequency area, £200 for the 1 - 4 year flood frequency area, £500 for the 5 - 19 year flood frequency area and £10,000 for the 20 - 100 year flood frequency area.

It was estimated that in 100 years, 2,200 miles of highways and roads would be flooded to a greater or lesser degree depending on the magnitude of the flood. On metalled roads, damage would be from deposition of driftwood and silt and the loss of small sections by scour. On sealed highways, silt and driftwood would be deposited, shoulders scoured, culverts washed out and water tables silted up. In addition, some bridges would be washed out in larger floods. The following damages were estimated: 0 - 11 months flood frequency areas, £660; 1 - 4 year flood frequency areas, £1,100;

5 - 20 year flood frequency areas, £1,600; 20 - 100 year flood frequency areas, £4,760.

Estimates of the damage to Railways was based on the cost of repairing lines damaged in the 1947 and 1948 floods. They did not include extra operational costs, or indirect losses due to loss of traffic, hold up of wagons or the losses incurred by the travelling public. Damage was put at £300 for the 0 - 11 months flood frequency area, £700 for the 1 - 4 year flood frequency area, £1,400 for the 5 - 19 year flood frequency area, and £2,000 for the 20 - 100 year flood frequency area.

Damages to Palmerston North City included the area affected by the Manawatu River and the Mangaone and Kawau Streams. The figures for damages to city services were estimates only. They included repairs to sewers, the stormwater system, telephones, electricity and water supply, streets and removal of debris etc. The damages were placed at £530 for the 0 - 11 month flood frequency area, £630 for the 1 - 4 year flood frequency area, £22,685 for the 5 - 19 year flood frequency area and £256,302 for the 20 - 100 year flood frequency area.

A summary of the estimated distribution of flood damage is presented in tabular form in Table IX.

2. Estimated Increase in Market Value of Land

As a result of flood protection, the Catchment Board believed land values would automatically increase as a result of a change to higher intensity use, and resultant greater productivity. It was estimated that land in the area that was prone to direct flood damage would increase in value by £1,095,000 while land in the area of indirect benefit would increase in value by £12,500. The distribution of these increases over the various areas directly affected by the scheme is shown in more detail in Table X.

In addition to the estimated enhanced land value was an estimated 22,250 acres on the banks of the Manawatu River and 6,250 acres on the banks of the Oroua River that would be prevented from eroding. The following values were placed on the enhanced value of these sections:

Erosion

Manawatu River		
7,500 acres @ £10 an acre	=	£ 75,000
7,500 acres @ £5 an acre	=	£ 37,500
7,250 acres @ £2.10s. an acre	=	£ 18,125
22,250 acres		£130,625
Oroua River		
3,000 acres @ £5 an acre	=	£ 15,000
3,250 acres @ £2.10s. an acre	=	£ 8,125
6,250 acres		£ 23,125

Total: 28,500 acres = £153,750

In all then it was estimated that the total increase in land value would be £1,261,250.

TABLE X - ESTIMATED INCREASE IN LAND VALUES

Year	(1) Moutoa	(2) Flax Area	(3) Koputaroa	(4) Makerua	(5) Taonui
1 year	700 acres @ £38 = £26,600	3,700 acres @ £35 = £129,500	-	-	4,400 acres @ £33 = £145,000 Still liable to 20 year flooding
5 year	500 acres @ £35 = £17,500	-	-	2,680 acres @ £20 = £53,600	3,800 acres @ £20 = £76,000
20 year	1,700 acres @ £15 = £25,500	-	3,500 acres @ £10 = £35,000	-	5,200 acres @ £10 = £52,000
100 year	2,100 acres @ £5 = £10,500	-	2,200 acres @ £2.10.0. = £5,500	18,900 acres 6,900 @ £15 = £103,500 6,000 @ £10 = £60,000 6,000 @ £5 = £30,000	
Totals	£80,100	£129,500	£40,500	£247,100	£286,450

(6) Oroua West	(7) Longburn Ashhurst	(8) Palmerston North City	(9) Mangaone Kawau	(10) Feilding Awahuri	Totals
275 acres @ £20 = £5,500	105 acres @ £30 = £3,150	-	3,260 acres @ £10 = £32,600 Palmerston North City 100 acres @ £50 = £5,000	150 acres @ £10 = £1,500 (50 acres in Bush)	£349,050
800 acres @ £10 = £8,000	355 acres @ £20 = £7,100	-	1,100 acres 500 @ £10 = £5,000 Palmerston North City 1,200 building sections @ £35 = £42,000 200 acres @ £50 = £10,000	50 acres @ £10 = £500 Feilding Borough = £2,000	£221,700
-	2,000 acres @ £15 = £30,000	670 acres 2,680 sections @ £40 say = £100,000	-	150 acres @ £7 = £1,050 Feilding Borough = £3,500	£247,050
7,600 acres 3,000 @ £5 = £15,000 4,600 @ £ £2.10.0. = £11,500	1,000 acres @ £5 = £5,000	300 acres @ £50 = £15,000	-	500 acres @ £2.10.0. = £1,250 Feilding Borough = £7,200	£277,700
£40,000	£45,250	£115,000	£94,600	£17,000	£1,095,500

Source: Manawatu Catchment Board Records

3. Estimated Increase in Production with Improved Land Use

The estimated increase in production following the flood scheme was calculated by the Catchment Board. Their estimates are presents in the Tables XI and XII. The increased production would not be immediate and the Catchment Board calculated that it would be a minimum of 20 years before maximum production was attained. Table XI shows the estimated graduated increase in production:

TABLE XI - ESTIMATED INCREASE IN PRODUCTION REVENUE

1st year	Nil	11th year	£150,000	
2nd year	£ 2,000	12th year	160,000	
3rd year	5,000	13th year	170,000	
4th year	15,000	14th year	180,000	
5th year	40,000	15th year	200,000	
			£1,422,000	works completed
6th year	60,000	16th year	210,000	
7th year	80,000	17th year	215,000	
8th year	100,000	18th year	220,000	
9th year	120,000	19th year	225,000	
10th year	140,000	20th year	230,000	maximum
			£2,522,000	

100 year increase in revenue £18,400,000

Source: Manawatu Catchment Board Records

4. Estimated Costs of the Scheme

The estimated capital cost of the scheme as presented in Table XIII amounted to a total of £1,130,000. These estimates were suitable for presentation to The Soil Conservation and Rivers Control Council and Treasury for their decision as to a government loan subsidy basis.

TABLE XII - ESTIMATED INCREASE IN PRODUCTION WITH CHANGE OF LAND USE

Years	(1) Moutoa	(2) Flax Area	(3) Koputaroa	(4) Makerua	(5) Taonui
1 year	700 acres 200 cows @ 275 lbs butterfat = £4,125 50 acres potatoes @ £70 = £3,500	Maximum Production will be maintained	-	-	1,467 cows @ 250 lbs butterfat = £27,506 Sheep 4,000 @ £1 = £4,000
5 years	5,000 acres 140 cows @ 275 lbs butterfat = £2,887 100 acres potatoes @ £70 = £7,000	Maximum Production will be maintained	-	2,680 acres 50 acres onions @ £200 = £10,000 100 acres potatoes @ £70 = £7,000 900 cows @ 30 lbs butterfat = £2,025 Sheep 250 @ £1 = £250 Cattle 50 @ £3 = £150	1,100 cows @ 25 lbs butterfat = £2,062 Sheep 10,000 @ £1 = £10,000 200 acres potatoes @ £70 = £14,000
20 years	1,700 acres 400 cows @ 275 lbs butterfat = £8,250 100 acres potatoes @ £70 = £7,000	Maximum Production will be maintained	3,500 acres On 1,000 acres 100 cows @ 275 lbs butterfat = £2,062 On 2,500 acres 2 ewes per acre @ £1 = £5,000	-	2,300 cows @ 275 lbs butterfat = £47,437
100 years	2,100 acres 105 cows @ 275 lbs butterfat = £2,165	Maximum Production will be maintained	50 cows @ 275 lbs butterfat = £1,030	100 acres onions @ £200 = £20,000 200 acres potatoes @ £70 = £14,000	100 cows @ 275 lbs butterfat = £2,062
Totals	£34,927	-	£8,092	£53,425	£107,067

(6) Oroua West	(7) Longburn Ashhurst	(8) Palmerston North City	(9) Mangaone Kawau	(10) Feilding	Totals
Increase butterfat 90 cows @ 30 lbs = £200	50 cows @ 30 lbs = £135	-	1,100 cows @ 20 lbs butter-fat = £1,500 Increase 25 cows @ 275 lbs butterfat = £515 1,500 sheep @ £1 = £1,500	100 cows @ 10 lbs butterfat = £75 Market Garden £100	£43,156
620 cows @ 15 lbs butterfat = £697	250 cows @ 30 lbs butterfat = £562	-	-	120 cows @ 15 lbs butterfat = £135 Market Garden £200 Increase 5 acres Market Garden @ £200 = £1,000	£37,968
-	1,000 cows @ 10 lbs butterfat = £750 100 acres potatoes @ £70 = £7,000	-	-	120 cows @ 10 lbs butterfat = £90 10 acres potatoes @ £70 = £700	£78,289
Increase cows 700 cows @ 275 lbs butterfat = £14,437 less sheep 4,000 £10,437	Increase cows 50 cows @ 275 lbs butterfat = £1,030	-	-	-	£50,724
£11,334	£9,477	-	£3,515	£2,300	£230,137

The original Economic Report made no mention of (a) the estimated expenditure of landowners to give the increased production of £230,000 as set out in the Economic Report; and (b) the cost of annual maintenance of levee's berms, etc.

The Soil Conservation and Rivers Control Council requested information on these two details before making final judgement on the economic merits of the proposed scheme. The Cathment Board estimated an increased cost to the landowners in the area amounting to £535,000, and noted that the estimating of maintenance costs was difficult but calculated them to be around £30,000 a year. The composition of the maintenance costs was as follows:

1. Berms to be kept clear of weeds and debris. This was to be done in the lower area by suitable grazing and it was thought that it should not be a charge on the ratepayers, as it would be self supporting.
2. Willows, Poplars and other trees to be layered and kept in order.
3. Growth and snags removed from all channels.
4. Stopbanks maintained.
5. Bank protection work maintained.
6. Small tributaries dredged and weeds etc. removed.
7. Structures kept in good order.

The estimated cost of this was as follows:

Labour - 20 men @ £600	£12,000
Vehicles - Light and heavy	5,000
Bulldozers and heavy plant	10,000
Materials	3,000
	£30,000

5. Summary of Estimated Costs and Benefits

In all it was estimated that some 127,007 acres (308,229 hectares) with an estimated Capital Value of £23,000,646 would benefit either directly or indirectly from the flood scheme. The estimated savings from preventing flood damages over a 100 year period were £2,411,021, while it was considered land values would increase by £1,201,750 and production revenue would increase by £18,000,000 over the 100 year period because of the scheme. Against this estimated overall benefit of £22,072,771 for the 100 year period was an estimated capital outlay of £1,130,000 plus an annual maintenance cost of £30,000 a year (£3,000,000 over 100 years) and £535,000 required by farmers to enable them to take full advantage of the scheme.

TABLE XIII - ESTIMATED CAPITAL COST OF SCHEME

	Acquisition of Land and Compensation		
1.	Land in floodway as detailed in Appendix 'D'	£124,000	
2.	Land compensation in other areas	5,000	
3.	Loan liabilities of local authorities to be taken over	58,500	£187,500
	Clearing		
4.	Clearing of berms	4,000	
5.	Clearing obstructions from channels in Manawatu and Oroua Rivers	3,500	

TABLE XIII - continued

6.	Clearing Willows from the Oroua - 15M to 24M	£ 6,000	£ 13,500
	Earthwork		
7.	Stopbanks from Sea to Foxton	5,000	
8.	Stopbanks and guide banks Moutoa area	101,000	
9.	Stopbanks - Buckley area and lower Makerua	23,000	
10.	Stopbanks - Kara Stream	3,000	
11.	Stopbanks - Makerua area - less material from Item 13	38,000	
12.	Stopbanks - Himatangi area	2,500	
13.	Levelling berms in Opui Bends area	24,000	
14.	Stopbanks - Taonui area - less material from Item 13	17,000	
15.	Stopbanks - Palmerston North area	4,000	
16.	Stopbanks - above Palmerston North area	10,000	
17.	Stopbanks - Oroua River	50,000	
18.	Removing of stopbanks not re-used	1,000	278,500
	Grassing		
19.	Re-grassing of stopbanks, berms etc.	11,500	11,500
	Structures		
20.	Sluice Gate at Wall's Spillway	200,000	
21.	Burke's Drain Floodgate	10,000	
22.	Alterations to bridges, small sluice gates and other small items	10,000	220,000
	Bank Protection		
23.	Heavy Protection - Rock work	104,000	
24.	Medium Protection - Rock and Willow	24,000	
25.	Light Protection - Willows and tree groynes	40,000	168,000
	Planting and Fencing		
26.	Planting willows and poplars	2,000	
27.	Planting trees for future bank protection	1,500	
28.	Fencing of plantations and Board's land	9,000	12,500

TABLE XIII- continued

	Cut-Offs		
29.	McCool's Cut	500	
30.	Cut-off at 26M	13,000	
31.	Cut-offs on Oroua River	6,000	19,500
	Miscellaneous		
32.	Improvements to Stoney Creek	500	
33.	Improvements to Mangaone Stream and Whiskey Creek	70,000	
34.	Improvements to Makino Stream	15,000	85,500
		TOTAL	£996,500
	Contingencies 10%		100,000
		TOTAL	£1,096,500
	Engineering Supervision		33,500
		GRAND TOTAL	£1,130,000

E. Comments on the Catchment Board Evaluation Process

Comments on the Catchment Board's estimation of costs and benefits of the scheme may be directed in two major areas:

1. Content, benefits and costs included or not included.
2. Method of computing costs and benefits.

The calculation of costs and benefits as shown in the Economic Report followed the traditional guidelines for the economic evaluation of a flood control project. To some extent there may be considered deficiencies in terms of over simplification and omission. Economic efficiency as a means of evaluation necessitates the comparison of the cost of inputs and the value of benefits generated. Input costs can be estimated reasonably accurately from known physical quantities and unit prices, but benefits have to be estimated on the basis of factors which are neither entirely predictable nor completely under human control.

Input costs consist of capital costs and maintenance costs, and associated costs necessary to realise the full potential of a scheme. These were covered in the Economic Report (although maintenance costs and on-farm costs had to be requested by the Council). Although the construction costs were to be spread over a fifteen year period, no allowance was made for increased prices and wages or inflation in the cost of the scheme. In a similar manner, there was no allowance for such increases in the estimates of maintenance costs. The initial cost estimates also ignored the traditional contingency factor of ten to fifteen percent of the construction cost which is usually added to cover discrepancies between the estimated and actual quantities involved, omission of work, unforeseen construction difficulties, changes in plans and other uncertainties.

A major omission in the original costing was that of associated development costs that would be required to realise the project objectives and benefits. These included:

1. Increased on-farm costs such as fencing, buildings, regrassing, tile or mole drainage, purchasing of additional stock and increased fertilizer costs, etc.

2. The increased expenditure by Drainage Boards needed to improve drainage facilities (drains, pumps and staff wages).

The way in which the benefits of the scheme were calculated is also open to critical review. The benefits of a flood protection scheme can best be described as the estimated improvements and increased production attributable to the project. This is measured by the difference in conditions and circumstances which would exist with and without the project. Benefits are not derived from a comparison of before and after conditions as calculated by the Manawatu Catchment Board, but the emphasis is on the two sets of estimated future conditions, that is, the future with flood protection and without flood protection. The increase in net gain with the project, over that without, is the measure of the net benefit of the project.

In urban areas, the difference between probable damage without flood protection and the reduced damage with protection, plus the increased market value of land and production attributable to the flood scheme, determines the flood control benefits. In rural areas reduced damages to crops, livestock, buildings, etc. and the increased production and real estate value attributable to the scheme, measure the benefits of the scheme.

In addition to the direct benefits, there are indirect benefits such as the reduction in loss of life and the enhancement of the general welfare and security of the people. These social factors were not considered by the Catchment Board, yet they are of major importance to the occupants of the area affected by a flood control scheme. Associated with such social costs are environmental costs. There was no consideration of the environmental impacts of the Lower Manawatu Flood Control Scheme in the Catchment Board's evaluation of the scheme yet such impacts have important implications not only for the subsequent environment, and associated social conditions, but also for the economic success or otherwise of the scheme. These environmental considerations are discussed in more detail in Chapter 6.

The Catchment Board's method of estimating losses was based on an extrapolation of reported losses drawn from a number of different sources. These losses can only be as reliable and comprehensive as the reporters who could have omitted some factors and double counted others. It is also possible that the criteria used by the different sources or reporters were not necessarily strictly comparable and that this was not recognised by the Catchment Board. Perhaps the most serious limitation on the estimation of losses (apart from the area of discussion which exists over the interpretation of the hydrologic records), is the fact that flood damages are a function of the depth and duration of inundation, the velocity and frequency of flood waves and amount of silt deposited, as well as the structural composition of buildings affected by the flooding. The Catchment Board had virtually no data on any of these flood characteristics on which they could accurately estimate flood damages.

Costs and benefits in the Catchment Board's evaluation are expressed in monetary terms. Many of these benefits or costs will however occur in the future. It is therefore necessary to estimate these factors as they occur during the total "economic life" of a project. (The economic life of the Lower Manawatu

Flood Control Scheme was never stated.) Consideration must be made of society's preference for present over future benefits and an adjustment (social discount rate) made to compensate for this valuation. A discounting technique such as the Social Time Preference Rate or Opportunity Cost Rate should have been applied and all future benefits and costs referred to in "net present value" terms or as discounted cash flows.

Accepting that a discount rate must be applied, there remains the fundamental problem of the choice of an appropriate rate. Disregarding the debate between the various techniques, there remains the situation that the discount rate chosen should be at least the minimum attractive rate of return on long term government investment. In New Zealand, the Treasury recommends an interest rate of ten percent. The Catchment Board made no acknowledgement of the need to apply such a discount rate. This could affect the profitability of the project to a considerable extent.

A flood control scheme involving structural measures, such as in the Lower Manawatu Flood Control Scheme, automatically and incidently provides flood loss reduction services to all floodplain occupants, if they are to provide a service to any individual or subset of occupants. As such, protection afforded is not subject to the "exclusion principle" of economics, which states that anyone unwilling or unable to pay the price or fee for a commodity or service can be excluded from the consumption or enjoyment of the same. Consequently, such a flood protection scheme must take on the attribute of a public good. The situation thereby arises where the cost of a project is borne by society at large, but a small number of individuals may receive the bulk of the benefits of the scheme.

Conventional economic evaluations, such as adopted by the Catchment Board, are only concerned with those costs and revenues which directly affect profitability. It is suggested, however, that, in the light of the above discussion, the desirability or otherwise of a project should be judged from a social or community viewpoint. This would involve consideration of all costs and benefits resulting from a project including social and environmental costs and benefits as well as purely economic costs and benefits.

The diversion of resources into flood protection would seem to suggest that a social evaluation of the economic merit of a scheme would be beneficial and that it should be as comprehensive as possible. Economic theory provides the rationale for the identification of utility with willingness to pay and the expression of the later quantity in many cases, as the market valuation. Where goods or items are non-priced, there is a methodology available for the derivation of surrogate values, and the including of external costs and intangibles in such an evaluation. Society's valuation of the advantages and disadvantages of a particular scheme in monetary terms may then be used as a statement of the implications of an action in terms of net social welfare. This provides the decision maker with a useful guide in the complex planning process. The choice of adjustment (or degree of control) could then be based on the use of a benefit-cost approach with the selection of that ratio which maximises the excess of benefits over costs. In doing this, the benefits can be measured as the net income for the uses planned for each degree of control and costs as the increase in investment and operating expenses (plus maintenance cost increases), and the estimate of flood damages. The degree of protection given should then be based on the incremental cost of the last unit of protection as compared with the incremental benefits, after allowing for project-induced losses. One is thus seeking the point where the total cost is at a minimum or the incremental cost of additional protection measures just equals the incremental damage reduction.

The use of such a benefit cost approach is justified "where it is important to take a long view, (in the sense of looking at repercussions in the further, as well as the nearer, future) and a wide view (in the sense of allowing for side effects of many kinds, on many persons, industries, regions, etc.), that is, it implies the enumeration and evaluation of all the relevant costs and benefits". (Prest and Turvey, 1965)

CHAPTER 5

THE LOWER MANAWATU FLOOD CONTROL SCHEME DESIGN

The actual flood control scheme had three major aims:

(a) To prevent flooding of as much land as possible.

(b) To stabilise the river in a permanent channel.

(c) To reduce maintenance to a minimum.

The following additional factors were also considered.

(a) The "regime" condition of the river should be maintained as far as possible.

(b) Stopbank levels should be kept as low as possible.

(c) Disturbance of existing farming and settlement should be avoided as far as possible.

(d) Cost must be kept in mind throughout. (Evans 1964, p 412).

The scheme consisted of stopbanking the Manawatu River from the sea to the Gorge, except in a few places, where the area flooded was not sufficient to warrant it. The Oroua River was also stopbanked for 29 km from its junction with the Manawatu River, giving a capacity designed to carry a maximum of 25,000 cusecs, when the Manawatu River was not in full flood. Other tributaries to be stopbanked were the Tokomaru, (designed to carry 5,000 cusecs when the Manawatu River was at a level of 7.6 metres at Shannon Bridge), and the Mangaone which was designed so as to give complete protection on the Palmerston North side and a 25 year protection on the South West side. The Kawau Stream was also stopbanked.

The stopbanks on the Manawatu River, which involved the major work, was designed to give:

(a) One metre freeboard along the portion which could flood Palmerston North, with a flow at 150,000 cusecs.

(b) A freeboard of 0.75 metres along the portion upstream of the area from Palmerston North to the Gorge, except for an area 0.25 metres lower, leading to a ponding area described below.

(c) A 0.75 metre freeboard for the remaining portion from Palmerston North to the Sea, when the flow was at 150,000 cusecs.

A significant feature of the scheme was the provision of emergency spillways and ponding areas designed so as to keep the flow within the stopbanks. Spillways were provided on both the Manawatu and Oroua Rivers. On the Oroua River spillways were provided 5 km above the junction with the Manawatu River and were designed to come into effect if the flow in the Oroua exceeded 25,000 cusecs. The other spillway located near the start of the stopbanks was designed to come into operation if the combined flows in the Manawatu and Oroua Rivers exceeded 150,000 cusecs. These spillways were designed so as to discharge flows into ponding areas in the lowest part of the Taonui Basin by a direct restricted channel. The storage here would take 19½ hours to fill up to the 10.5 metre level and the likelihood of a flow requiring a storage greater than this was considered by the Catchment Board to be extremely remote. (Evans 1964). The other area of spillways was located immediately above Palmerston North and were designed to come into effect when the flow in the Manawatu River reached 165,000 cusecs. This ponding area was capable of holding the excess flow that would occur in a maximum flood, and even after it filled a flow of 185,000 cusecs (500 year Return Period) should pass Palmerston North with between 0.2 and 0.3 metres of freeboard.

Advantage was taken of the Whirokino Cut which was made in 1942 and shortened the river course by 9 km enabling the River from Whirokino to the Sea to carry 150,000 cusecs. It was proposed for 35,000 cusecs to flow through the old loop past Foxton and the rest along the Whirikino Cut. The loop area however, has since silted up and the only water in the old loop today is tidal. The River from the upper end of the Moutoa or Walls spillway to Whirikino was able to carry only 65,000 cusecs before the scheme. To enable a flow of 150,000 cusecs to be carried a floodway across from Walls spillway to Whirikino was built. This floodway was about 10 kilometres long and bounded on each side by stopbanks 5 metres high. A set of sluice gates were constructed at Walls spillway to control the flow of water through the channel. In time of flood, the flow in the original river channel was to be restricted to 45,000 cusecs and the rest of the flow was to be diverted through the floodway. No water would be passed through the floodway until the flow reached 45,000 cusecs so it would be possible to use this land for grazing, and so recoup some of the expenditure, involved in the construction costs.

There are at least 70 culverts under the stopbanks, and a number of existing sluice gates were modified for the new bank heights. There were also two weirs built in the Opiki area. The culverts vary from 2 to 3 metres in diameter and have sluice gates that shut automatically when the river rises.

A number of factors considered in the design were;

1. It was believed that it would be advisable to keep bank levels as low as possible because of the danger to floodplain occupants, if the banks were overtopped. The height of stopbanks were determined from calculated levels for a flow of 150,000 cusecs. The calculation of flows in the area from the sea to the Oroua River mouth were based on cross-sections taken at 0.4 kilometre intervals. For the remainder of the Manawatu River, a trial and error basis was used to determine the average cross sectional properties, and an average gradient was then used to estimate the flow when full flood conditions existed.

2. The Soil Mechanics Branch of the Department of Scientific and Industrial Research tested soil available for stopbank construction, so that dimensions could be designed to give a minimum cost. A top width of 0.7 metres and side slopes of 1 in 20 with a slope angle of 1 in 4 on the land side where stopbank height exceeded 12.5 metres were used. These dimensions were greater than those used in the district in previous years, but it was considered such high banks needed to be conservatively designed

and a reasonable factor of safety should be included.

3. The location of stopbanks were so placed as to allow sufficient berm width to take maximum flood, without raising the flood level to an undue height. The banks were only located after levels were taken and a detailed survey carried out. The spacing of the stopbanks basically followed the findings of Grant who analysed the effects of varying distances between stopbanks and their height on the amount of land flooded, and the cost of construction. Grant concluded that a distance of 0.6 kilometres between banks to be the most economic. This would give a depth of 2 to 3 metres in lower reaches, and it was thought that the effect on channel velocities would be small and the river should adjust to the new conditions without too much deepening and widening.

4. Cutoffs were kept to a minimum because bank erosion was already a serious problem. They were used only where it was possible to eliminate one or more severe bends which would be difficult to maintain, as cutoffs shorten the course of the river and result in increased velocities and greater bank erosion.

5. The Moutoa floodway was designed to carry floodwaters between its stopbanks. This land was to be kept grassed but short to allow for maximum flow with the minimum damage and silting up. The floodway was to be kept to a width of 610 metres as far as possible. The floodway commenced about Hamiltons Line and continued along the general line of the river to Walls spillway, where it left the river and rejoined it at Whirikino.

6. With extensive use of stopbanks, it was essential that the river be stabilised in as permanent a course as possible. Consequently, bank protection work was very important. All bad bends were protected with rock to prevent erosion. On less severe banks, poplars and willows and other suitable growth was established. From the Gorge to Longburn bridge, velocities are swift, up to 3 metres per second, and large rocks were required for bank protection. Below this point, velocities are much less and therefore such large rock is not required. Rock protection consists of lining the bank with a continuous cover of rock from the bed of the river to berm level. Before placing rock on banks, the bank must be battered to a suitable slope. The exact slope and method of placing rock on the bank was dependent upon local circumstances.

7. It was considered desirable to avoid disruption of existing settlement and farming as far as possible, and consequently scheme followed existing banks where possible with minimum effect on present land use, and only four houses required removal.

CHAPTER 6

THE EFFECT OF THE FLOODPLAIN MANAGERS' HAZARD PERCEPTION ON ADJUSTMENTS ADOPTED

A. INTRODUCTION

The discussion of the Manawatu Catchment Board's decision making process in earlier chapters, revealed that a number of factors considered to be important in the appraisal of a flood scheme were not fully examined. This would appear to be the case in terms of:

1. the absence of any investigation of the floodplain managers' perception of the hazard, and the relationship between this hazard perception and land use and,
2. the absence of any consideration of the potential environmental effects of the scheme.

Whilst the very existence of the Lower Manawatu Flood Control Scheme would negate in part any post hoc evaluation that merely indicated that according to some criterion, or for this or that reason, the scheme should not have been undertaken, an examination of the scheme may elucidate factors of general application for consideration in the formulating of protection projects for other areas.

The focussing of attention on the varying role of perception in the adjustment decision was stimulated by United States research which indicated that different groups perceive the existence or severity of the same hazard event in different ways and that it is the flood plain managers' perception of the flood hazard rather than the technical experts hazard perception that most significantly influences post-scheme land use. The major variation in perception was that between the technical expert and the flood plain manager, but variation in hazard perception among users of the same resource has also been observed (Burton and Kates, 1946). This knowledge when coupled with the observation that post scheme land use changes have not eventuated as predicted by the Catchment Board in their pre-scheme evaluation, suggested that an appraisal and comparison of the floodplain managers' and the Catchment Board's hazard perception could produce significant insights into understanding the nature of responses made by floodplain managers to the flood hazard and to flood protection schemes.

It is considered that the difference in the perception of the flood hazard held by the technical expert and that held by the resource user is the major reason for the difference between post scheme land use changes that have taken place and those the Catchment Board considered would occur. If this premise is correct then it follows that by identifying those factors that influence the farmers perception of the flood hazard and consequent land use, a more accurate estimate of the floodplain managers response to the provision of flood protection measures could be made.

Such claims have important implications for the decision making process in that it is suggested that increased precision in the prediction of post scheme land use changes could result from the inclusion of the resource users hazard perception in the adjustment decision and the identification of the relationship between this perception and land use.

The Catchment Boards' perception of the flood hazard and views on post scheme land use changes have been outlined in earlier chapters. The floodplain managers' perception of the flood hazard has never been sought. Thus what might be considered the most important factor in determining the viability of a protection scheme was omitted from consideration in the decision making process.

It is proposed to examine the rural floodplain managers' perceptions of the flood hazard in the lower Manawatu region as an illustration of the potential importance of this hazard perception to the planning of flood protection schemes.

The discussion of the importance of environmental considerations will follow the perception study. In this way the effect of two major deficiencies in the Catchment Boards decision making process can be illustrated.

B. SAMPLE FRAME DESIGN

The large number of farms in the area affected by the flood control scheme (over 1700 farms) necessitated some form of sampling for study purposes. A ten percent random sample of farms over eight hectares in size was made. The impact of the flood hazard and the flood control scheme were not evenly distributed over the study area. To make allowance for this and to ensure all such areas were included in the sample a stratified random sample was made. Each area was proportionately represented in the sample in order to eliminate between strata variation.

The Choice of Stratification Factors

Greater precision is obtained if a combination of stratification factors are used. The formation of strata can be done subjectively (Moser and Kalton 1971, p 168) as it is not the method of selecting strata, but the random sampling within strata that guarantees against selection bias. In designing the sample frame it was considered necessary to ensure that:

1. the stratification factors were as closely related to the subject as possible, as no gain in precision would be obtained by stratifying factors unrelated to the survey subject.
2. Strata were arranged so they differed as widely as possible from one another, and the population of each strata was as homogenous as possible.

In this study a number of factors could have been used for stratification purposes. These included; flood frequency areas, drainage board areas, scheme rating areas, land use capability areas, land use types, soil types and county boundaries.

Of these alternatives, land use capability areas were rejected because of the non-availability of such data for the region and the skills and amount of time needed for such an analysis were beyond the scope of this study. County boundaries which were used in a previous study (McNeil Adams, 1968) were rejected because it was felt these were political or administrative boundaries that were unrelated to either the flood hazard or to land use. Land use types and soil types were considered but were rejected in favour of F.F.A.'s and D.B.A.'s, as it was believed these two factors reflected the differential flood impact more accurately. F.F.A.'s represented the theoretical liability of flooding in the past and it was considered that post scheme changes would vary differentially by such areas. Drainage Board areas were selected because of the importance of drainage facilities to the improvement of farm output and to the level of development of farm lands, and the fact that different boards displayed varying degrees of competence and activity. The distribution of F.F.A.'s and drainage board areas is shown in fig 6.1.

Method of Drawing the Proportional Stratified Random Sample

The basic observational unit then was the farm with a two factor stratification based on drainage board areas and flood frequency areas. The term 'stratum' as used below is thus a unique combination of a drainage board area and flood frequency area. The boundaries of these stratum were determined from an examination of;

1. A Manawatu Catchment Board map of flood frequency areas showing areas of 0-11 months, 1-4 years, 5-19 years, 20-100 years flood frequency areas, and an area designated as receiving indirect benefits from the scheme. These boundaries are shown in

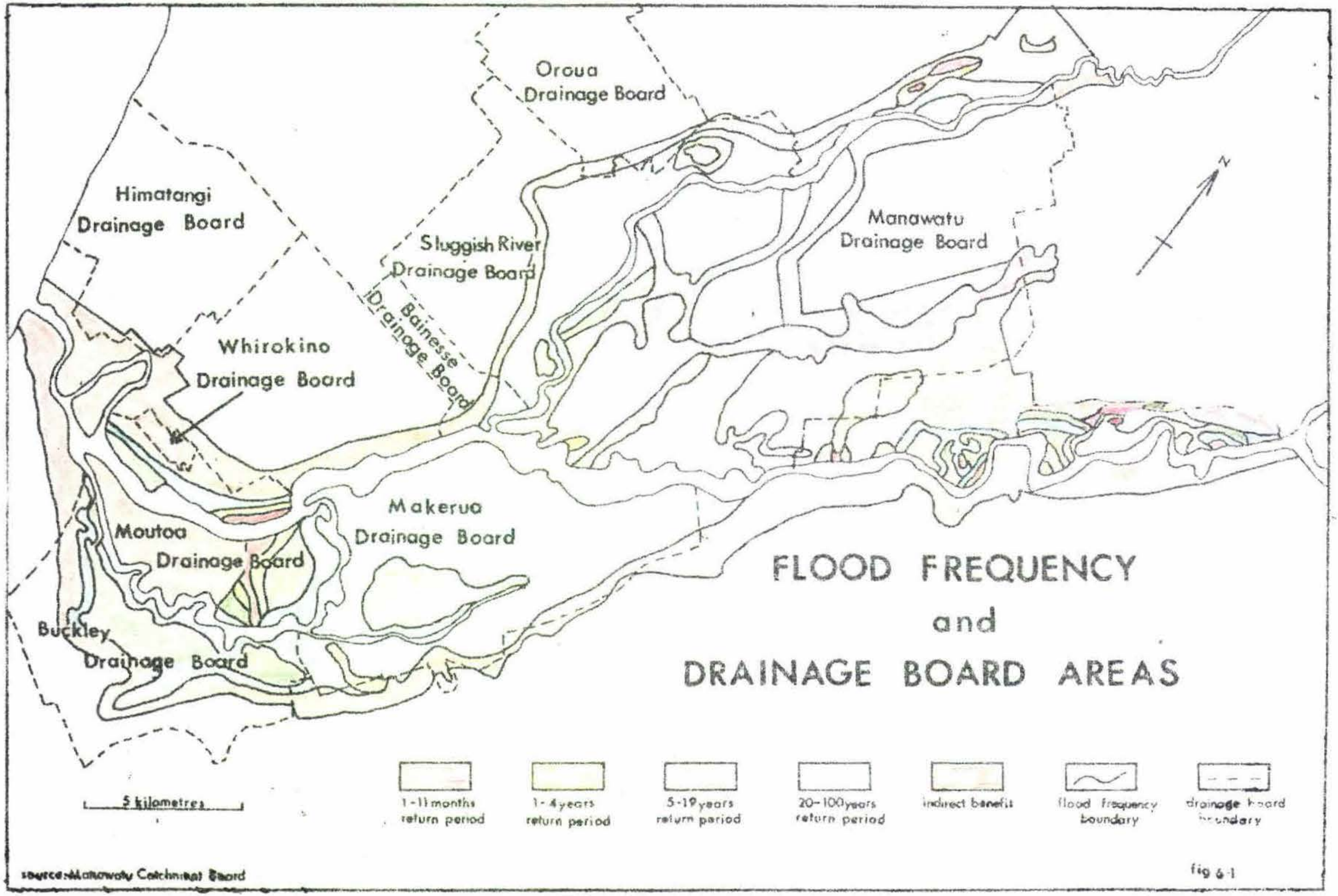

Oroua
Drainage Board
Himatangi
Drainage Board
Sluggish River
Drainage Board
Bainesse
Drainage Board
Manawatu
Drainage Board
Whirokino
Drainage Board
Makerua
Drainage Board
Moutoa
Drainage Board
Buckley
Drainage Board
N
FLOOD FREQUENCY
and
DRAINAGE BOARD AREAS
5 kilometres
1-11 months return period
1-4 years return period
5-19 years return period
20-100 years return period
indirect benefit
flood frequency boundary
drainage board boundary
source: Manawatu Catchment Board

fig 6·1

fig 6.1. Scale one inch to one mile.

2. A Manawatu Catchment Board map showing 'drainage board area' boundaries (fig 6.1). Scale one inch to one mile.

The term drainage board area as used in this text refers to the Himatangi Drainage District, the Sluggish River Drainage District, the Oroua Drainage Board District, the Manawatu Drainage Board District, the Makerua Drainage Board District, the Buckley Drainage District, the Moutoa Drainage Board District, the Whirokino Drainage District and the Bainesse Drainage District.

3. Valuation Department Plans showing the boundaries and location of valuation roll numbers and plot numbers. Scale one inch to twenty chain.

4. A Manawatu Catchment Board list of farms, by valuation roll numbers that were rated for the scheme.

Without the possibility of validation existing it was necessary to accept that all of the above information was accurately recorded by the various governmental departments.

In order to identify which stratum each farm unit lay in, it was necessary to photographically reduce the Valuation Plans from a scale of one inch to twenty chains to one inch to one mile so that an overlay of F.F.A.'s and D.B.A.'s could be made. The resulting overlay is shown in fig 6.1. From this overlay the total area of each stratum was calculated using a planimeter, and the number of farms in each stratum was calculated by visual observation.

Although few farms lay completely within any one flood frequency area, each farm was assigned to that flood frequency area in which the greatest area of each farm lay. Farms were then selected from each stratum using a set of random number tables. A ten percent sample of farmers was made within each stratum in order to take account of the varying farm sizes over the scheme area. A total of 187 farmers were sampled and of these 168 responded. The distribution of these farms by stratum and the areas involved is shown in Table XIV.

The inquiry was initially a postal questionnaire. Data was gathered on farm production and expenditure in pre and post scheme years with emphasis on determining the farmers perception of the flood hazard and the effect of the Lower Manawatu Flood Control Scheme on farm production and activity. The survey was conducted in five different flood frequency areas and nine drainage board areas as well as areas that lay outside of a drainage board area but within the area the Catchment Board designated as being affected by the scheme. All members of the sample were potential flood victims or should have gained benefits from the Lower Manawatu Flood Control Scheme, as defined by the Catchment Board. Some had experienced bad floods in the past while others had little or no flood experience.

The postal questionnaire as shown in Appendix A was distributed but only a twenty percent response was obtained, and consequently follow up field interviews were necessary in which farmers were asked to elaborate on their perception of the hazard in the field interview. The data on farm production and expenditure was gathered with the intention of comparing trends and changes in this area with

TABLE XIV - DISTRIBUTION OF SAMPLE FARMS: HECTARES AND NUMBER OF FARM UNITS

Drainage Board Area	Flood Frequency Area				
	0-11 months	1-4 years	5-19 years	20-100 years	Indirect Benefit
Manawatu	294 (9)	189 (7)	240 (8)	241 (8)	521 (25)
Makerua	-	102 (3)	-	714 (22)	13 (1)
Moutoa	28 (1)	24 (1)	74 (3)	72 (3)	54 (2)
Bainesse	-	-	-	-	30 (1)
Sluggish River	10 (1)	28 (1)	-	271 (9)	100 (4)
Whirokino	-	-	-	-	26 (1)
Buckley	-	-	148 (5)	72 (3)	176 (5)
Himatangi	-	-	-	-	56 (2)
Oroua	-	-	-	-	(2)
Above P.N.	26 (1)	20 (1)	48 (2)	26 (2)	36 (1)
Outisde D.B.A.	8 (1)	15 (1)	15 (1)	46 (1)	375 (30)

(Number of farms in brackets) Source: Field Survey

the farmers hazard perception. Few farmers were either able or prepared to give information on this so it was not possible to extend this line of inquiry.

The major objectives of the perception study were

1. to identify and compare the farmers' and the Catchment Boards' hazard perception and
2. to test for any variation in the perception of the hazard among floodplain managers and if any variation was found to exist then to attempt to account for the variation by identifying those factors that influenced the farmers' perception.

C. THE CATCHMENT BOARDS' HAZARD PERCEPTION

The Catchment Boards' perception of the flood hazard was taken as being the flood frequency areas outlined in Chapter Two. The Catchment Boards' hazard perception was based almost entirely on the estimated probability of river flooding. Apart from brief reference to some 14,400 hectares located on the periphery of the scheme area there was no reference to the problem of local flooding caused by impeded drainage.

D. THE FLOODPLAIN MANAGERS' HAZARD PERCEPTION

The farmers' hazard perception was determined by asking those farmers at present in the floodplain to identify;

a) the area of their farm they considered was flooded in pre and post scheme years.

b) the length of time they thought production was disrupted in pre- and post-scheme years because of flooding.

c) any changes in production (type and intensity) made possible by the flood scheme.

Pilot interviews with farmers revealed that a positive distinction was made between river flooding and local flooding and that these two forms of flooding had a varying spatial impact over the region. Consequently the farmers perception of river flooding and local flooding were sought, although attention was focussed upon river flooding as the Catchment Board paid little attention to local flooding.

1. Farmers' perception of river flooding

Considerable variation in the perception of the flood hazard was found to exist amongst those farmers interviewed, as can be seen in Table XV. Sixty-five percent of those interviewed believed their farms were in such a position as to never have been threatened by flood waters. Of those who considered flooding to have been a problem, or potential problem, 49 percent could not place a temporal span on the occurence of such events. These farmers expressed their hazard perception with statements such as "this farm was flooded - every time the river rose; only in major floods; occasionally ..." Those farmers who placed a temporal span on the occurence of flooding considered such events occurred at least once in every five years. These observations implied that where flooding was more frequent the floodplain manager was more able to identify the hazard event and the possibility of its occurence than in areas of low hazard intensity where the identification of the flood event was not as positive.

2. Farmers' perception of local flooding

Farmers in all flood frequency areas reported local flooding to be a disruptive factor in farm production. The perceived severity of the problem as shown in Table XV indicated the problem was considered to be most severe by those located in the high hazard frequency areas. The impact on farm production varied over the scheme area depending upon the duration, depth and extent of inundation (absolute area and percentage area of an individual farm inundated) as well as the nature of land use and the time of year of the occurence of the flood event. For example, the greater the inundation - other things being equal - then the greater the damage caused. Damage would vary however depending upon the time of year at which inundation occurred. The regeneration of grass growth is much faster when warm weather conditions follow inundation, but high summer temperatures may cause rotting of the pasture. In a similar manner length of pasture at time of inundation affects later growth with long grass creating adverse open pastoral conditions later. Farmers were more able to identify the occurrence of local flooding than river flooding. This was possibly because local flooding was experienced more often than river flooding, with every farmer being affected at least once in every five years.

TABLE XV - FARMERS PERCEPTION OF RIVER FLOODING AND LOCAL FLOODING

	FARMERS PERCEPTION OF RIVER FLOODING					FARMERS PERCEPTION OF LOCAL FLOODING			
	floods at least once a year	floods every 1 - 5 years	floods only in major floods	occasionally floods	never floods	never floods	never floods badly	floods reasonably badly	serious flood area
0 - 11 months	(13) 100%							(9) 69%	(4) 31%
1 - 4 years	(5) 36%	(7) 50%			(2) 14%		(2) 7%	(13) 93%	
5 - 20 years	(2) 11%	(1) 5%	(10) 53%	(5) 26%	(1) 5%		(13) 69%	(6) 31%	
20-100 years			(5) 11%	(3) 7%	(40) 83%	(30) 63%	(18) 37%		
Indirect Benefit area			(3) 4%	(3) 4%	(68) 92%	(71) 96%	(3) 4%		
Total	(20) 12%	(8) 5%	(18) 11%	(11) 7%	(111) 65%	(111) 65%	(25) 15%	(28) 18%	(4) 2%

(Number of farms in brackets) Source: Field Survey

E. A COMPARISON OF THE FLOODPLAIN MANAGERS' AND THE CATCHMENT BOARDS' HAZARD PERCEPTION (River Flooding)

The most obvious difference between the floodplain managers' and the Catchment Boards' hazard perception was the different means of expressing hazard perception. The Catchment Board perception was a quantitative expression of the theoretical likelihood of occurence of flows of certain magnitudes and areas that would be inundated by such flows (flood frequency areas). The farmers' hazard perception's included both qualitative expression's and quantitative expressions of the likelihood of flooding.

A second area of difference was that the Catchment Board focussed little attention on the problem of local flooding whereas the farmer considered this to be of considerable importance. The fact that the Catchment Board did not consider the impact of local flooding for all of the scheme area necessitated restricting the comparison of the farmers' and Catchment Board's hazard perception to river flooding.

If the perception of the hazard of river flooding by the farmers and the Catchment Board were the same, it would follow that all farmers in the same flood frequency area would have the same hazard perception and that this perception would be the same as that held by the Catchment Board.

The distribution of farmers perception of the likelihood of flooding within each of the flood frequency areas identified by the Catchment Board is illustrated in Table XV..

It is apparent that in all flood frequency areas except for the 0 - 11 months flood frequency area there was more than one hazard perception expressed by farmers' suggesting that the farmers' hazard perception was differdent to the Catchment Board hazard perception. A number of factors may be responsible for this.

1. the flood frequency boundaries may not be accurate,
2. the farmers' hazard perception is different to that of the Catchment Board,
3. those who experience the same hazard intensity perceive the severity of the problem in different ways.

Accepting that the flood frequency boundaries are accurate, an investigation of the second and third conclusions can be made. In order to further compare the farmers' and Catchment Board's hazard perception, a number of assumptions as to the meanings of the qualitative descriptions given by farmers were made. In accordance with this, it was assumed that the farmers' perception dâscription of:

1. 'a major flood' corresponded with the Catchment Board's 20 - 100 year flood frequency area.
2. 'occasionally floods' corresponded with the Catchment Board's 5 - 19 year flood frequency area.
3. 'never floods' corresponded with the Catchment Board's area designated as receiving indirect benefits.

The distribution of perception with these assumptions is shown in Table XVI.

TABLE XVI - FARMERS' PERCEPTION OF RIVER FLOODING
(Assumption Set Number One)

Flood Frequency Area	0-11 months	1-4 years	5-19 years	20-100 years	Indirect benefit area
0 - 11 months	(13) 100%				
1 - 4 years	(5) 36%	(7) 50%			(2) 14%
5 - 19 years	(2) 11%	(1) 5%	(5) 26%	(10) 53%	(1) 5%
20-100 years			(3) 7%	(5) 10%	(40)·83%
Indirect Benefit area			(3) 4%	(3) 4%	(68) 92%

The greatest agreement between farmers' and Catchment Board bazard perception occurred in the 0 - 11 month flood frequency area where there was complete agreement in hazard perception and in the area designated as receiving indirect benefits where ninety-two percent of farmers held the same hazard perception as the Catchment Board. This would appear to suggest that where the temporal spacing is well defined, the farmers' perception of the hazard is also clearly defined, but where the spacing is in an area of intermediate frequency, that perception becomes distorted and open to varying interpretations.

A second set of assumptions was made so that an alternative set of data could be obtained with which the above calculations and conclusions could be compared. The two qualitative descriptions ("floods in time of major flood" and "occasionally floods") were combined for each flood frequency area, but it was considered that the terms could not be interchangeable between flood frequency areas. The qualitative descriptions were therefore assigned the quantitative value of the flood frequency area they fell within. A similar distribution to that obtained under the first set of assumptions was obtained, as shown in Table XVII.

TABLE XVII - FARMERS' PERCEPTION OF RIVER FLOODING
(Assumption Set Number Two)

F.F.A.	0-11 months	1-4 years	5-19 years	20-100 years	Indirect benefit area
0-11 months	(13) 100%				
1-4 years	(5) 36%	(7) 50%			(2) 14%
5-19 years	(2) 11%	(1) 5%	(15) 79%		(1) 5%
20-100 years				(8) 17%	(40) 83%
Indirect benefit area				(6) 8%	(68) 92%

(Number of farms in brackets) Source: Field Survey

The major difference obtained under these second set of assumptions was an increase in the agreement between the farmers and Catchment Board's perception in the 5-19 year and 20-100 year flood frequency areas. The distribution remained unaltered in the 0-11 month and 1-4 year flood frequency areas.

Both sets of data revealed the greatest similarity of perception in the areas of highest flood frequency and the area designated as receiving indirect benefits, although the second set of assumptions showed a far greater agreement in hazard perception in the 5-19 year flood frequency than did the first set of assumptions.

It was considered that the second set of assumptions (that is those held for Table XVII) were the more realistic.

Based on the distribution of perception obtained under this set of assumptions it appeared as though the majority of farmers (sixty-five percent) held the same perception of hazard occurrenceas the Catchment Board. An examination of the farmers overestimation and underestimation of the flood hazard is shown in Table XVIII. The Catchment Board's hazard perception was used as the basis for these calculations. Of those farmers whose perception was different to the Catchment Board, seventy five percent underestimated the flood hazard and only twenty five percent overestimated the hazard.

There are two possible reasons for underestimating the flood hazard. These are:

1. believing there is no flood hazard, or
2. believing the temporal spacing between flood events to be greater than the Catchment Board considered them to be.

In all cases in this study, those who underestimated the hazard considered their farm to never have been threatened by river flooding.

Of the fourty three farmers who underestimated the flood hazard, forty were located in the 20-100 year flood frequency area and believed river flooding to never have been a problem. These farmers represented ninety three percent of those who underestimated the flood hazard.

Those farmers who overestimated the flood hazard were located in the 1-4 and 5-19 year flood frequency areas and the area designated as receiving indirect benefits. Those in the

1-4 and 5-19 year flood frequency areas considered flooding to occur at least once in every 4 years while those in the area of indirect benefits considered flooding to occur every 20 to 100 years.

TABLE XVIII

FARMERS OVERESTIMATION AND UNDERESTIMATION OF THE RIVER FLOOD HAZARD

Catchment Board Perception (F.F.A.)	Farmers Hazard Perception					
	Same as Catchment Board Perception		Underestimated		Overestimated	
0-11 months	(13)	100%				
1-4 years	(7)	50%	(2)	14%	(5)	36%
5-19 years	(15)	79%	(1)	5%	(3)	16%
20-100 years	(8)	17%	(40)	83%		
Area of indirect benefit	(68)	92%			(6)	8%

(Number of farms in brackets) Source: Field Survey

F. VARIATION IN PERCEPTION AMONG FARMERS

Considerable variation in hazard perception among the resource users was revealed in the course of the study. Seventeen percent of those interviewed considered river flooding would have affected their land at least once in every five years, while eighteen percent thought the land would have been flooded occasionally or in every major flood and sixty-five percent thought there was no flood hazard. (Table XV).

This variation is of considerable importance in attempting to compare the farmers' and Catchment Board's perception and understand post scheme land use changes that have occurred. A considerable amount of the variation can probably be explained by the differential spatial impact of the flood events themselves. Farmers' perception cannot however, be explained solely in terms of the magnitude and frequency of flood events. In addition to the damage potential or damages experienced in the past, variation could also arise from definitions used to describe flood events, time periods used for descriptions, methods of computation used and the accuracy and completeness of reporting on the part of the farmer. Possible variations in individual personalities of the farmers, particularly their outlook towards nature, attitude towards fate and individual tolerance of particular situations or events, would influence hazard perception.

The qualitative expressions of perception used by some farmers indicated in Table XV are not mutually exclusive. These different expressions of perception may simply reflect a different choice of words to describe the same hazard perception. Nevertheless, it was thought that by incorporating the assumptions made for Table XVII an examination of the effect of various factors on the farmers' hazard perception could be made.

It is beyond the scope of this paper to examine the effect of farmers' personality attributes on their hazard perception.

Instead, it is proposed to examine the effect of past flood experience, amount of land in the floodplain and effect of flooding from different sources on the farmers' hazard perception and farmers attitude towards the scheme, as it is considered that these are the most important physical determinants of perception.

1. Effect of past flood experience on hazard perception

Burton (1962) believed the floodplain managers' hazard perception was influenced by his past flood experience, particularly the recency of the last flood event and the damages suffered.

In order to determine if this situation held true for the study area it was first necessary to identify the individuals flood experience as it was not possible to use flood frequency areas as the basis for identifying the flood experience of different farms and farmers because,

(i) individuals had been in the area for varying time periods and consequently two individuals on land with the 'same' hazard intensity would have different flood experiences and,

(ii) flood frequency areas represent the area that would theoretically be flooded by different flows. It is possible that different parts of the same flood frequency area have been affected differently in the past.

Problems in identifying the flood experience of various areas arose because of absence of records of areas flooded other than in 1953 and there are no records of losses suffered in floods.

The farmers flood experience therefore had to be determined from the field interviews.

It was decided to include flood experiences that an individual had experienced in other areas, and in the scheme area at a time when the individual was not responsible for his property - as when he was a son or daughter of a farmer affected by flooding.

The individuals past flood experience was scored on three levels:

(i) no experience

(ii) minor experience - not flooded very often or little damage caused

(iii) major experience - experienced major damage or regular flooding.

The flood frequency area in which the farm unit being observed was located, was taken into consideration due to the varying hazard intensity over the study area. In this way it was possible to note what hazard intensity was being commented upon by farmers, and the effect of past flood experience on the same flood event could be examined.

(a) Effect of past flood experience on perception of River Flooding

The farmers perception of river flooding as shown in Table XIX indicated in all but the 0-11 months flood frequency area there was some variation in perception between those with different flood experiences, particularly between those with no flood experience and those with major or minor flood experience.

TABLE XIX - FARMERS PERCEPTION OF FLOODING BY PAST FLOOD EXPERIENCE

Catchment Board Hazard Perception (F.F.A.)	Farmers Flood Exper-ience	Farmers Hazard Perception				
		floods at least once a year	floods every 1 - 5 years	flood in time of major flooding	floods occasion-ally	never floods
0 - 11 months	major	(7) 100%				
	minor	(4) 100%				
	none	(2) 100%				
1 - 4 years	major	(3) 43%	(4) 57%			
	minor	(2) 40%	(3) 60%			
	none					(2) 100%
5 - 19 years	major	(1) 20%	(1) 20%	(2) 40%	(1) 20%	
	minor			(6) 60%	(4) 40%	
	none	(1) 25%		(2) 50%		(1) 25%
20 - 100 years	major			(2) 67%	(1) 33%	
	minor			(3) 60%	(2) 40%	
	none					(40) 100%
Indirect benefit area	major			(2) 6%	(3) 9%	(27) 85%
	minor			(1) 5%		(21) 95%
	none					(20) 100%

(Number of farms in brackets) Source: Field Survey

All those in the 0 - 11 months flood frequency area expressed the same hazard perception regardless of hazard experience. This suggests that where the hazard has been severe in its impact, new-comers to the area quickly take on the perception attitudes of others in that area.

In the other flood frequency areas there was little variation in perception between those with major and minor flood experience. This was particularly so in the 1 - 4 year and 20 - 100 year flood frequency areas and areas designated as receiving indirect benefits. In the 5 - 19 year flood frequency areas, the extent of agreement was not as great as there was a considerable range of perception expressions reported. If the qualitative expressions of perception in the 5 - 19 year flood frequency area are combined then the same similarity in the hazard perceptions between those with major flood experience and those who had experienced only minor flooding - as occurred in the 1 - 4 year and 20 - 100 year flood frequency areas - exists.

The only group who considered that their land was not liable to flooding apart from those in the area of indirect flood scheme benefit were those who had no experience of river flooding. This contrasts with some overseas studies which indicate that many people once flooded, believe they will never be flooded again, expressing such opinions as "lightning never strikes twice in the same place", "we have had a one hundred year flood so we won't have one for another one hundred years", (Burton and Kates, 1964).

This implies that the lower Manawatu floodplain occupant has a more realistic outlook towards the possibility of flooding than his overseas counterpart. Whether this is due to a higher standard of education in regard to the flood hazard by Catchment Board and Agriculture Department officials or simply to a greater contact with and understanding of the vagaries of nature than others in similar situations elsewhere, is a matter for further study.

In the area designated as receiving indirect benefits all 'experience groups' expressed a similar perception of river flooding, in believing their land to never be liable to be flooded. Eight percent of the farmers in this group had however, experienced flooding of a major or minor nature, and it is notable that they believed their land was still in a floodable position. This suggests that past experience of river flooding has influenced the individuals perception of the hazard.

(b) Effect of past flood experience on attitude towards future river flooding

All farmers interviewed were aware of the Lower Manawatu Flood Control Scheme yet attitudes towards the likelihood future flooding varied considerably, as can be seen in Tables XX and XXI. It appears that the floodplain manager's attitude towards the likelihood of future flooding is related to his past flood experience, as those who had experienced major or minor flooding in the past were more pessimistic about the likelihood of future flooding than were those who had never experienced flooding. All of those who had never experienced flooding thought their land would never flood in the future.

While this suggests that the floodplain managers' hazard perception is influenced by past hazard experience, it must be noted that the level or severity of that experience plays a minor role in attitude formation. That is, it is it appears as though it is the experiencing of a flood not the severity of impact that influences attitude towards future flooding. (Tables XX and XXI)

If one assumes that those in the 0-11 months and 1-4 years flood frequency areas have experienced more frequent and regular inundation than those in the 5-19 years and 20-100 years flood frequency areas then the distribution of attitudes towards future flooding suggests that past experience of flooding be it major or minor, is moderated by the frequency of past flood experience.

TABLE XX

EFFECT OF FLOOD EXPERIENCE ON FARMERS ATTITUDES TOWARDS FUTURE FLOODING

Farmers flood experience	Farmers attitude towards future flooding		
	optimistic	pessimistic	neutral
major	(8) 36%	(14) 64%	
minor	(10) 41%	(12) 50%	(2) 9%
none	(121) 91%		(1) 1%

(Number of farms in brackets) Source: Field Survey

TABLE XXI

EFFECT OF FLOOD EXPERIENCE AND FARM LOCATION ON

FARMER ATTITUDES TOWARDS FUTURE FLOODING

F.F.A.	Farmers flood experience	Farmers attitude towards future flooding		
		optimistic	pessimistic	neutral
0-11 months	major minor none	(1) 14% (1) 25% (2) 100%	(6) 86% (3) 75%	
1-4 years	major minor none	(2) 29% (2) 40% (2) 100%	(5) 71% (3) 60%	
5-19 years	major minor none	(2) 40% (2) 20% (3) 75%	(3) 60% (6) 60%	(2) 20% (1) 25%
20-100 years	major minor none	(3) 100% (5) 100% (40) 100%		
indirect benefit area	major minor none	(74) 100%		

(Number of farms in brackets) Source: Field Survey

There was less optimism as to the possible occurrence of future flooding amongst those with past flood experience (major or minor) than those with no past flood experience in the 0-11 months, 1-4 years and 5-19 year flood frequency areas. In the 20-100 year flood frequency area and areas designated as receiving indirect benefits, past flood experience had no moderating effect as <u>all</u> floodplain managers were optimistic that the flood hazard had been eliminated.

A content analysis of reasons given to explain attitude towards future flooding (Table XXII) revealed that the majority of floodplain managers attributed their attitude to the fact that they believed their land was never flooded in the past (seventy-two percent). The other farmers who thought flooding would never occur in the future, attributed this to "it has happened once and therefore will not occur again" (four percent). "The stop banks and flood scheme will provide protection" (seven percent). Fifteen percent of those interviewed believed flooding could occur in the future, and attributed this attitude to "the banks could break" (eleven percent). Two percent of those interviewed expressed no definite attitude.

TABLE XXII - EXPLANATION FOR ATTITUDE TOWARDS FUTURE FLOODING

Explanation for attitude	Number	Percentage
never flooded in past	121	72
has happened once therefore wont occur again	7	4
flood scheme will prevent any flooding	11	7
stopbanks could be overtopped	7	4
stopbanks could break	19	11
no reason for attitude expressed given	3	2

Source: Field Survey

2. Effect of amount of farm in floodplain on perception of River Flooding

It is possible that farmers' perception of the flood hazard could be affected by the amount (both absolute and percentage) of the farm that lay in the floodplain or was susceptible to flooding of a disruptive nature.

In order to identify the effect varying areas of each farm lying in different flood frequency areas had on the floodplain managers hazard perception the following considerations were made. Each farm was assigned to a major and a secondary flood frequency area. The major flood frequency area was that in which the greatest area of the farm lay, and the secondary flood frequency area was that area in which the second largest area of a farm lay. Where two flood frequency areas were evenly represented a farm was assigned to the higher of the two. For this section of the study the 0-11 months and 1-4 year flood frequency areas were combined. Only the percentage area of land in each flood frequency area was considered. No account was taken of the variation in absolute area.

The distribution of various perceptions by these F.F.A. combinations as shown in Table XXIII indicated a general trend of increasing severity from the low to high flood frequency areas.

The most notable conclusion that can be drawn from Table XXIII is that the major flood frequency area has the greatest effect on the floodplain managers' perception. This is indicated by the perceived greater severity of impact in the high flood frequency areas compared to the low flood frequency areas.

The secondary flood frequency areas did have some moderating effect on the floodplain managers' hazard perception. This effect was not discernible in the high hazard frequency areas. In the 20-100 year F.F.A. and the area designated as receiving indirect benefits, the presence of small areas of more frequent inundation resulted in the hazard being perceived as a greater problem in areas where a high hazard frequency area was the secondary area of the farm than where this secondary area was not present or where it was a lower hazard frequency area. The small number of farms involved however makes such conclusions rather tenuous.

TABLE XXIII

FARMERS HAZARD PERCEPTION BY MAJOR AND SECONDARY FLOODPLAIN LOCATION

Floodplain location		Farmers Hazard Perception				
Major F.F.A.	Secondary F.F.A.	flood every year	flood at least every 5 years	flood occasionally	flood in major floods	never flood
0-4 years		(11)58%	(6) 32%			(2)10%
	5-19 year	(1)100%				
	20-100 year	(4)80%	(1) 20%			
	indirect benefit area	(2)100%				
5-19 years	1-4 years			(1) 33%	(2)67%	
	20-100 years	(2)13%	(1) 7%	(4) 27%	(8)53%	
	indirect benefit area					(1)100%
20-100 year	0-4 year				(5)56%	(4)44%
	5-19 year			(2) 6%		(33)94%
	indirect benefit area			(1) 25%		(3)75%
indirect benefit area	0-4 year			(1) 11%		(8)89%
	5-19					
	20-100			(1) 5% (1) 2%	(3)15%	(16)80% (44) 98%

(Number of farms in brackets) Source: Field Survey

It is not possible to draw any conclusions other than those noted above. One must consider the fact that the distribution of perception may have been affected by the hazard experience of the floodplain manager as described in an earlier section. As this hazard experience could not be taken into consideration and because of the small sample numbers, there wasno way of accurately gauging the impact of the varying hazard potential for different farms.

3. Effect of flooding from different rivers on hazard perception.

River flooding in the region was from a number of different sources. The major source of flooding was the Manawatu and Oroua Rivers, but the Tokomaru River, Whiskey Creek and Mangaone Stream as well as other tributaries also contributed to the flood hazard.

Land in the Oroua and Sluggish River Drainage Board areas was subject to flooding from the Oroua River. Land in the Himatangi, Whirokino, Moutoa and Buckley Drainage Boards was flooded by the Manawatu River. The Makerua Drainage Board area suffered the floodwaters of the Manawatu and Tokomaru Rivers. The Bainesse Drainage Board land was flooded by the Manawatu and Oroua Rivers while the Manawatu Drainage Board area was flooded by these two rivers as well as the Mangaone Stream and Whiskey Creek.

A further complicating factor was that each of the sources of flooding, inundated different areas of the Drainage Board area and that the severity and frequency of flooding by the various sources was also very different. It was these facts that prompted the examination of the differential effect of the various flood sources on perception. It was recognised that Drainage Board activity in these areas would also influence the farmers hazard perception.

The following groupings of Drainage Board Areas was decided upon as these reflected the different sources of flooding:

(a) Oroua and Sluggish River

(b) Himatangi, Whirokino, Moutoa, Makerua and Buckley

(c) Bainesse and Manawatu

(d) areas that lay outside a Drainage Board area, including the area above Palmerston North.

The resultant perception distribution illustrated in Table XXIV indicated that the different sources of flooding had little impact upon the floodplain managers hazard perception there being no significant variation in perception among those in the same flood frequency area within each of these source areas.

4. Variation in farmers perception of local flooding

The problem of local flooding has been experienced by most farmers in the area liable to river flooding. An examination of the effect of the length of time an individual had been farming in the region on his hazard perception was undertaken and the results are shown in Table XXV. It can be seen that the number of years an individual had been in the area did not significantly influence his perception. This indicated that either new arrivals

TABLE XXIV

FARMERS PERCEPTION OF RIVER FLOODING BY SOURCE OF FLOOD

flood frequency area	Source of flooding	Farmers Perception of the Flood Hazard				
		0-11 months	1-4 years	major floods only	never floods	occasion-ally floods
0-11 months	A	(1) 100%				
	B	(1) 100%				
	C	(9) 100%				
	D	(2) 100%				
1-4 years	A		(1) 100%			
	B	(2) 50%	(1) 25%		(1) 25%	
	C	(2) 29%	(4) 57%		(1) 14%	
	D	(1) 50%	(1) 50%			
5-19 years	A					
	B	(1) 14%		(4) 50%		(3) 38%
	C	(1) 13%	(1) 13%	(5) 61%	(1) 13%	
	D			(1) 33%		(2) 68%
20-100 years	A			(1) 11%	(7) 78%	(1) 11%
	B			(2) 7%	(25) 89%	(1) 4%
	C			(2) 25%	(5) 63%	(1) 12%
	D				(3) 100%	
indirect benefit area	A			(1) 17%	(5) 83%	
	B				(11) 100%	
	C				(25) 96%	(1) 4%
	D			(2) 6%	(27) 88%	(2) 6%

(Number of farms in brackets)

Source: Field Survey

Key

A Oroua and Sluggish River
B Himatangi, Whirokino, Moutoa, Makerua and Buckley
C Bainesse and Manawatu
D areas that lay outside a Drainage Board area, including the area above Palmerston North

to the area quickly took on the characteristics or opinions of those already in the area, or else the high frequency of occurrence enabled the hazard to be quickly identified.

TABLE XXV - FARMERS PERCEPTION OF LOCAL FLOODING BY YEARS ON THE FARM

Flood Frequency Area		Never floods	Never floods badly	Floods reasonably badly	Serious flood area
0 - 11 months	Pre scheme Post scheme			(7) 64% (2) 100%	(4) 36%
1 - 4 years	Pre scheme Post scheme		 (1) 33%	(11) 100% (2) 67%	
5 - 19 years	Pre scheme Post scheme		(8) 67% (5) 71%	(4) 33% (2) 29%	
20 - 100 years	Pre scheme Post scheme	(17) 49% (13) 100%	(18) 51%		
Indirect benefit area	Pre scheme Post scheme	(47) 94% (24) 100%	(3) 6%		

The distribution of perception by time of locating in the floodplain (pre-scheme or post-scheme date), indicated that those who had been in the area prior to the scheme considered the problem to be more severe than did those who had located after the flood scheme.

The flood control scheme itself made little difference to the internal drainage conditions. In fact in some areas surface water could not enter the river system as readily after the scheme and the problem in these areas was therefore worse after the scheme than before it. The scheme did, however, enable increased Drainage Board activity and increased drainage facilities by farmers. It is possibly the effect of this post scheme activity that is reflected in the perceptions expressed in Table XXV.

5. Farmers' Perception of Effect of Scheme on Farm Production

The farmers' perception of the effect of the flood scheme on farm production is illustrated in Tables XVI to XVIII where the perceived effects of the change distribution of river flooding and local flooding are shown.

(a) River Flooding

Of those interviewed only 23 percent considered the scheme had enabled an increase in production, while 69 percent considered the scheme had had no effect on production and eight percent thought production was worse because of the scheme. Those who thought that production had benefited from the scheme, considered that more sound farm management and more positive planning could take place because of the elimination of the flood hazard. Others attributed scheme benefits to the prevention of stock losses and pasture damage.

TABLE XXVI - FARMERS PERCEPTION OF EFFECT OF ALTERED RIVER FLOODING ON PRODUCTION

Flood frequency area	Farmers Perception		
	increased or more intensive production	production not affected	production worse
0 - 11 months	(12) 92%	(1) 8%	
1 - 4 years	(11) 79%	(1) 7%	(2) 14%
5 - 19 years	(11) 58%	(4) 21%	(4) 21%
20-100 years	(6) 12%	(34) 71%	(8) 17%
Indirect benefit area		(74) 100%	

(Number of farms in brackets) Source: Field Survey

The farmers who considered the scheme had not affected production included those in the high hazard frequency areas who had never experienced flooding and those in the low frequency areas who considered flooding had never occurred or its occurrence was so infrequent as not to influence production patterns.

In some areas the floodplain managers thought production had suffered because of the scheme. Concern was expressed at the effect of levees cutting across farms and the increase of land in berm areas. Others believed the elimination of periodic inundation to be detrimental to production in that fertile river silt was no longer periodically deposited over their lands and the natural fertility of the soil was therefore lost.

A greater percentage in the high flood frequency area thought production had benefited from the scheme (ninety-two percent in the

TABLE XXVII

FARMERS PERCEPTION OF EFFECT OF ALTERED LOCAL

FLOODING ON PRODUCTION

Flood Frequency Areas	Farmers Perception		
	increased or more intensive production	production not affected	production worse
0-11 months	(5) 38%	(7) 54%	(1) 8%
1-4 years	(5) 36%	(7) 50%	(2) 14%
5-19 years	(8) 44%	(8) 42%	(3) 14%
20-100 years	(7) 15%	(37) 77%	(4) 8%
indirect benefit area	(3) 4%	(65) 88%	(6) 8%

(Number of farms in brackets) Source: Field Survey

TABLE XXVIII

EFFECT OF FARMERS PAST FLOOD EXPERIENCE ON

PERCEPTION OF EFFECT OF FLOOD SCHEME

Farmers flood experience	Farmers Perception		
	increased or more intensive production	production not affected	production worse
major	(20) 37%	(34) 63%	
minor	(19) 41%	(18) 39%	(9) 20%
none	(1) 2%	(62) 91%	(5) 7%

(Number of farms in brackets) Source: Field Survey

0 - 11 month flood frequency area) than did those in the areas of low hazard frequency (twelve percent in the 20 - 100 year flood frequency area). The situation regarding those who thought the scheme had had no effect on production was the reverse of the above. That is, a greater percentage in the low hazard frequency areas than in the high hazard frequency areas thought production had not changed because of the scheme. Those who believed production had declined because of the scheme represented eight percent of all farmers and were spread over the 1 - 4, 5 - 19 and 20 - 100 year flood frequency areas.

The influence of past flood experience on the perceived scheme effects on production is shown in Table XVIII. The most notable feature is the high percentage (92 percent) of those with no flood experience who thought the scheme had no effect on production. A greater percentage of those who had experienced major flooding (63 percent) considered the scheme to have had no major effect on production than did those with only minor flood experience (39 percent). The percentage of each of these two groups who considered production had benefited from the scheme were fairly evenly divided (37 percent and 41 percent).

(b) Local Flooding

The majority of floodplain managers (seventy four percent) believed that there had been no effect on production as a result of post scheme changes in internal drainage conditions. Seventeen percent believed that such changes had resulted in increased production while nine percent considered production to be worse because of the new conditions, which indicated that only a net gain of eight percent of the farmers believed they were better off because of the scheme's effect on internal drainage.

A greater percentage of those in the low hazard intensity areas considered that no change in production had occurred because of the flood scheme than did those in the high hazard intensity areas (Table XXVII). The distribution of perception of the effect of internal drainage was much the same as that for river flooding.

6. Conclusion

The above investigation of hazard perceptions indicated that:

(a) different groups perceive the existence or severity of the same hazard event differently, that is the Catchment Boards' and floodplain managers' hazard perceptions are not the same.

(b) users of the same resource (in this case farmers) perceive the hazard event in different ways.

Some evidence has been presented which suggests that the floodplain managers perception of the flood hazard is not solely a function of the frequency and impact of the hazard event. It is likely that other factors, such as the amount of land in the floodplain and attitude of others in the same area, influence the floodplain managers hazard perception.

The large number of floodplain managers who considered the scheme had been of no benefit suggests that an education programme by some official body, identifying the new hazard boundaries and changed conditions could generate beneficial effects in the adjustment to the post scheme situation. Such a suggestion is based on the observation that it is not the existence of the potential hazard but the floodplain managers' perception of this hazard that determines his adjustment to the environmental conditions.

G. THE ENVIRONMENTAL IMPACT ON THE LOWER MANAWATU REGION

The Catchment Boards evaluation process for the Lower Manawatu Flood Control Scheme made no attempt to assess the full physical consequences of the project. There was no consideration of the effects of changing river regimes, altered channel design, or the destruction of wetlands. While these factors cannot be expressed in monetary terms, they are still social costs that need to be considered. In a similar manner, no values were assigned to lowlands for flood sediment and nutrient storage, or to water quality, nutrient exchange, biotic productivity, existing flora and fauna, aesthetic qualities, or destruction of historical sites.

It may be suggested that the lack of ecological considerations indicates a certain predisposition in the Manawatu Catchment Board evaluation process towards monetary benefits and present, compared with future, requirements. To some extent it would also reflect the state of the art in the 1950's. It has been noted that flood control projects such as the Lower Manawatu Flood Control Scheme have in many cases led to the degradation and destruction of bottomland ecosystems and environmental quality, through the dramatic reduction in biological productivity of plants and animals that depend on periodic overflows for sediment and nutrient influx and deposition, and, consequently, ultimate survival (Jahn 1969, Hines 1969, Chorley and Kates 1969).

It is considered that there is a need to attempt to understand how environmental interactions might be incorporated in flood programs and so develop a better balance between flood protection and environmental quality. There is a growing recognition of the importance of environmental impacts of water resource developments, but the lack of feasible analytical techniques at present hinder developments in this field. A framework for assessing such impacts has not yet been devised, but the 'Environment Impact Matrix' can be used to assess what actually follows water resource development and so contribute to the knowledge of the effects of water resource projects, in order that they may be taken into consideration in future projects. Some of the possible environmental effects of the Lower Manawatu Flood Control Scheme will be discussed here as an illustration of the importance of this to be decision making process.

In proposed developments such as the Lower Manawatu Flood Control Scheme, it is usual practice to include an analysis of the need for development and the associated costs and benefits. In the past such analysis was based almost completely on economic criterion. In the Lower Manawatu Flood Control Scheme this was the only reference used. More recently society has recognised the need to consider the effect of the proposed development on the environment and has called for the consideration of ecological as well as social and economic costs in the appraisal of a project.

The Environmental Impact Matrix, devised by the United States Geological Department (Survey Circular 645), is used here to identify the proposed actions and environmental impacts of activities involved in the Lower Manawatu Flood Control Scheme. The Matrix is a general checklist of the full range of actions and impacts on the environment that may result from proposed actions. The horizontal axis of the matrix represents the proposed actions which may impact upon the environment. The vertical axis represents those elements in the environment that may be affected by the proposed actions.

In this study the original Impact Matrix was narrowed to include only those actions and impacts relevant to the scheme. Once this was done the magnitude and importance of the impact was assessed and the five most significant impacts isolated for further discussion. Magnitude is used here as a definition of scale or extensiveness of the impact. For example the flood control scheme could alter the drainage pattern and would therefore be considered as having a large magnitude of impact on drainage. The second aspect of any action that needs to be considered is importance (that is, significance) of the particular action in the specific area under study. Thus it could be considered the overall importance of the flood scheme on drainage may be small because the scheme may affect only a small area of drainage.

The conventional means of compiling an Impact Matrix is to assign various weights (1 - 10) for magnitude and importance of impact. The Environmental Impact Matrix devised for this study, as shown in Table XXIX, includes only those impacts that have had a significant adverse environmental impact. No weighting for magnitude and importance of impact have been assigned because of the general absence of any information on this for the Lower Manawatu Flood Control Scheme. It is apparent that there were many environmental impacts as a result of the scheme as can be seen in Table XXIX The five major impacts are discussed below. Passing reference is made to subsiduary impacts.

1. A primary consideration must be the effects of restricting water flow to a set channel, by canalization, canal dredging and straightening, channel revetments and use of canals. Although no studies have been conducted it is extremely likely that many adverse environmental effects, notably on soil fertility, grazing, agriculture, cropping and grass growth have resulted from the scheme. In the past the region developed because of periodic inundations which deposited fertile river silt on the floodplain lands ensuring high natural fertility. With the preventing of such inundation, the soils have been denied their source of natural

TABLE XXIX

ENVIRONMENTAL IMPACT MATRIX FOR THE MANAWATU

Proposed Actions which may Cause Environmental Impact

EXISTING CHARACTERISTICS AND CONDITIONS OF THE CATCHMENT			(A) Modification of Regime				(B) Land Transformation and Construction						(E) Land Alteration
			a exotic flora or fauna introduction	f alteration of drainage	g river control and flow modification	h conclisation	d highways and bridges	e roads and trails	f railroads	j channel dredging and straightening	k channel revetments	l canals	a erosion control and terracing
PROPOSED ACTIONS			x	x	x	x	x	x	x	x	x	x	x
(A) Physical and Chemical Characts	1) Earth	c) soils	x	x		x	x	x	x			x	
		d) land form		x			x	x	x		x	x	
	2) Water	a) surface		x		x	x	x	x			x	
		c) undergro-und										x	
		f) recharge										x	
	4) Processes	a) floods	x	x	x	x				x	x	x	x
		b) erosion		x	x	x	x	x		x	x	x	
		c) deposition		x	x	x				x	x	x	x
(b) Biological Condits	1) Flora	c) grass		x		x							
		d) crops		x									x
		e) microflora			x							x	x
		f) aquatic plants			x							x	x
	2) Fauna	c) fish	x							x	x		x
		f) microfauna			x								x
(1) Cultural Factors	1) Land use	b) wetlands		x	x	x					x	x	
		d) grazing		x							x		x
		e) agriculture		x							x	x	x
	2) recreation	a) hunting		x							x		x
		b) fishing	x	x						x	x	x	
		d) swimming	x							x			
		f) picnicking	x								x		
Other	1) aesth-etics and human inter-rest	a) scenic views	x				x	x	x		x	x	
	3) ecolog-ical relat-ionship	d) food chains		x	x	x				x		x	

Source: USA Geological Department, Survey Circular 645 fertility (and artificial fertilizers have had to be applied to maintain productivity). Discussions with local farmers and Mr Brown (Past Secretary of the Catchment Board) revealed agriculture, grazing and cropping in the more frequently inundated areas of pre-scheme years, have consequently suffered. Good grass growth in these areas has also suffered because of the prevention of periodic inundation. Pests and diseases such as grass grub, which were never a problem in pre-scheme years have emerged as a problem since the scheme. This may be a direct or associated product of the scheme. The decline in grass production has affected grazing and other agricultural practices in these areas.

2. The second major consideration is the effect of altered drainage conditions. The major impact has been in the wetland areas which have been seriously reduced, resulting in the destruction of much of the microflora and microfauna of the area as well as aquatic plant and bird life of the area. Consequently hunting and fishing have been indirectly affected by such actions. The altered drainage conditions have also impacted other areas, where land which in pre-scheme years was not affected by local flooding, is affected today. This situation has been caused by two factors:

(i) Increased runoff from areas higher up. For example, land at the bottom of the Taonui Basin now receives runoff four hours after it falls on the land above it, whereas in pre-scheme years it took 24 hours to reach this point.

(ii) The levee banks in some areas prevent surface water from entering the river system.

These events also affect the agriculture, cropping, grazing and grass growth of the area in detrimental ways.

3. The altered drainage conditions, the introduction of canals and canalization, channel straightening and channel revetments has affected the landform particularly in the Makerua area where Mr Brown (a past Secretary of the Catchment Board) has observed the land has sunk six to eight metres since natural periodic inundation has been prevented. This has affected the natural drainage conditions and water table. Although no research has been conducted in this area the major impact may be felt in the future when the peat soils may dry out completely if they are continued to be denied feeding by flooding.

4. The containing of flows between stopbanks has altered river flows by increasing velocities particularly in times of flood. Research in other parts of the world suggest that this could have particularly significant effects in reducing the aquatic plant and fish life as well as microflora and microfauna of the river although no research has been conducted in this area in New Zealand. These features have also been affected in a minor way by erosion control which has altered the sediment load of the river and the nature of the river bed load. Foodchains may have been upset (at least in the short run) by such altered conditions.

5. A fifth major impact has arisen from the installation of channel revetments and introduction of willow trees along much of the river banks. This has prevented access to much of the river for fishermen, swimmers and picnickers as well as detracting from the scenic qualities of much of the area and altering plant and fish life of the area, again possibly upsetting foodchains and ecological conditions of the region.

Other environmental effects of the scheme have come from the installation of bridges which have altered flow characteristics and plant and aquatic life, as well as affecting erosion and channel deposits in the immediate area. Highway construction as well as the introduction of additional roads and altered railroad routes have also affected landform soils and drainage, particularly surface water flows. The magnitude and importance of these events are however, relatively low because they do not affect a very big area.

CHAPTER 7

THE EFFECT OF THE FLOOD SCHEME ON LAND VALUES

At the time of formulating the flood control scheme the Catchment Board considered different areas would be affected to varying degrees. The most obvious differentiating factor was the flood frequency areas as defined by the Catchment Board but the effect of this was modified by drainage board activity etc. It was considered that the sample frame as used in Chapter 6 based on flood frequency and drainage board boundaries would therefore be suitable for an analysis of the differential impact of the flood scheme.

The best measure of the effect of the flood scheme would have involved an analysis of changes in farmers net margins and return on stock or changes in farmers net incomes. Such an analysis was not possible as there was not a sufficient number of farmers who were prepared to make such records available, and data stored at the Valuation Department on stock numbers etc was both inaccurate and incomplete.

The only alternative measure that could be used was changes in the value of land over the region. The Valuation Department makes five yearly surveys of land values by County regions. The area covered by the flood scheme includes parts of the Kairanga, Manawatu and Horowhenua Counties. Capital value, Unimproved value and Improved value have been recorded for the Kairanga and Horowhenua Counties for all Valuation dates.

In the Manawatu County however, the valuation system used by the Valuation Department has been changed since the scheme began and Capital Value and Improved Value are no longer recorded having been replaced by a 'Land Value' which includes elements of both Capital and Improved Value plus some additional measures. Consequently the only value that was available for the entire region since the scheme began was the Unimproved Value.

The Unimproved Value is defined by the 1951 Valuation of Land Act as "the sum which the owner's estate or interest therein, if unencumbered by any mortgage or other charge therein, might be expected to realise at the time of valuation if offered for sale on such reasonable terms and combinations as a bonafide seller might be expected to impose, and if no improvements had been made on the said land". The Unimproved Value then measures the inherent potential of land before improvements added by man. It is therefore a measure of the suitability of the physical properties of the land for agricultural development.

It was originally planned to examine Unimproved Values for pre-scheme and post-scheme dates in order to identify long term trends in changing values. This was not possible as the Valuation Department has destroyed all records prior to the early 1950's. An analysis of pre-scheme value trends was therefore not possible.

The dates at which valuations in the various Counties have been made are different. In the Kairanga County valuations have been made in 1958, 1963, 1968 and 1973. In the Horowhenua County valuations have been made in 1955, 1960 and 1970. In the

Manawatu County valuations have been made in 1956, 1966 and 1971. All data collected was therefore converted to base dates of 1956, 1966 and 1972 either by extrapolation or reversion of the inter-valuation trends. By converting data to these base dates, it was thought that some allowance could be made for the effect of inflation and 'natural' land price increases. To make further allowance for this both absolute value changes and percentage changes were calculated.

Data was gathered for individual farms and collated by flood frequency area and drainage board area to show

1. the average value per hectare
2. the percentage increase in value per hectare
3. the range of value per hectare

The average value per hectare for each of the flood frequency areas as shown in Table XXX suggests that the flood hazard did not have a marked differential impact outside of the 0 - 11 months flood frequency area, at the time of construction of the flood control scheme. If the flood hazard did have a significant effect, then it would be expected that the highest flood frequency area would have the lowest value and the lowest flood frequency area the highest value. In actual fact the 0 - 11 month flood frequency area did have the lowest value and the 20 - 100 year flood frequency area had an average value almost double that. However the 1 - 4 year flood frequency area had an average value of only two dollars a hectare less than that of the 20 - 100 year flood frequency area and the area designated as receiving indirect benefits had the second lowest value per acre. This suggestedthat while the flood hazard may have had some effect on land values, it was likely that some other factors modified land values.

TABLE XXX - AVERAGE VALUE PER HECTARE BY FLOOD FREQUENCY AREAS

Floor Frequency Areas	1956 $	1966 $	1973 %
0 - 11 months	148	250	836
1 - 4 years	277	428	1221
5 - 19 years	232	361	1174
20-100 years	279	413	1528
Indirect benefit area	227	324	1051

Source: Compiled from Valuation Department Records

The fact that the hazard did have some effect on land values is reflected in the increases in values shown in Tables XXX and XXXI. Table XXXI shows the percentage increase in "inter valuation" dates and demonstrates the fact that the greatest increases in value in the 1956-1966 period were recorded in the areas of highest hazard frequency and the lowest increases in the areas of lowest hazard frequency.

TABLE XXXI - INTERVALUATION PERCENTAGE INCREASES IN UNIMPROVED VALUE

Floor Frequency Areas	Percentage Increase	
	1956-66	1966-73
0 - 11 months	66	237
1 - 4 years	54	183
5 - 19 years	55	225
20-100 years	48	270
Indirect benefits areas	42	224

Source: Compiled from Valuation Department Records

The distribution of increase for the 1956-66 period suggests the flood scheme released the differential latent potential of the different flood frequency areas and that this was reflected in changes in land values. The percentage increases in values for the period 1966-73 as shown in Table XXXI suggested that the effect of the flood hazard may have been removed by this later period as the distribution of percentage increases in values followed no set pattern.

Table XXXII, which further breaks down the distribution of values shows that the trend noted in Table XXXI holds true for all Drainage Board Areas expect for the Buckley Drainage Area and the area that lies above Palmerston North. The small number of farms in these areas may be partly responsible for this deviation from main trends.

TABLE XXXII

PERCENTAGE ANNUAL INCREASE IN VALUE ($) PER HECTARE

Drainage Board Area	Year	Flood Frequency Area				
		0-11 months	1-4 years	5-19 years	20-100 years	indirect benefits area
Manawatu	1956-66 1966-73	4.2 63	2.3 41	2.8 44	2.6 47	2.4 43
Makerua	1956-66 1966-73		6.8 23		4.5 25	5.9 21
Moutoa	1956-66 1966-73	10.7 30	10.9 27	7.8 28	7 23	9 27
Whirokino	1956-66 1966-73					10.1 27
Bainesse	1956-66 1966-73					9.6 29
Sluggish River	1956-66 1966-73	7.8 21	4.3 26		5.6 30	5.2 25
Oroua	1956-66 1966-73				1.3 52	5.5 21
Buckley	1956-66 1966-73			.8 23	13 61	4.8 26
Outside of a Drainage Board Area	1956-66 1966-73		8 8	9 22	3.6 54	5.3 24
Area lying above Palm Nth	1956-66 1966-73		3.8 39	3.3 41	6.1 35	

Source: Compiled from Valuation Department Records

The average value per hectare recorded by flood frequency and drainage board areas is shown in Table XXXIII. An examination of the distribution of values in this table and in Table XXXII indicates that there was a considerable range in values and changes in values in the same flood frequency areas over the different drainage board areas, and that not all drainage board areas followed the trends outlined above. The most notable exceptions were the Buckley Drainage area and the area located above Palmerston North. One notable fact to emerge from these two tables was the great increase in land values in the later valuation dates, which leant support to the decision to use base years for the purposes of calculating the various trends.

The range in value per hectare for flood frequency areas within the different drainage board areas shown in Table XXIX revealed a similar trend to that noted for Tables XXXII and XXXIII. That is there was considerable variation within the same flood frequency areas between the different drainage boards.

The data presented in Tables XXXII to XXXIX did not produce many discernable trends, but served to demonstrate the dangers of over generalising in observations on the hazard and scheme effects from Tables XXX and XXXI.

The fact that changes and trends were not distributed exactly over the scheme area does not negate the drawing of the earlier conclusions as to the effects of the flood hazard and flood scheme on land values. They do suggest that the flood hazard and the flood scheme have not been the only factors that have determined land values, but they do suggest they have been important contributing factors.

TABLE XXXIII - AVERAGE $ VALUE PER HECTARE BY FLOOD FREQUENCY AREAS AND DRAINAGE BOARD AREAS

Drainage Board Area	Year	Flood Frequency Area				
		0-11 months	1-4 years	5-19 years	20-100 years	Indirect Benefit Area
Manawatu	1956	190	287	341	307	336
	1966	269	353	435	386	415
	1973	1199	1365	1763	1666	1656
Makerua	1956		257		287	235
	1966		433		415	373
	1973		1122		1152	934
Moutoa	1956	96	131	193	240	213
	1966	200	274	344	408	403
	1973	618	801	1018	1058	1152
Whirokino	1956					176
	1966					353
	1973					1006
Bainesse	1956					79
	1966					156
	1973					472
Sluggish River	1956	158	314		307	255
	1966	282	450		480	388
	1973	692	692		1499	1042
Oroua	1956				321	216
	1966				499	245
	1973				1278	1140
Outside of Drainage Board Area	1956		314	156	418	250
	1966		566	297	569	383
	1973		878	749	2702	1018
Buckley	1956			210	57	210
	1966			378	131	311
	1973			1004	692	873
Area lying above Palmerston Nth	1956		353	262	415	
	1966		499	349	670	
	1973		1829	1337	2311	

Source: Compiled from Valuation Department Records

TABLE XXXIV- RANGE IN VALUE PER HECTARE BY FLOOD FREQUENCY AREA AND DRAINAGE BOARD AREA

Drainage Board Area	Year	Flood Frequency Area				
		0-11 months	1-4 years	5-19 years	20-100 years	Indirect Benefit Area
Manawatu	1956 1966 1973	82-311 151-408 672-1856	171-400 220-447 952-1869	269-420 358-502 1342-2247	176-292 265-539 1046-2707	267-425 297-579 1211-2672
Makerua	1956 1966 1973	- - -	245-267 344-522 964-1280	- - -	161-388 245-534 776-1357	195-321 242-519 591-1298
Moutoa	1956 1966 1973	96 200 618	131 274 801	141-260 277-378 811-1174	146-326 220-504 774-1533	136-341 319-433 915-1310
Whirokino	1956 1966 1973	- - -	- - -	- - -	- - -	176 353 1006
Bainesse	1956 1966 1973	- - -	- - -	- - -	- - -	49-116 109-205 405-598
Sluggish River	1956 1966 1973	158 282 692	232-400 334-564 1043-1533	- - -	215-465 262-742 638-2299	193-331 277-494 690-1454
Oroua	1956 1966 1973	- - -	- - -	- - -	220-289 346-742 989-1404	277-366 418-581 1068-1488
Buckley	1956 1966 1973	- - -	- - -	205-218 349-398 808-1100	57 131 692	138-262 176-450 541-1248
Outside Drainage Board Area	1956 1966 1973	- - -	314 566 878	133-178 237-282 566-932	304-531 549-588 2578-2828	208-294 316-450 702-1263
Area above Palmerston North	1956 1966 1973	- - -	247-418 465-529 1686-1052	178-319 237-445 873-1698	415 670 2311	- - -

Source: Compiled from Valuation Department Records

CONCLUSION

The Lower Manawatu Flood Control Scheme has both directly and indirectly altered the physical shape and setting of the lower Manawatu region. Parts of the study area have been changed from unproductive lands (in the sense of their agricultural usage) to productive lands. Changes in the intensity and nature of land use have been noted and commented upon above.

Other studies (McNeil Adams 1968) have noted such changes and attributed them to the effects of the Lower Manawatu Flood Control Scheme implying the scheme represented not only a beneficial impact upon the area but also the 'best' adjustment (or only adjustment) man could have made to the flood hazard in the area.

While it is recognised that some areas have benefited from the flood control scheme, the point has been raised whether or not there have been some detremental effects, particularly long term environmental effects on the region. Of more central importance to the thesis is the fact that of the alternative adjustments that were theoretically possible many were not considered by the Catchment Board in their decision on the adjustment to the flood hazard in the Lower Manawatu region.

This latter observation led to an examination of the decision-making process of the Manawatu Catchment Board and an examination of and comparison of the Catchment Board's and the Resource users' perception of the flood hazard and effects of the flood scheme on landuse and production.

The research findings revealed significant differences existed between the Catchment Board's and floodplain managers' perceptions of the flood hazard. Characteristics and attributes of the floodplain managers' were then examined in an attempt to isolate those factors that might influence an individuals hazard perception and so provide possible insights into the difference between the Catchment Board's and resource users' hazard perception.

It was noted that the individuals hazard perception was influenced by his past hazard experience and possibly by the area of a farm that lay in the floodplain. Of these two factors 'past hazard experience' had the more significant influence. The farmers attitude towards future flooding was also shown to be affected by his past hazard experience. The considerable variation that existed amongst resource users of the same resource was partly explained by reference to the above factors.

The identification of the fact that the hazard perceptions of the Catchment Board and the farmers did vary and that the floodplain managers' hazard perception influenced his attitude to the flood hazard and the flood scheme and therefore his production patterns, suggested that the resource users' hazard perception should be sought in decisions as to the nature of future hazard adjustments.

The study noted possible defects in the official decision making process and suggested possible avenues that could be explored in improving the decision making process to ensure an improved adjustment to the flood hazard in the future. The research findings hold implications not only for future projects in other areas but also for the future of the Manawatu region affected by the scheme. It is important to remember that the 'planning' of a flood protection scheme does not end when the scheme or plant is built. There is an inherent responsibility on the part of the decision makers to continue their planning by taking into consideration the new and changed conditions. Responses by farmers and other bodies in the area as well as environmental changes must continue to be monitored in an attempt to ensure best use is made of the new conditions.

This study suggests a form of advocacy planning as a means of ensuring that this best use is achieved. The process should begin by soliciting the resource users view of the hazard and it should continue to elicit their view of post scheme conditions. Only in this way can the real problems and deficiencies in official policies be realised and either corrected by a reappraisal of the problem, or an educative programme introduced directed at informing the resource users of the potential of the changed conditions, for increased production and new land uses.

By revealing that land use changes have not occured as originally predicted by the Catchment Board, and that many factors that have not yet been fully identified influencing a resource user's response to the flood hazard, this thesis has probably raised more questions than it has answered. The intention or purpose of the study has thus been fulfilled, that is, there has been shown to be a need for more involvement in the decision making process by those affected by the decisions. This arises from the observations that the resource users perception of a situation influences the response to that situation and that perception varies between and among different groups.

APPENDIX A

(1) What is the basis of ownership of this farm?

a) owned

b) leased

c) other (please state)

(2) Is this property farmed as an independent unit or is it farmed as part of a larger unit? Please give details.

(3) How long have you farmed this property? .... years

(4) What is the size of this farm? .... acres

(5) What changes in farm size have occurred since 1950?
(Size change and date)

One of the aims of this survey is to examine trends in farm expenditure before and after the flood scheme. Would you please indicate average annual expenditure on the following items.

(6)

	Pre Scheme (1950-63)	Post Scheme (1963-73)
fencing		
stumping		
clearing		
drainage		
grassing		

	Pre Scheme (1950-63)	Post Scheme (1963-73)
buildings		
farm machinery		
fertilizer		
spraying		
feed purchased for stock		

(7) How many were employed on this farm in

	Permanent Staff	Seasonal Labour
1955		
1965		
1973		

(8) What wages were paid to these employees in:

	Permanent Staff	Seasonal Labour
1955		
1965		
1973		

(9) How many acres of land are flooded each year. Please indicate average acreage and length of time pasture etc. is unable to be used.

	Impeded drainage	River flooding
Before the scheme		
After the scheme		

DAIRYING

(10) Please complete as much of the following as possible:

	1955	1965	1973
number of cows milked			
replacements carried			
bobby calves sold			
calves carried			
butterfat production			
town milk production			
number of herd wintered off			

SHEEP

(11) Please complete as much of the following as possible:

	1955	1965	1973
number of ewes			
number of hoggets			
number of wethers			
number of lambs			
number of others			
number of sheep sold yearly			
wool production			

RUN CATTLE

(12) Please complete as much of the following as possible:

	1955	1965	1973
number of breeding cattle			
number of steers			
number of bullocks			
number of beef cattle			
number of dry cattle			
number of others			
number summer grazed			
number winter fattened			
number cattle sold annually			
number of other animals (hens, pigs etc.)			

CROPPING

(13) Please complete as much of the following as possible. Please indicate type of crop and acreage grown in following years:

type of crop	1955	1965	1973

In order to ascertain what effect <u>you</u> think the flood scheme has had on your farm activity please answer the following:

(14) Do you consider that the productivity of your farm has benefited directly or indirectly from works undertaken in conjunction with the flood scheme? If so then

a) What do you think the direct benefits (e.g. increased production) have been and what would you estimate their value to be?

b) What do you think the indirect benefits have been and what would you estimate their value to be?

(15) How much would you estimate these benefits to be worth in total?

(16) Have you undertaken any improvements or expenditures which you could not have previously done prior to the flood protection scheme? Please give details of nature and cost.

(17) Have you undertaken any improvements or expenditures to take advantage of the flood protection scheme? Please give details of nature and cost.

(18) Have there been any harmful side effects from the scheme?

(19) What do you think the nature and productivity of your farm would be like today if the flood scheme was not present?

BIBLIOGRAPHY

Books

Acheson, A.R., 1968, River Control and Drainage in New Zealand

Allee, D.J. and Chapman, D., 1973, The Economics of Water Development and Environmental Quality. In C.R. Goldman (ed) Environmental Quality and Water Development.

Burton, I., 1961 (a), Some Aspects of Flood Loss Reduction in England and Wales. In G.F. White (ed), Papers on Flood Problems.

Burton, I., 1961 (b), Invasion and Escape on the Little Calumet. In G.F. White (ed), Papers on Flood Problems.

Burton, I., 1962, Types of Agricultural Occupance of Floodplains in the United States.

Burton, I., 1965, Investment Choices in Public Resource Development. In A. Rotstein (ed), The Prospect of Change, 149-173.

Burton, I., et al, 1968, The Human Ecology of Extreme Geophysical Events, Natural Hazard Working Paper No. 2.

Chorley, R.J. and Kennedy, B., 1971, Physical Geography. A Systems Approach.

Dasgupto, A.K. and Pearce, D.W., 1972, Cost Benefit Analysis. Theory and Practice.

Department of Agriculture, 1968, Farming in the Manawatu.

Eckstein, O., 1958, Water Resource Development. The Economics of Project Evaluations.

Eipper, A.W., 1973, The Role of the Technical Expert in Decision-Making. In C.R. Goldman (ed), Environmental Quality and Water Development.

Foster, E.E., 1949, Rainfall and Runoff.

Finer, H., 1944, The T.V.A. Lessons for International Application.

Frost, M.J., 1971, Values for Money. The Techniques of Cost Benefit Analysis.

Goldman, C.R., 1973, Environment Impact and Water Development. In C.R. Goldman (ed), Environmental Quality and Water Development.

Henwood, K. and Coop, C., 1973, Impact Analysis and the Planning Process. In C.R. Goldman (ed), Environmental Quality and Water Development.

Hoyt, W.G. and Langbein, W.B., Floods.

Kates, R.W., 1962, Hazard and Choice in Floodplain Management.

Kates, R.W., 1965, Industrial Flood Losses. Damage Estimation in the Lehigh Valley.

Kinori, B.Z., 1970, Manual of Surface Drainage Engineering. Vol. 1.

Krutilla, J.V. and Eckstein, O., 1957, Multiple Purpose River Development.

Krutilla, J.V., (ed), 1972, Natural Environments. Studies in Theoretical and Applied Analysis.

Leopold, L.B. and Maddock, T., 1954, The Flood Control Controversy.

Lowenthal, D., (ed), 1967, Environmental Perception and Behaviour.

McCloskey, M., 1973, Alternatives in Water Project Planning: Ecological and Environmental Considerations. In C.R. Goldman (ed), Environmental Quality and Water Development.

McHarg, L. and Clarke, M.G., 1973, Skippaca. Watershed and the Evansburg Project : A Case Study for Water Resources Planning. In C.R. Goldman (ed), Environmental Quality and Water Development.

Maass, A., et al, 1962, Design of Water Resources Systems.

Ministry of Works, 1971, Landuse Capability Survey Handbook.

Moser, C.A. and Kalton, C., 1971, Survey Methods in Social Investigation.

Murphy, F.C., 1958, Regulating Floodplain Development.

Nemec, J., 1964, Engineering Hydrology.

Peterson, E.T., 1954, Big Dam Foolishness; The Problem of Modern Flood Control and Water Storage.

Renshaw, E.F., 1959, Toward Responsible Government : An Economic Appraisal of Federal Investment in Water Resource Progress.

Saarinen, T.F., 1966, Perception of the Drought Hazard on the Great Plains.

Saarinen, T.F., 1970, Environmental Perception. In P. Bacon (ed), Focus on Georgraphy: Key Concepts and Teaching Strategies, 63-99.

Saunders, B., (ed), 1964, Introducing the Manawatu.

Tolley, G.S. and Riggs, F.E., (ed), 1961, Economics of Watershed Planning.

White, G.F., 1945, Human Adjustment to Floods. A Geographical Approach to the Flood Problem in the U.S.A.

White, G.F., (ed), 1958, Changes in the Urban Occupance of Floodplain in the U.S.A.

White, G.F., (ed), 1961 (b), Papers on Flood Problems.

White, G.F., (ed), 1964 (a), Choice of Adjustment to Floods.

White, G.F., (ed), 1964 (b), Floodplain Adjustments and Regulation. In V.T. Chow, Handbook of Applied Hydrology; and Compendium of Water Resources Technology.

White, G.F., 1969, Strategies of American Water Management.

White, G.F., et al, 1969, A Unified National Program for Managing Flood Losses. Report of the National Task Force for Flood Control. 89th Congress 2nd Session 1967.

White, G.F., 1973, Public Opinion in Planning Water Development. In C.R. Goldman, (ed), Environmental Quality and Water Development.

Wolfe, J.N., (ed), 1973, Cost Benefit and Cost Effectiveness.

World Meteorological Organisation, 1969, Estimation of Maximum Floods, Technical Note No. 98.

Articles

Benson, M.A., 1960, Characteristics of Frequency Curves Based on a Theoretical 1000 year Record, United States Geological Survey Water Paper No. 1543 A.

Benson, M.A., 1962 (a), Evaluation of Methods for Evaluating the Occurrence of Floods. United States Geological Survey Bulletin 1580 A.

Benson, M.A., 1962 (b), Factors Influencing the Occurrence of Floods in a Humid Region of Diverse Terrain, United States Geological Survey Water Supply Paper 1580 B.

Burrows, H.H., 1923, Geography as Human Ecology, A.A.A.G., Vol. 13, 1-14.

Burton, I. and Kates, R.W., 1964 (a), The Floodplain and the Seashore; A Comparative Analysis of Hazard Zone Occupance. The Geographical Review, 54, 366-385.

Burton, I., and Kates, R.W., 1964 (b), Perception of Hazard in Resource Management, Natural Resources Journal, 3, 412-441.

Burton, I., et al, 1965 (b) The Shores of Meglopolis: Coastal Occupance and Human Adjustment to the Flood Hazard, Publication in Climatology, XVIII, 3.

Erickson, N.J., 1971, Human Adjustment to Floods in New Zealand, N.Z. Geogr., 27, 105-129.

Goddard, J.E. and Weathers, J.V., 1969, Principles and Procedures in Floodplain Management, A.S.C.E. Hydraulics Division, 95 (H.Y. 4, No. 6696).

Goddard, J.E., 1971, Floodplain Management must be Ecologically and Economically Sound, Civil Engineering A.S.C.E., 41, 9, 81-85.

Gumbel, E.J., 1958, Statistical Theory of Floods and Droughts, Journal of the Institute of Water Engineers, 12, 157-184.

Hammond, R.J., 1966, Convention and Limitations in Benefit Cost Analysis, Natural Resources Journal, 6, 195-222.

Hart, H.C., 1957, Crisis, Community and Consent in Water Politics, Law and Contemporary Problems, 22, 510-537.

Hines, N.W., et al, 1970, Suggestions for a Floodplain Zoning Ordinance, Land and Water Law Review, 5, 2.

James, D.L., 1965, Nonstructural Measures for Flood Control, Water Resources Research, 1, 9-24.

James, D.L., 1967, Economic Analysis of Alternative Flood Control Measures, Water Resources Research, 3, 333-343.

James, D.L., 1972, Role of Economics in Planning Floodplain Landuse, ASCE Hydraulics Division, 98, H.Y.6, 981-992.

James, L.D. and McFall, R.L., 1970, Principles and Procedures in Floodplain Management, ASCE Hydraulics Division, 96,H.Y.1, 302-3.

Krutilla, J.V., 1966, An Economic Approach to Coping with Flood Damage, Water Resources Research, 2, 183-190.

Langbein, W.B., 1953, Flood Insurance, Land Economics, 29, 323-330.

Leopold, L.B., et al, 1971, A Procedure for Evaluating Environmental Impact, U.S. Geological Survey Circular 645.

Lind, R.C., 1967, Flood Control Alternatives and the Economics of Flood Protection, Water Resources Research, 3, 2, 345-57.

Long, S.G.W., 1949, Runoff in the Manawatu Catchment, N.Z. Engineering, Sept., 15.

Russell, C.S., 1970, Losses from Natural Hazards, Journal of Land Economics, 46, 4, 383-393.

Weber, E.W. and Sutton, W.G., 1965, Environmental Effects of Floodplain Regulations, ASCE Hydraulics Division, 91, HY4, 59-70.

Whipple, W., 1968 (a), Optimum Investment in Structural Flood Control, ASCE Hydraulics Division, 94, HY 6, 1507-1515.

Whipple, W., 1968 (b), Flood Control Alternatives and Flood Insurance, Civil Engineering, ASCE, Feb. 1968, 68-69.

Whipple, W., 1969, Optimising Investment in Flood Control and Floodplain Zoning, Water Resource Research, 5, 41, 761-766.

White, G.F., 1960, Strategic Aspects of Urban Floodplain Occupance, Journal of the Hydraulics Division, ASCE, 86, 89-102.

White, G.F., 1961 (a), Choice of Use in Resource Management, Natural Resources Journal, 1, 23-40.

White, G.F., 1966, Optimal Flood Damage Management, Retrospect and Prospect in A.V. Kneese and S.C. Smith, Water Research.

Wolman, M.G., 1971, Evaluating Alternative Techniques of Floodplain Mapping, Water Resources Research, 7, 6, 1383-91.

Unpublished Reports

de Leon, P.R.L., 1967, Preliminary Report on Drainage Improvement in the Taonui and Lockwood Area. Unpublished Report, Manawatu Catchment Board.

Evans, P.G., 1951, Manawatu Catchment Board Lower Manawatu Scheme Economic Report. Unpublished Report. Manawatu Catchment Board.

Forbes, R.N., 1970, Report on Agriculture and the Benefits from Water Control in the Taonui Basin - Colyton Catchment.

Holley, D.J.B., 1946, Report on a Proposed Scheme of Flood Control for the Lower Manawatu River. Unpublished Notes. Manawatu Catchment Board.

Taylor, C.E., n.d., Historical Notes on the Manawatu Area. Cyclostyled Notes, Manawatu Catchment Board.

Maps

Unpublished map, Rainfall Associated with Storm Types, Manawatu Catchment Board.

Rainfall records, N.Z. Meteorological Service

N.Z. Valuation Department records, Palmerston North Office.

Newspapers

Dominion, 1953, February 7th

Manawatu Evening Standard, 1953, February 7, 19

Manawatu Herald, 1953, April 24.

The Times, 1945, July 18, 1953, February 7, 11.