INQUIRY INTO FLOOD MITIGATION MEASURES FOLLOWING CYCLONE BOLA

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Research
Jennifer Boshier, BE(Chem)

Consultants
Craig Trotter, BSc Hons, PhD
Barry Harris, MAgrSc Hons
William Kirkland, MAgrSc, and
Jeremy Neild, BAgrSc
Graeme Smart, BE Hons, PhD
George Stainton

Editor
Jeanne Boland, BA Hons, MA

Typist
Kim Monkhouse

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Parliamentary Commissioner for the Environment
PO Box 10-241
Wellington
New Zealand

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FOREWORD

Public awareness of the widespread devastation caused by the Cyclone Bola storm in March of this year is fading from the national memory. The Bola storm did not cause new environmental problems but it did exacerbate already existing ones.

The Bola storm highlighted the risks that many communities in New Zealand have from flooding rivers. The damage that is caused by floodwaters has been all too apparent this year. There have been two major storms in the East Coast region, flooding in the Wairarapa and Manawatu regions and two major floods in Greymouth.

The Planning and Development Select Committee requested me to conduct an inquiry into flood mitigation measures. This inquiry was to examine the effectiveness of present policies and practices, as well as assess the likely effects of new policies on future flood protection measures.

The stated reasons for reducing the effects of flood damage have, in the past, centred on protection of rural and urban assets including agricultural production. This goal has, in general, been achieved and many communities have benefited. However, it is also true to say some communities have suffered and some land areas have become degraded.

There has been a change in policy from trying to contain flood waters to trying to avoid damage from flood waters over the last 10 years. But the policies and practices for avoidance measures are not as specific and responsibilities are not as clear as for containment measures.

This inquiry has concluded that it is time to change policies and practices to the goal of sustainable land use for all the New Zealand land area. Policies and practices for today should recognise that sustainability of land use applies to both the hill country and flood plains. The policies should recognise that measures to keep people away from floodwaters, as well as floodwaters away from people are required as well as measures to deal with the consequences of flooding. A number of recommendations have been made in this report for the Planning and Development Select Committee's attention. I trust the Committee will give them due consideration and will urge Government action so that progress in limiting flood damage to communities can then be made.

Helen R. Hughes

Helen R Hughes
Parliamentary Commissioner for the Environment

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EXECUTIVE SUMMARY

1 **The more serious floods in New Zealand arise from high intensity, long duration rainfall periods. The severity of the flood depends largely on:**

* the size and nature of the catchment receiving the rain;
* the amount of soil and debris that has accumulated in the river channels over time;
* the ability of the river channel to contain floodwaters;
* the extent and time that floodwaters remain on the surrounding floodplain.

2 **The damage caused by high intensity rainfall includes:**

* the loss of soil;
* the loss of trees within plantations as well as access within forests;
* the loss of farm assets including stock;
* the loss of pasture for primary production;
* the loss of horticultural crops through inundation by floodwaters;
* the damage to public property and services by floodwaters;
* the potential social disruption to some of the one million people who live on floodplains.

3 **The following are policies and practices that mitigate the effects of major flood events:**

* soil conservation works, on individual farms or on a group of farms within a catchment, to minimise erosion of soil;
* large-scale afforestation which minimises erosion of soil and slows down the accumulation of debris in river channels;
* river control and management through river control schemes or individual works which improve the ability of the river channel and adjacent land to transport floodwaters;
* flood hazard mapping to assess the risk of damage from floodwaters on the floodplains;
* land use planning which guides development on the floodplains so that capital investment and infrastructure will not be put at undue risk from floodwaters;
* flood forecasting and flood warning systems installed to give advice on a developing flood situation;

* floodplain management planning which examines all the policies and practices that reduce flood damage in a more coordinated manner.

4 **These policies and practices have limitations:**

* river control schemes, which have been the principal means of flood mitigation over the last 40 years, require continuous assessment and maintenance to secure their integrity;

* public perception of river control schemes has been that the schemes offer an absolute standard of flood protection and unwise intensive development behind stopbanks has often been encouraged;

* soil conservation works are perceived by the public as works to protect and enhance agricultural production rather than as works to protect the soil and land resource;

* where flood hazard information has been collected, it has not always been utilised to provide effective controls in district planning schemes;

* zoning of floodplains has been unpopular with landowners and many local authorities who do not wish to see a fall in the market value of land.

5 **The effectiveness of these policies and practices during the Bola storm in the East Cape region was:**

* soil erosion was minimised in hill country catchments by large scale afforestation where trees were older than 8 to 10 years, or by indigenous forest;

* less damage occurred on farms where soil conservation works had been established;

* the Waipaoa River Flood Control Scheme enabled a major flood (in excess of a 100 year period) to pass to the sea;

* the partially completed stopbank at Te Karaka prevented floodwaters from flowing through the town centre;

* the civil defence organisation in the East Cape Region received timely advice on the developing flood situation from information obtained from the Catchment Board's flood forecasting system.

6 **Assessment of the effectiveness of the policies and practices for this inquiry was assisted by:**

* the New Zealand Land Resource Inventory land classification system developed by the Ministry of Works (now DSIR's) Soil Conservation Centre. This system allows land use options to be assessed based on land capability, including the erosion potential of the land;

* information about sediment transport in rivers as it affects river control design and management;

* a benefit/cost analysis of the Waipaoa River Flood Control Scheme which shows a positive internal rate of return of 13 per cent, even without quantifying the social and environmental benefits of the scheme;

* evidence of removal of material from a stream bed instead of more accumulation in a fully forested catchment in the Waipaoa River headwaters.

7 **Constraints to assessing the effectiveness of the policies and practices were:**

* a lack of agreed methodology to quantitatively assess effectiveness of soil conservation works for erosion control;

* a lack of agreed standards or guidelines for river control design work which take into account the nature and variability of river systems in New Zealand;

* the difficulty of quantifying social and environmental benefits of river management schemes and works into benefit/cost analyses.

8 **Future mitigation of flood damage to achieve a goal of sustainable land use both in hill country catchments and on floodplains requires action by both central and regional government:**

(a) **Central Government**

(i) **Ministry for the Environment**

* development of policies for soil conservation within the context of sustainable land use, including the NWASCA 1987 policy statement (sec. 2. 8. 1);

* development of monitoring policies for soil conservation within the context of sustainable land use to evaluate whether policy objectives are being achieved (sec. 2. 8. 1);

* the funding of part of the cost of soil conservation activities in the context of sustainable land use in recognition of the importance of the off-site benefits and the benefits that will be accrued to future generations (sec. 2. 8. 1);

* provision of positive suggestions to the new Gisborne Regional Council as to how changes to achieve sustainable land uses and mitigation of damage from floods can be instituted in the north of the East Coast region.

* the undertaking of research into systems for allocating financial responsibility for future flood mitigation measures and for resource management. These systems would: (a) delineate between individual, regional and national user/beneficiaries as well as risk generators; and (b) delineate between those who contribute to off-site risks and those who benefit from the protection provided (sec 7. 1);

* the undertaking of research into more consistent assessment frameworks and presentation to give due account to social and environmental factors as well as financial factors (sec. 3. 6);

(ii) **Resource Management Law Reform**

* inclusion in any new planning legislation of the requirement for natural hazard

mapping, including flood hazard mapping (sec. 4. 6);

* consideration of extending the term of a Section 34 notice or similar mechanism up to 15 years in any new water and soil management legislation.

* inclusion in any new planning legislation of the intent to restrict unwise developments in flood prone areas (sec. 4. 6);

* inclusion in any new planning legislation of floodplain management planning as a basis for planning land uses on floodplains (sec. 6. 3);

(iii) Ministry for the Environment, Ministry of Agriculture and Fisheries and Ministry of Forestry

* recognition that policies on soil conservation and land management should be integrated to achieve the goal of sustainable land use (sec 2. 8. 1);

(iv) Ministry for the Environment and the new Resource Management Agencies

* recognition that sufficient funding for future capital works, such as flood protection schemes and other resource management projects should be made available to complete works as quickly as possible. Delays in construction adversely affect economic viability when the project is subjected to discounting (sec. 3. 6);

(v) Local Government Reform

* recognition that flood forecasting and flood warning should become a regional responsibility and function (sec. 5. 6);

(vi) Department of Scientific and Industrial Research

* maintenance and refinement of the New Zealand Land Resources Inventory land classfication system so as to continue to provide a sound basis for land use planning according to the capability of the land (sec. 2. 2);

* continuation of research into the effectiveness of soil conservation activities in the context of sustainable land use and to evaluate and quantify, if possible, the on-site and off-site benefits to be achieved (sec. 2. 8. 1);

* integration of Water Resources Survey telemetry sites into the relevant regional resource management agency's telemetry system (sec. 5. 6).

* consultation with the Ministry for the Environment and the New Zealand Catchment Authorities Association, or its successor, to ensure that the research needs of water and soil resource management are identified and met;

* encouragement to continue to provide training in land use assessment and management to staff of the new regional resource management agencies (sec. 7. 1);

(b) The new Resource Management Agencies

* emphasis on social and environmental impacts as well as financial ones where these factors are significant in assessments of flood mitigation measures and

other resource management activities (sec. 3. 6);

* planning and appraisal of future flood mitigation measures on a catchment or sub-catchment basis (sec. 6. 3);

* documentation of one or two areas with recently completed soil conservation measures in a catchment or sub-catchment each year for the purpose of accumulating baseline data for the future assessment of the effectiveness of these works (sec. 2. 5. 3);

* provision of resources to document the effectiveness of soil conservation measures after a significant storm in a catchment or sub-catchment for which detailed information is available (sec. 2. 5. 3);

* recognition of the importance of maintenance of existing river control schemes where these schemes are meeting agreed objectives for mitigation of flood damage (sec. 3. 7);

* production of flood hazard information according to an agreed regional list of priority areas (sec. 4. 3);

* provision of flood hazard information to the public and other relevant regional agencies (sec. 4. 4);

* recognition that the civil defence section and the flood forecasting section of the organisation should be co-ordinated so that flood situations can be identified and information disseminated in time to mitigate damage (sec. 5. 5);

* extension or upgrading of flood forecasting telemetry systems so that major catchments can be monitored for developing flood situations (sec. 5. 6);

(c) The new Gisborne Regional Council

* increased consideration to the long term planning of soil conservation works and large scale afforestation on the basis of the sustainability of land use, as particularly reflected in the potential of land for erosion (sec. 2. 2);

* increased recognition of the sustainability of land use, as particularly reflected in the potential for erosion of hill country land in indicating appropriate land uses in district and regional planning schemes (sec. 2. 2);

* encouragement of soil conservation and pastoral agriculture, or production forest on the 110,000 hectares of Class 2 land instead of pastoral agriculture with no soil conservation works (sec. 2. 9);

* encouragement of production/protection forestry or managed reversion on the 77,500 hectares of Class 3b, 3c, 4 land instead of pastoral agriculture (sec. 2. 9);

* recognition that any policy development or implementation of policy for promoting sustainable land use that impacts on Maori land should involve consultation with Te Runanga O Ngati Porou and Runanga O Te Aitanga-A-Mahaki (sec. 2. 9);

* development of policies and funding arrangements for sustainable land uses in consultation with communities in the East Cape (sec. 2. 9);

* maintenance of the Waipaoa River Flood Control Scheme and augmentation of the effectiveness of the Scheme by integration with other flood mitigation measures (sec. 3. 6);

* provision of the long-term security of the Waipaoa River Flood Control Scheme by giving high priority to afforestation and other soil conservation measures in the Upper Waipaoa River Catchment within best technical options (sec. 3. 6);

* full appraisal of the commercial and conservation impacts when assessing the total worth of afforestation undertaken in the Upper Waipaoa River Catchment (sec. 3. 6);

(d) The new Hawkes Bay Regional Council

* development of policies for sustainable land uses in consultation with communities in the new Hastings and Wairoa districts (sec. 2. 9).

(e) The New Zealand Catchment Authorities Association or its successor

* consideration to establishing both a Soil Conservation Action Team and a Flood Hazard Action Team to assist the new regional resource management agencies if needed after a major storm or flood. These teams could be appointed on an annual basis (sec. 2. 5 and sec. 4. 2).

TERMS OF REFERENCE

The Planning and Development Select Committee of the House of Representatives requested the Parliamentary Commissioner for the Environment, subject to s. 16(1)(d) of the Environment Act 1986, to conduct an inquiry into flood protection measures following the Cyclone Bola storm in March 1988. The terms of reference for the inquiry were:

1 To evaluate those policies and management practices designed to prevent or ameliorate the effects of major flood events prior to Cyclone Bola (March 1988). This will include:

   (a) identifying those policies and management practices designed to prevent, or ameliorate the effects of major flood events, both by local and central government agencies;

   (b) identifying the adequacy of these practices in the context of Cyclone Bola in 1988;

   (c) conducting a cost benefit analysis of these practices.

2 To assess the likely effects of new policies and institutional arrangements on future flood protection measures in the East Cape.

3 To report findings and remedial advice to the Planning and Development Select Committee for use or referral as appropriate.

Flood mitigation involves a variety of interrelated measures to minimise the effects of flood hazard. This inquiry has focussed on: flood forecasting and flood warning systems, flood hazard mapping, land use planning, physical works for flood containment and soil erosion control, and floodplain management. The effectiveness of these measures to mitigate flood damage has been examined and recommendations on the development of future policies for flood mitigation measures are given. All recommendations are directed in the first instance to the Planning and Development Select Committee with the expectation that the Committee will endorse them and urge action by government at both national and regional levels. New resource management agencies are expected to be established by the Local Government Reform process currently in progress. Recommendations for regional government have thus been addressed to the new agencies.

The main source of information for this inquiry has been the East Cape Catchment Board. Information on various aspects of the inquiry was requested from other catchment boards and territorial authorities. The wider perspective gained by these contributions has highlighted the variable nature of the flood hazard throughout New Zealand and the means by which regions have sought to minimise flood damage.

1 BACKGROUND

1.1 Introduction

The main cause of rivers flooding in New Zealand is precipitation, with the most serious flooding arising from high intensity long duration rain periods. Intense rainfall can arise either from a cyclonic system or from a low pressure system. The most intense 24 hour rainfalls can be expected to occur in the north and east of the North Island and the west of the South Island.

The severity of a flood depends largely on the intensity and duration of rainfall, the size of the catchment receiving the rain, the vegetative cover on the land, the shape of the river channel and the nature of the surrounding floodplain. The factor that people can most readily influence is the vegetative cover on the land. Vegetative cover can also affect the extent of soil erosion that occurs during prolonged heavy rain.

1.2 Nature and extent of Bola storm

Cyclone Bola was the fourth tropical cyclone to affect New Zealand in the last 20 years. Most tropical cyclones tend to dissipate to a general low pressure area and bring heavy rain to northern and eastern North Island areas. Bola, however, maintained its cyclonic form.

Northland experienced cyclonic winds and floods of between a one in 50 and one in 200 year return period. There was widespread damage to horticultural crops and shelter. In the Bay of Plenty there was extensive silt and flood damage to the kiwifruit industry with an estimated 25 per cent of vines affected. High winds in the central North Island caused extensive damage to forestry. In Taranaki there was wind damage to horticulture and dairy production in coastal areas.

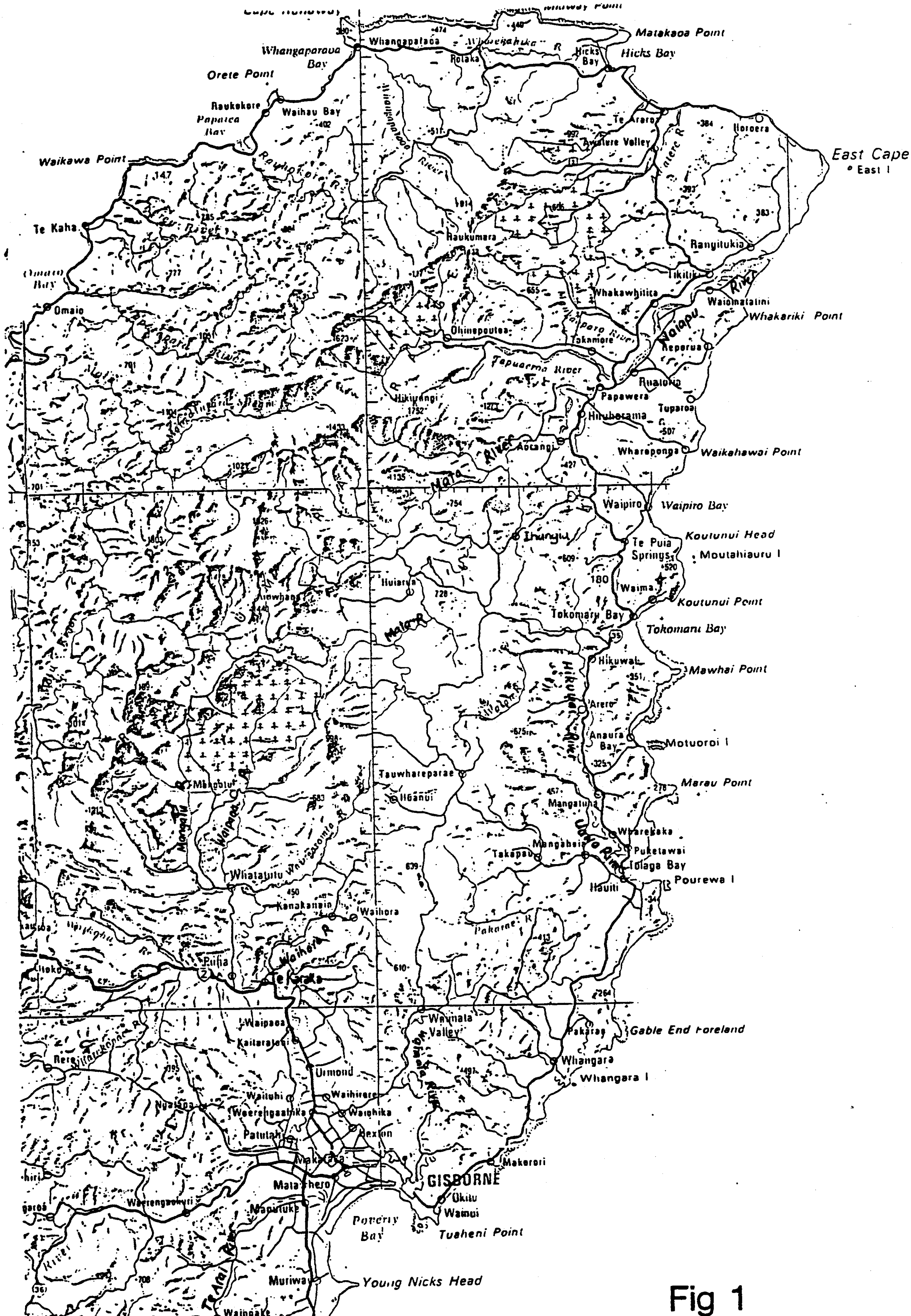
The prospect of heavy rainfall from Cyclone Bola in the East Cape region was anticipated by the New Zealand Meteorological Service. What was not expected was the non-stop rain over the period 6-9 March 1988. A peak rainfall of 916 mm over these three days was measured inland from Tolaga Bay; 600 mm was common and 400-500 mm widespread. These rainfall figures are the highest since records began in 1876.

Localised storms are common throughout New Zealand in which the total rainfall can be as high as those levels experienced during the Bola storm. The Bola storm affected most of the East Cape region but contained localised areas of intense rainfall within the main storm. The most intense rainfall areas were inland from Tolaga Bay, the Mata River catchment inland from Te Puia and the Te Arai catchment south of Gisborne. Further south, the Wairoa district and the Tutira-Waikare district north of Napier were hard hit by the Bola storm.

1.3 Effect of the storm in the East Cape region

The most intense rainfall fell on the steep, highly eroded hill country of the East Coast. Damage was more widespread than previous storm events due to the storm's regional nature. The bulk of the damage occurred in catchments with minor or no soil conservation works and no flood control schemes. Hill country to the south and west of the Poverty Bay flats, severely damaged in the July 1985 storm, was damaged again. All the old slip scars reopened and many new shallow slips developed. Severe erosion occurred in the Mata, Ihungia and Hikuwai catchment areas with both surface slipping and gully erosion occurring (refer to figure 1). Widespread cracking and deepseated slumping in many areas is of great concern since less intense rainfall could initiate further severe erosion.

All rivers in the region were affected, with peak flows in the Waipaoa River exceeding



Matakaoa Point
Hicks Bay
Whangaparaoa Bay
Orete Point
Raukokore
Waihau Bay
Waikawa Point
Te Kaha
Omaio
Te Araroa
East Cape
East I
Rangitukia
Tikitiki
Waiomatatini
Whakariki Point
Raukumara
Ruatoria
Hikurangi
Tapuaeroa River
Waiapu River
Mata River
Waipiro
Waipiro Bay
Koutunui Head
Te Puia Springs
Moutahiauru I
Koutunui Point
Tokomaru Bay
Hikuwai
Mawhai Point
Anaura Bay
Motuoroi I
Marau Point
Tolaga Bay
Pourewa I
Te Karaka
Gable End Foreland
Whangara
Whangara I
Ormond
GISBORNE
Poverty Bay
Tuaheni Point
Young Nicks Head
Muriwai
Waingake

Fig 1

discharges reached in the 1948 flood. The Uawa River at Tologa Bay deposited silt to depths up to 2 m. The rivers suffered bank erosion, scour and slumping.

The East Cape Catchment Board (1) estimated damage to the Waipaoa River Flood Control Scheme, the Te Karaka Flood Control Scheme and the Board's Drainage and River districts was $4 million. This estimate did not include damage to extensive lengths of riverbank and stopbanks on rivers not administered as a Drainage or River District.

Damage to farming in the East Coast/Hawkes Bay area (1765 farmers affected) included crop losses, erosion of pasture, stock deaths, fencing destruction and loss of access. Although much of the land which slipped can be regrassed, research conducted by the Department of Scientific and Industrial Research (DSIR) Soil Conservation Centre has shown that pasture production on landslide scars remains well below the production of uneroded sites, even 40 years after oversowing and with regular topdressing (2).

The most severe damage was siltation of intensively used valley floors on the Poverty Bay flats, at Tolaga Bay and the Waiapu flats. The Bola storm arrived just as harvesting of horticultural and viticultural crops was starting. The Poverty Bay flats suffered significant localised flooding which overtaxed the drainage system.

Damage to the region's infrastructure was severe. Roading and bridges were affected by the Bola storm. Railcorp estimated the cost of repair of the railway line to Gisborne including the Waipaoa River bridge at $3. 5 million. Roads within Cook County suffered extensive damage as did State Highway (SH) 36. Full reinstatement of damaged roads and bridges is estimated at $9. 7 million. Within Cook County SH36 requires repairs costing an additional $2. 03 million.

The loss of the water supply pipeline to Gisborne from the dams and bush catchment 35 kilometres away was a major impact of the Bola storm. Limited alternative water supplies for Gisborne City were provided from groundwater and from the Te Arai river catchment until remedial measures were put in place. Restoration of the water supply to Gisborne is estimated at $6. 6 million.

Major housing damage occurred in the region. Some 300 houses required either relocation or substantial renovation.

The total value of losses in principally young East Coast forests has been estimated at $8.6 million. This covers erosion and flooding damage to forests and includes damage to bridges, fences, roads and tracks.

There were other losses which are more difficult to quantify. The East Cape region has been affected by the economic downturn but people were meeting the challenge of the changing economic climate. For many people, unfortunately, the Bola storm dealt a severe blow to their ability and confidence to carry out plans for future development.

1. 4 Changes in considering flood hazards

Attempts to control flooding date from the time of European settlement in New Zealand. In the early days there was little regard for the impact of land development on the soils and hydrology of catchments. However, the disastrous floods on the east coast of the North Island in 1938 brought recognition of the need for catchment control which linked soil conservation and flood control.

The 1941 Soil Conservation and Rivers Control Act provided for the setting up of catchment boards and the foundation for managing flood-prone land in New Zealand. Subsequent to the passing of the 1941 Act, structural river works were the main means of achieving flood

mitigation. This was largely due to the need to protect life and property on the rapidly developing floodplains where many communities were situated.

Since the 1970s there has been a decrease in the planning and construction of new major flood control schemes as many high priority works have been implemented. There has also been a change away from containment measures to avoidance measures through planning legislation. Both the Town and Country Planning Act 1977 and the Local Government Amendment Act 1979 empower local territorial authorities to adopt measures to avoid damage from flooding.

The National Water and Soil Conservation Authority (NWASCA) was established in 1967 with the Soil Conservation and Rivers Control Council and the Water Resources Council responsible to the Authority. NWASCA was the co-ordinating and promoting agency on water resource and soil conservation matters; the catchment boards were delegated to carry out the statutory functions.

The emphasis of NWASCA on river control works to contain and mitigate flood damage slowly changed from the late 1970s to include promotion of policies aimed at the inclusion of flood hazard information into district and regional planning. These policies recognised that developments on a floodplain were always subject to the risk of flood damage and should be carried out with knowledge of that risk.

A major study on urban flood hazard in New Zealand (3) was undertaken by Dr Ericksen in the early 1980s. The research demonstrated that flood hazard is a function both of the flood event and the human use of the floodplain. Flood hazard can be described as the potential for a community to suffer flood losses to property, social disruption, and human casualties when a flood event occurs. Dr Ericksen concluded that there are many adjustment options that can be promoted to reduce flood loss susceptibility. These should be looked at in a unified manner with no one option being favoured at the expense of others.

In November 1987, NWASCA adopted a new floodplain management policy (4) which superseded its previous river control policy. The change of name of the policy indicated the shift in emphasis in policy development for natural hazards. The policy aim is to reduce the nation's flood losses consistent with the rational use of flood-prone land.

The Cyclone Bola storm should thus be seen within this changing emphasis, encapsulated in the NWASCA policy, towards floodplain management planning. Many catchment boards have already prepared flood hazard information for floodprone areas of their region and are having a greater or lesser influence on planning for prevention of future flood loss problems.

The adjustment options that are available can be broadly categorised as follows:

Category		Adjustment Option
1	Keeping flood waters away from people	Soil conservation, river control and management
2	Keeping people away from flood waters	Land use planning, flood forecasting and flood warning, floodplain management plans
3	Dealing with the consequences of flooding	Civil defence planning, disaster relief, insurance

This inquiry is concerned with categories 1 and 2 as, to some extent, the Primary Production Select Committee's Inquiry into Government Assistance to the East Coast region in the wake of Cyclone Bola dealt with category 3. It should be noted, though, that floodplain management planning incorporates all three categories of adjustment options.

2 KEEPING FLOODWATERS AWAY FROM PEOPLE - SOIL CONSERVATION

2. 1 Introduction

Land management affects not only the soil resource but also impacts upon water resources and flooding. In many places in New Zealand, soil and debris washed down from the hills during heavy rain moves into waterways. The eventual result is that river channels have less capacity to carry floodwaters.

In extreme cases, such as in the Gisborne - East Coast region, siltation is reducing the flow capacity of not only the river channels but also the floodway, that land adjacent to the river, between the stopbanks (refer figure 2).

Fifty years ago a devastating storm in the Esk Valley provided the impetus for the Soil Conservation and Rivers Control Act 1941 to be passed. This Act recognised that the growing land degradation which was arising from development of fragile lands for pastoral and arable use contributed to off-site effects such as downstream river channel instability and flooding. The Act provided for a partnership of national, regional and local interests to work together on soil conservation and river control. This work has been undertaken by catchment boards throughout New Zealand.

The emphasis of soil conservation works has changed over the years. Initially, erosion control works were undertaken predominately for off-site benefits. In the 1950s and 1960s on-farm erosion control activities were carried out, reflecting the nation's emphasis on primary production. The 1980s has seen another change. Soil conservation is now viewed as an important and necessary tool for the integrated management of the nation's soil and water resources.

This view is reflected in the NWASCA policy statement adopted in 1987 in which soil conservation is defined as "The management of land to yield the greatest sustainable benefits to present generations while maintaining the potential of that land to meet the needs and aspirations of future generations". To the public, however, erosion control works continue to be perceived largely as works to protect and enhance agricultural production, although some change in attitude is evident following Cyclone Bola (1).

Each catchment board has its own combination of geology, soils, geography and climate to understand and manage. In the East Cape Catchment Board area two main rivers, the Waipaoa and the Waiapu, rise on the southeast flanks of the Raukumara Ranges and flow through sedimentary soft-rock hill country. Over many thousands of years, these rivers have formed floodplains which are important to the region, especially the Poverty Bay flats (some 10,000 hectares) which have been intensively developed for horticulture.

During the past 110 years, extensive deforestation in the East Cape region has led to a phase of greatly accelerated, widespread, severe erosion. Evidence for this claim is clearly apparent in the way in which river channels have changed. Until the turn of this century, rivers in the region were reported as occupying well-defined channels in V-shaped valleys, with beds of hard boulders which were used to provide roading metal. Today, these original beds in certain reaches of the rivers have been covered by up to tens of metres of eroded material (5). In places, the rivers now meander over beds that are several hundred metres wide. Roading metal has to be brought in from outside the region.

The geology of the East Coast is essentially predisposed towards erosion. The two main rock types (mudstones and argillites) are inherently unstable, and have been weakened by the

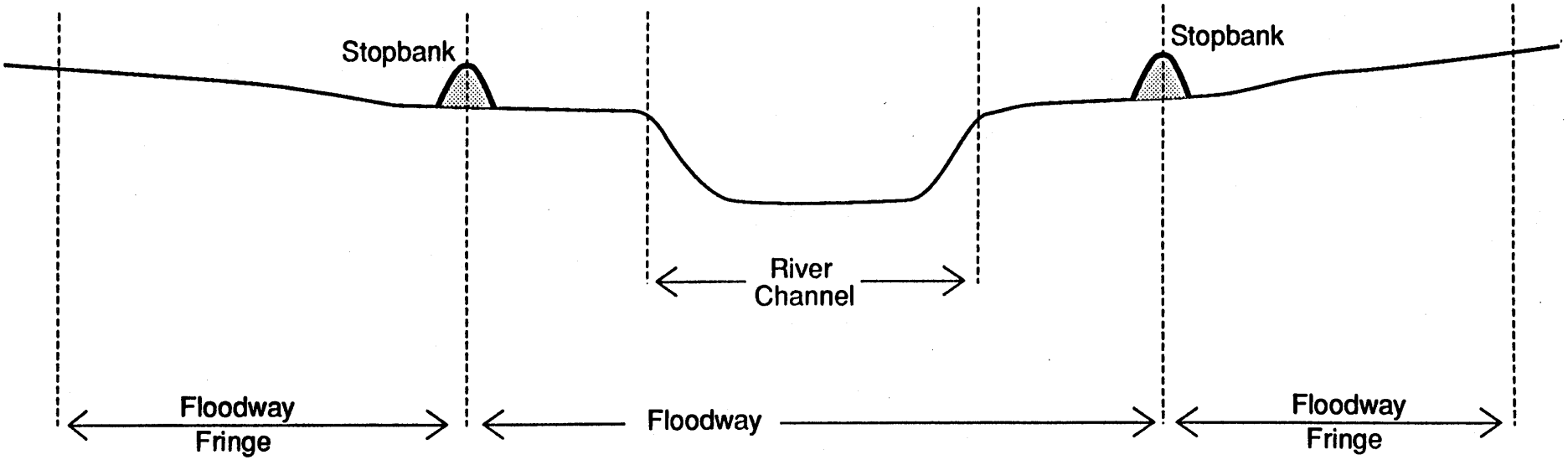


Fig 2: Cross-section of Floodplain

extensive faulting and crushing that has occurred throughout much of the region, in response to tectonic activity. When deforestation occurred, the potential of this landscape for rapid erosion was released. Without the benefit of restraining root systems and water usage by trees, the weaker, wetter soils collapse as soil slips. Runoff increased when land was converted to pasture, and this results in gully erosion - a particularly serious form of erosion on country underlain by shattered mudstone and argillite rocks. Once started, gully erosion can proceed at such rates as to make control extremely difficult and costly. Gully erosion undermines the hill slopes and often leads to sideslope collapse on a massive scale. The resulting debris forms the major component of debris in riverbeds. The more insidious large-scale forms of erosion such as slumping have also been accelerated by the general rise in the hillslope water-tables that occurs under pasture.

The areas of land affected by erosion in the East Coast region are very substantial. While 31,000 ha of highly erodible land have received soil conservation treatments, 75,000 ha in this category remains untreated. Soil conservation measures have helped maintain agricultural production on 28,000 ha of somewhat less erodible land. A further 110,000 ha of this less erodible land remains untreated.

The Hawke's Bay and Wairarapa regions also have hill country erosion problems although not on the same scale as on the East Cape.

The Hawke's Bay Catchment Board area extends over 15,000 km^2 and includes the catchments of five major rivers. Aggradation of shingle in the middle reaches of the Waipawa River, the past repeated flooding of the Heretaunga Plains by the Tukituki, Ngaruroro and the Tutaekuri Rivers, and the severe and widespread erosion of the volcanic ash cover of the mountains and hill country are some of the problems in the southern part of the Board's area. The catchment of the Wairoa River, to the north, is one of the largest of any river in the country. Storms continue to cause severe erosion in the Wairoa catchment and to generate large floods, as was graphically illustrated during the Bola storm.

The hills in the east of the Wairarapa Catchment Board's region are also formed from sedimentary deposits. They are subject to severe erosion when a dry period is followed by intense and prolonged rainfall.

2. 2 Land use capability

The question of sustainable land use in the East Coast region was first addressed as part of what is now known as the Taylor Report (6). This report divided the Gisborne - East Coast area up into two zones based on the need for erosion control. The "critical headwaters" zone was declared to be unsuited to pastoral farming but able to be effectively afforested. The "pastoral forelands" zone was considered to have a long term future in farming, if suitable erosion control works were undertaken.

The simplistic broad zoning of the Gisborne - East Coast region into the critical headwaters and pastoral forelands areas created a good deal of antagonism among local farmers. In 1978, this zoning was superseded when the East Cape Catchment Board - as part of its "Red Report" (7) - adopted the much more detailed NZ Land Resource Inventory land classification system, developed by the then Ministry of Works and Development (now DSIR's) Soil Conservation Centre. For reasons of practical management, the East Cape Board grouped the detailed land classes into categories that required similar land management. These categories and the land use capability classes for each category are given in Table 1. These categories of land use became widely accepted by both local and central government as the basis for land use advice in the East Cape region. Before soil conservation works are carried out on farm properties in the East Cape Catchment Board's area, a 1:15,000 scale (approximately) land resource survey of the property is undertaken by Board staff.

TABLE 1: EAST COAST LAND USE CATEGORIES

CATEGORY	RECOMMENDED USE	LUC CLASSIFICATION	TOTAL AREA (ha)
1	(a) Arable farming	Classes II & III	63,900
	(b) Arable and pastoral farming	Classes IV & VI	170,700
2	(a) Conservation farming and farm scale forestry	Units VIIe1, 2, 5, 7 and VIIw	102,200
	(b) Conservation farming, farm scale and large scale forestry on some areas	Units VIIe3, 4, 6, 8, 19 and 21	70,900
3	(a) Large scale production forestry (low priority for protection)	Units VIIe9, 10, 11 and 17	55,600
	(b) Large scale and farm scale protection/ production forestry (medium priority for protection)	Units VIIe12, 14, 16 and 20	50,300
	(c) Large scale production/ protection forestry (high priority for protection)	Units VIIe13, 15 and 18	65,100
4	Protection forest	Class VIII	44,600

Source: Red Report (1978)

The NZ Land Resource Inventory system is used by all the catchment boards in New Zealand. The catchment boards work directly with the individual land inventory classes to assess the land's limitation to productive use. This information forms part of the natural resource database that the new resource management agencies will need for management purposes.

The present approach to erosion assessment used by catchment boards is based both on evaluating the severity of the erosion that is already present, and on assessing the capability of the land according to its potential for future erosion. Soil conservation works, however, tend to be targeted to the control of existing erosion, and not to the prevention of future erosion. By concentrating on existing erosion, there is also a tendency to place less emphasis on the implications of current management practices for long-term land use sustainability. From a long-term land use perspective, it is more appropriate to place an increasing emphasis on the land's potential for erosion and to increasingly match the erosion potential rating to genuinely sustainable land uses.

The erosion potential approach can be used to indicate how much land would need to be treated if erosion was to be comprehensively controlled. It also shows the state to which pastoral land would ultimately deteriorate if erosion control works are not undertaken. The erosion potential of land is one of the parameters derived as part of land classification according to the NZ Land Resource Inventory system. The potential for erosion could also be given more recognition in the territorial land use planning schemes of the East Cape region.

RECOMMENDATION

That the new Gisborne Regional Council should give increased consideration to the long term planning of soil conservation works and large scale afforestation on the basis of the sustainability of land use, as particularly reflected in the potential of land for erosion.

RECOMMENDATION

That the new Gisborne Regional Council should take increased account of the sustainability of land use, as particularly reflected in the potential for erosion of hill country land in indicating appropriate land uses, in district and regional planning schemes.

2. 3 Objectives of soil conservation

Information on soil conservation was requested from three catchment boards, the East Cape, Hawke's Bay and Wairarapa Boards. The major emphasis of the East Cape Catchment Board (1) has been to achieve the maximum possible amount of effective erosion control works and to promote soil conservation. The goal of these objectives is to enhance productivity of land both on-site and off-site (through reduced siltation of lowlands), and to reduce sediment yield into streams and rivers to reduce the likelihood of flooding.

Soil conservation objectives for the Hawkes Bay Board (8) have been based on introducing deeper-rooting tree species into the pastoral environment. The basis for this approach has been the relatively greater stability of this type of country under the original forest cover.

The Wairarapa Board's (9) objectives are: to mitigate erosion, to promote sustainable use of soil, and to prevent or reduce damage to property by floods.

2. 4 Means of achieving objectives

Erosion control in the East Cape area and in many other areas is achieved through implementation of soil and water conservation plans (farm plans) on individual properties. The plans consist of a comprehensive assessment of the land's capability and inherent limitations, together with a programme of works. They are normally prepared on the request of a landowner and cannot be imposed on the landowner. Most plans operate for a period of 5 years but can be extended if necessary by a further 5 years. The East Cape Board currently operates 107 soil and water conservation plans with some 450 plans having been completed in the past. Limited farm incomes has meant that many farmers have not had the finances to proceed in recent years.

Since 1981 the Board has also promoted catchment control schemes. These are, effectively, a collection of farm plans covering a whole catchment area, to give both catchment wide and off-site benefits. Three such schemes, involving 50 properties, are currently in operation.

The Hawke's Bay Board's efforts in soil conservation have also focussed on the water and

soil conservation plan. In more recent years the Hawke's Bay Board has also initiated five small catchment control schemes, wind erosion control schemes and woodlot planting on land unsuitable for pastoral purposes.

The Wairarapa Board has also focussed on farm plans with 450 currently in operation. Seven catchment control schemes, including Whareama, the first in New Zealand, are in operation and cover virtually all the problem areas.

The erosion control techniques employed by the East Cape Catchment Board and other Boards for both farm plans and catchment control schemes can include:

* pole planting using both poplar and willow. Pole planting represents approximately 80 per cent of the East Cape Board's total soil conservation works expenditure. It is carried out to stabilise slips and earth flows, and as support planting for gully control and water control schemes;

* afforestation of blocks ranging generally from 5-50 hectares in size, including some silviculture for tree health. This afforestation is separate from the large scale afforestation carried out by the New Zealand Forest Service from 1968 to 1986;

* gully control structures, e. g. debris dams, drop structures, flumes;

* water control structures e. g. , slope smoothing, grading banks, spring tapping and support planting of willows/poplars;

* retirement of land, either temporary or permanent, from stock grazing to retain groundcover;

* minor river works, e. g. stopbanks and river bank protection may need to be incorporated into a farm plan.

These techniques of soil conservation are used as appropriate to the particular requirement of the land. The East Cape Board has found that the more expensive techniques of afforestation, gully control structures and water control are excluded from farm plans where the local share of money required is greater than in past years, even though these are the more effective erosion control techniques.

The promotion of soil conservation can also be achieved through:

Public Education Programmes

In the past catchment boards have used a variety of means to promote soil conservation e. g. radio programmes, newspaper articles and brochures. Strategies on publicity and education to raise public awareness for the need for soil conservation throughout the community are being developed by many catchment boards and are seen as an important part of a board's activities.

Section 34 approvals

These notices are issued under the Soil Conservation and Rivers Control Amendment Act 1959 to allow catchment boards to control the removal of vegetation and the disturbance of land. Land use practices such as clearing for farming, forestry development and cutting of tracks are covered by such notices. The East Cape Board operates a

Public Notice on all LUC Classes VI, VII and VIII land throughout its district that pertain to certain land use practices. Permits are issued to applicants with general, and often specific conditions, imposed to minimise erosion risk and damage. However, provisions to enforce landowners to undertake soil conservation works are not in the legislation. These notices are only applicable for two years at a time. Renewal of a notice requires the agreement of the landowner who is causing the problem.

RECOMMENDATION

That if a similar mechanism to a Section 34 notice is to be included in new legislation on water and soil management, the Resource Management Law Reform should consider extending the term of a notice up to 15 years.

Section 35 notices

Individual notices can be issued under s. 35 of the Soil Conservation and Rivers Control Amendment Act 1959 to allow catchment boards to empower a landowner to change, or maintain, a particular land use or land use practice. This notice is intended to be used where a change of land use could detrimentally affect the conservation of soil, stability of detritus, deposition of materials in water courses or flooding. Although no notices under this section have been issued by the East Cape Board and few have been issued by other catchment boards, this measure could have some strategic uses.

Town and Country Planning

Many Boards, including the East Cape Board, have taken an active role in regional and district planning schemes and issues. There have been varying degrees of success. District planning schemes designate areas of land for particular land uses, e. g. , forestry. In practice, many schemes have not encouraged land use changes. In the East Cape region some District Schemes in the past had restricted forestry to Class VII land.

2. 5 Effectiveness of soil conservation

2. 5. 1 Introduction

The effectiveness of soil conservation works has been and still is difficult to assess primarily because of variability of geology and climate. Other factors which influence the effectiveness include:changes to farm management practices, the quality of maintenance of the works and the possible need to upgrade or replace works after storm events.

Some national surveys of soil conservation techniques and their effectiveness were undertaken through NWASCA and there have been regional surveys carried out by catchment boards. The fundamental problem of using surveys to assess the effectiveness of works is the difficulty of assessing the present stability of the landscape compared with past stability using only visual inspection.

Ease of assessment of the soil conservation techniques varies. Gully control presents few assessment problems, provided that there have been some (even minor) storms in the intervening period since the works were established. The effect of water control works on earthflow stability is also simple to assess. Failure to halt movement will result in obvious, renewed disruption to the earthflow surface which will have been smoothed and regrassed, to encourage run-off. Block planting of earthflows with pines has also been shown by the Forest Research Institute (10) to be a very effective stabilisation measure. Forestry has also demonstrated its effectiveness in the control of soil slipping during severe storms. The

effectiveness of pole-spaced planting schemes is much more difficult to assess, as it is observed that there are notable cases of both success and failure of works at apparently similar sites. The problem of specifying an optimum tree spacing that controls most of the erosion yet allows adequate pasture growth is a difficult one. However, techniques recently developed at the DSIR's Soil Conservation Centre appear to at last be providing answers on this matter.

A study of basic slope failure processes i. e. why a slope is failing and how it is failing should be linked into a soil conservation effectiveness survey. An understanding of these slope failure processes will have an influence on assessing how suitable the various soil conservation techniques are for that site. Most works, if effective, will manifest their effectiveness over time periods ranging from:

- one to two years (water control by surface smoothing, drainage etc);
- four to five years (gully control);
- eight to 10 years (afforestation).

2. 5. 2 Catchment Boards' Assessments

The on-site benefits of implementing soil and water conservation plans in order to maintain agricultural productivity of the land have been conservatively estimated for the East Cape region as retaining 44,000 stock units of production. However, farm productivity is affected by other factors such as fertilizer application and economic or climatic variations. There have also been major changes in the encouragement given to farmers firstly to increase and then decrease stock numbers over the last ten years. Thus isolating the effect of soil conservation work alone on farm productivity is hard to quantify in the short term, but may be significant in the long term.

The East Cape Catchment Board (11) has surveyed an area hard hit by the Bola storm to assess the effectiveness of soil conservation works. The Waihora catchment which has a catchment control scheme encompassing most of the catchment was chosen. The level of erosion as at 1978 had taken some 120 years to develop. In the 10 years since then, there has been a 72 per cent increase in the level of erosion, with the majority of the erosion happening over the three days of the Bola storm. Established protection forest blocks in the study area had a marked ameliorating effect on soil erosion:between one and four per cent bareground occurred under forest, compared with 12 to 18 per cent on adjacent pastoral land. Although a high proportion of recent plantings of poplar and willow poles had moved or partly toppled, very few had been lost altogether as a result of the storm. Mature, established poplar and willow trees were rarely toppled and in many cases had achieved quite dramatic decreases in soil erosion severity between 1978 and 1988.

The survey of the Waihora catchment was made possible in part by the assistance given by three catchment boards in each sending a soil conservator to Gisborne to work with the Board's staff. This kind of cooperation among catchment boards ensures that the important work of monitoring the after-effects of a major storm can be carried out. There may be other situations, similar to the Bola storm, where the assistance of trained people to evaluate flood or storm damage is needed.

RECOMMENDATION

That the New Zealand Catchment Authorities Association or its successor should give consideration to establishing a Soil Conservation Action Team to assist a catchment board in carrying out an effectiveness survey after a significant storm.

The Wairarapa Board intends to evaluate erosion processes in the eastern hill country following the September 1988 storm and compare the results with detailed mapping of the area undertaken in 1983-85. Preliminary inspection of affected land has indicated that where erosion control works are well established, damage was minimal. One example was a property at Pongaroa which recorded a rainfall of 350 mm during the storm event. An extensive very unstable slumping area which was dewatered, fenced and planted in 1973 remained stable.

2. 5. 3 Strategy for assessing effectiveness

A pragmatic approach to assessing effectiveness would be to survey soil conservation works after a significant storm i. e. after there has been a physical test to the effectiveness. Such surveys should also locate adjacent areas of similar land where no works have been done to form a control.

The need for research into the effectiveness of soil conservation techniques and whether these techniques do conserve soil has been recognised by the DSIR Soil Conservation Centre. Research after Cyclone Bola was initiated (12) to provide some basic data on: the effectiveness or otherwise of soil conservation measures, to develop a method for assessing effectiveness and to provide information to assist decisions as to whether continued expenditure on soil conservation is warranted. The research developed a method for assessing storm damage in the Waihora catchment. This method requires testing against data in other catchments in the region as well as testing in other regions to see if it is applicable.

At the present time, and until the Soil Conservation Centre research is developed, the best way of assessing effectiveness would be to do case studies on works that have suffered a major storm, and that have good historical photographs, and mapping of the nature and extent of erosion. This could be compared to similar, adjacent land that has no conservation works.

This method is still subject to uncertainty as the soil conservation works chosen for study must have been completed and maintained over time. Some agreement will be needed regarding what size of storm or intensity of rainfall the works are expected to stand up against. To assess soil conservation measures after a severe or extreme storm may not give an indication of how well these works would cope with more typical conditions.

The size of storm or intensity of rainfall that would cause an effectiveness survey to be undertaken should be decided by each board. This kind of effectiveness survey will, of necessity, be carried out on an ad hoc basis, partially depending on the frequency of major storms. It will be necessary for catchment boards to extensively document, as case studies, one or two areas as they are completed each year, so that baseline data from a number of catchments is accumulated over time. These works can then be reassessed after a major storm.

RECOMMENDATION

That the new regional resource management agencies should make available resources to document the effectiveness of soil conservation measures after a significant storm in a catchment or sub catchment for which detailed information is available.

RECOMMENDATION

That the new regional resource management agencies should extensively

document one or two areas with recently completed soil conservation measures in a catchment or sub-catchment each year for the purpose of accumulating baseline data for the future assessment of the effectiveness of these works.

2. 6 Afforestation as a soil conservation measure

2. 6. 1 Introduction

The effectiveness of afforestation as a soil conservation technique has been the subject of research principally by the Forest Research Institute (FRI). Studies by the FRI (10) at Mangatu Forest in the Waipaoa River headwaters have shown that closed canopy pine forest can significantly reduce the average annual stream runoff in forest stream catchments. During minor flood events there would be a significant reduction in runoff volume as well as a retardation and diminution of flood peaks from forested catchments. During major storms, the principal role of afforestation is in the prevention of erosion and reduction in the amount of sediment entering waterways.

Large scale afforestation has been highly effective in reducing soil erosion in the East Coast region, as emphasised by the Bola storm. A preliminary assessment on the effectiveness of afforestation after the Bola storm has been carried out by the Forest Research Institute and a final report is due shortly. The preliminary report (13) found that native bush, established scrub regeneration and radiata plantations more than eight years old, suffered much less soil erosion than younger exotic plantations or pasture land. There was definite evidence, before the Bola storm, of degradation of the stream beds in a fully forested catchment at the Mangatu Forest, compared with unforested or partly forested catchments. There was also some evidence for reduced rates of aggradation in the middle reaches of the river over the period 1980-1986 (14). Thus some off-site benefits of afforestation were beginning to be found with only six per cent of the Waipaoa River catchment under forest cover.

2. 6. 2 The East Coast Project

The Taylor report (6) formed the basis of the East Coast Project with its division of land into the "critical headwaters" zone and the "pastoral forelands" zone based on the need for erosion control. The New Zealand Forest Service established forests at Mangatu, Tokomaru and Ruatoria in the critical headwaters zone from 1968 to 1986.

With the split of the Forest Service into a commercial agency and a policy agency, the East Coast Project came to an abrupt halt after only partial implementation. The Project was reviewed by central government (14). Submissions on the review were sought and evaluated by an Officials Committee. East Cape region submissions stressed the importance of the East Cape Project for erosion control purposes, especially after the Bola storm, in reducing the risk of downstream flood damage. Many people in the region considered that the region's declining economy and increasing social problems would benefit by addressing the issue of erosion control.

Government has agreed to provide $8 million of a $12 million erosion control programme in the Gisborne region. The central government funding recognises that afforestation can help reduce potential flood damage downstream where there are significant assets. The erosion control programme will allow the East Cape Catchment Board, in consultation with the Ministry for the Environment, to plant pine trees on 15,000 hectares of severely eroded land over the next five years. This programme will have performance targets and its objectives will be monitored by central government. After five years, central government expects the East Coast region to assume prime responsibility for funding erosion control measures.

However, the protection of significant urban and rural assets is only one reason for institut-

ing flood mitigation measures. If the goal of sustainable land use is to apply throughout New Zealand, then there will be some areas that will require active measures for soil conservation at the present time. One such area is the north of the East Coast region and some form of encouragement to change land uses may be necessary.

RECOMMENDATION

That the Government, through the Ministry for the Environment, should provide positive suggestions to the new Gisborne Regional Council as to how changes to achieve sustainable land uses and mitigate damage from floods can be instituted in the north of the East Coast region.

This erosion control programme, for 15,000 ha over the next five years in the East Coast region, will go some way towards afforesting the 75,000 ha of highly eroded land still to be planted. The benefits of afforesting the upper catchments will not be realised unless planting continues on this highly eroded land. The scale of the erosion problem can be made significantly worse by major storms such as the Bola storm, but minor storms also have an effect over time of increasing the quantity of highly eroded land. If the regional agency on the East Coast has not the resources to fund this level of afforestation after five years, then the region risks a greater flood hazard in the future. Had the catchment headwaters in the region been afforested at the rates originally envisaged in the Taylor Report, it is possible that the Bola storm could have been the first major event to degrade the upper tributaries and possibly also the middle reaches of the Waipaoa River. The amount of silt and debris deposited on river berms would have probably been reduced as well. This scouring of bed material would have reduced future flood hazards.

2. 7 Constraints to implementing soil conservation works

For the East Cape Catchment Board the greatest constraint on soil conservation work is funding. Government assistance for implementing farm plans has ranged from 60 per cent in the past to the present 35 per cent. The East Cape Board has observed that work demand usually falls with the drop in subsidy assistance because landowners are unable to fund their increasing share of the cost due to falling farm returns. While the funding for soil conservation is declining, the requirement for erosion control works is increasing in the East Coast region.

Attitudes to the need for soil conservation and to the place of afforestation in the rural community have been a constraint. The East Cape Board considers attitudes have changed steadily over the years and have changed rapidly in some areas as a result of the Bola storm. Attitudes of urban people are also changing. They are recognising that they are also beneficiaries of soil conservation work in the rural hill country. Much of this change is due to the Bola storm. However, changes towards sustainable land uses are still required even though the Taylor Report and others envisaged such changes 20 years ago for the East Coast region.

Mr H Guthrie-Smith commented after the 1938 storm in the Tutira district, "When we look at the area of storm damage and the dominantly pastoral land use, it is obvious there has been some imprudent land development. There has also been a lack of understanding on the part of some farmers for the requirement for conservation planting". The comment is still relevant today for both farmers and public authorities.

2. 8 The future of soil conservation

2. 8. 1 Policies for the future

The future direction of soil conservation should be to link it to the promotion of sustainable

land uses. To achieve this goal, the land uses that are sustainable will need to be identified for each region. Soil conservation policies should be integrated into land management policies for agriculture and for forestry. Farming and forestry should be seen as complementary rather than competitive land uses. This integration of policies would help to prevent the promotion of policies, as has happened in the past, which have had short term economic benefits but long term environmental costs.

New land management policies should be able to be applied over much larger areas of land than has previously been possible. In the past, a lot of emphasis has rested on promoting soil conservation on individual properties. Catchment control schemes recognised that the effectiveness of land management and soil conservation extended over individual boundaries. Although much progress has been made in the past, policies have not resulted in major improvements in long term sustainability. Policies are required that will enable steady progress to be made towards sustainable land uses, and land most in need of changes to land use to be targeted.

Change to sustainable land use would reduce the need for central government assistance after major storms or floods. A policy could be developed that would restrict an assistance programme only to land with a sustainable future in agriculture. Such a policy could be based on detailed land use capability information. This implies that those who use the land in some unsustainable way will accept the risks of doing so and forfeit the right to be compensated when disaster events create damages. To these operators government disaster relief may have, in the past, been linked to an insurance policy. By introducing a discriminatory payment based on sustainable land management, those who take higher risks, that is forego sustainable land use, can be regarded as being uninsured.

Central government developed an innovative farming assistance programme after the Bola storm. This programme was based on lost production and valuation and was structured to allow farmers to reassess their land management practices. The Ministry of Agriculture and Fisheries (MAF) has subsequently reviewed (15) the Bola farming assistance package as to its effectiveness. The results of the review could be used in structuring future storm assistance programmes and the Disaster Damage policy that MAF is currently developing. The DSIR is currently developing a proposal to model cyclonic storm damage in New Zealand. It is essential that this proposal is integrated with MAF research in this area.

Present central government policy for soil conservation is in a state of transition because of changes proposed in the resource management legislation. Once the legislative framework is in place, the Ministry for the Environment will be assessing the need for policies for soil conservation and sustainable land use. Changes in regional and local government to be implemented by 1 October 1989 will include the abolition of catchment boards and the setting up of resource management agencies whose functions will include water and soil management.

There is a need to monitor the policies set by central government for soil conservation and sustainable land use in order to evaluate how effective the policies are in meeting their objectives. The objectives of soil conservation and sustainable land use will have regional variations because of differences in geology, soils and climate. This will require the central government policy agencies to develop appropriate measures of effectiveness to suit the varying objectives of soil conservation and sustainable land use.

RECOMMENDATION

That the Ministry for the Environment, as government's policy agency for water and soil management, should develop policies for soil conservation within the context of sustainable land use including the NWASCA 1987 policy statement.

RECOMMENDATION

That the Ministry for the Environment should develop monitoring policies for soil conservation within the context of sustainable land use to evaluate whether policy objectives are being achieved.

RECOMMENDATION

That the Ministry for the Environment, the Ministry of Agriculture and Fisheries, and the Ministry of Forestry should ensure that policies on soil conservation and land management are integrated to achieve the goal of sustainable land use.

One of the means of evaluating soil conservation and sustainable land use policy is to develop measures to assess the effectiveness of soil conservation works and to evaluate both the on-site and off-site benefits of sustainable land use. Such research should continue to be funded by central government as it is in the nation's interest to have the means to assess the effectiveness of soil conservation works.

RECOMMENDATION

That the DSIR Soil Conservation Centre should continue research into the effectiveness of soil conservation activities in the context of sustainable land use to evaluate and quantify, if possible, the on-site and off-site benefits to be achieved.

2. 8. 2 Issues for the Future

Whatever the future structures of organisations responsible for soil conservation, the following issues will have to be faced:

(a) The better matching of land use to land use capability

The major limitation to long-term use of the hill country on the East Coast of the North Island is erosion. Under pastoral farming regimes, erosion rates are in general, much greater than soil formation rates on this country. To this extent, pastoral farming can not be considered a sustainable land use on much of this hill country. In some instances, erosion control works can be proposed that will reduce erosion to acceptable levels and retain the land for predominantly pastoral use. Whether such works are economically viable, or will be completed in the period between major storms is open to question. In many cases, afforestation of the land probably represents the only realistic, economically viable, erosion control option. Clearly, on some land types, the current land use is inappropriate both from the erosion and economic view points. The downturn in returns from pastoral farming of hill country land together with the impact of the Bola storm have provided an opportunity for a fundamental reassessment of land use in the hill country. Significant advantages could be made by matching land use and land use capability on a district basis. As regions assume greater responsibilities for resource management, the possibility for alternative land uses to be promoted arises. Task groups involving private interests and public agencies to produce redevelopment proposals would be another way to move towards more sustainable land uses.

(b) Landowner perception of and response to erosion control

The history of the East Coast hill country is one of periodic storm events that have generally only seen short-term responses to storm damage and little regard given to the long term effects of not implementing soil conservation measures. After the Bola storm the agricultural

disaster relief fund was structured so that farmers could reassess their situations. Preliminary information from MAF (16) indicates that for larger farms (greater than 12,000 stock units), the landholders have used the Bola storm payments to repair storm damage. Final decisions about change in land use may be made over the next 12-18 months. For smaller farms, landowners have used the Bola storm payment to reduce debt. The reduction in the cost of debt servicing, in some cases, will offset income losses. Farmers are tending to replace high cost capital items with lower cost substitutes. For many farmers decisions as to future land use may be made over the next year. The Bola storm payments for many small farms are considered too small to make a significant impact on changes in land use.

Information from the Hawke's Bay Catchment Board (8) indicates that the relief payments were too small to encourage changes in land use. The general reaction has been to plough the money back into the farm.

(c) Maintenance of regional infrastructure

Road, rail, power and telephone communication are an essential part of a region's infrastructure. Erosion control works are often necessary to protect these assets from damage. However, these works are often not carried out or, if they are carried out, are not managed in the succeeding years.

Before roads are reinstated or realigned, an aerial photo-graphic interpretation of landslide/ mass movement hazard along proposed routes should be carried out. These interpretations can be provided either by the catchment board or the DSIR Soil Conservation Centre and would ensure that proposed routes are not subject to hazards that can be avoided. Often, the expense of such preventive work is given as a reason for not doing it, but the expenses incurred for constant repair or reconstruction of roading can be considerable (e. g. when the toes of earthflows are cut with a road realignment).

(d) Financial incentives for soil conservation work

In the past, subsidies for soil conservation work have given mixed results in progressing the goal of sustainable land use.

Evidence from the Hawke's Bay Catchment Board (8) suggests that farmers do not view the subsidy as an incentive to carry out work but see it as a bonus or discount on the gross cost. There seems to be a price insensitivity towards grants where some farmers will carry out works qualifying for a 40 per cent grant whilst others refused to proceed at a 70 per cent grant. Many farmers consider money is better spent on fertiliser which has short term economic benefits than on soil conservation works whose benefits are long term.

If there is to be a move towards more appropriate forms of land use, then it is clear that in some areas the cost will be beyond the funding resources of the district. Without some form of central government assistance there will be little change in present practices. Government needs to appreciate that the current costs of erosion control are in major part related to past development and use of land beyond its ability to provide sustainable production. This past development and use was often encouraged as being in the "national interest". Central government assistance should also recognise its role to assume responsibility for benefits accruing to future generations. It is suggested that the portion of assistance provided by central government to landowners be termed a "conservation grant" as a term correctly reflecting the fact that erosion control has important benefits both to future generations and to off-site communities. However, any such assistance should enable regional authorities to target the most severely affected areas in need of erosion control and change of land use. One of the implications of the decrease in government assistance in the East Cape region is that farmers are tending to concentrate their local share contributions towards the cheaper

works such as pole planting on the slight to moderate erosion sites. If this trend continues, the more severe erosion problems may not be addressed.
If the primary objective is land conservation, it is inappropriate to apply a productive return criteria as the overriding factor in deciding if afforestation is in the national interest. If a forestry operation can at least financially break even in these areas, then the conservation values must result in a positive net benefit to society. In the past, this concept has been accepted by government and subsidies have been provided for conservation work. However, future contributions (in whatever form) to augment commercial return should be seen as a social investment, rather than a subsidised hand out, for future generations.

Consideration of mechanisms for combining the conservation and commercial aspects are beyond the scope of this study. They will require co-ordination and co-operation between different arms of government.

RECOMMENDATION

That the Minister for the Environment should fund part of the cost of soil conservation activities in the context of sustainable land use to landowners in recognition of the importance of the off-site benefits and the benefits to future generations.

2. 9 Policies for change to sustainable land uses

As part of this inquiry, a report (16) was commissioned from the Ministry of Agriculture and Fisheries to describe sustainable land use options for differing land types in the upper catchments of the East Cape region. Part of the study was to recommend practical methods of implementing such policies. A sustainable land use is described as maintaining a constant output in perpetuity given current technology and inputs.

This report recommends the following and implies some immediate changes in land use to achieve sustainability.

Land Use	Land Category (Red Report)
Agriculture	1
Agriculture with Conservation Measures	1, 2, 3a
Agroforestry	1, 2, 3a
Commercial Production Forestry	1, 2, 3a (+ location requirements)
Conservation Forestry	3b, 3c
Protection Forestry	4
Reversion	4, 3a, some 3c

Conservation Forestry is planted primarily for water and soil protection and erosion control and can provide limited harvestable timber. Protection Forestry is planted primarily for water and soil protection and erosion control but with no harvesting for timber production.

RECOMMENDATION

That the new Gisborne Regional Council should encourage soil conservation and pastoral agriculture, or production forestry on the 110,000 hectares of Category 2 land instead of pastoral agriculture with no soil conservation works.

RECOMMENDATION

That the new Gisborne Regional Council should encourage conservation forestry, or managed reversion on the 77,500 hectares of Category 3b, 3c, and 4 land instead of pastoral agriculture.

The limitations to change are economic in nature:

1 **Inadequate farm incomes**

Changes in land use would involve farmers not only in extra capital investment but also in changes to present cashflows as land is taken out of current production. These dual requirements can put marginal farming operations at risk.

2 **Forestry investment**

To attract private forestry investment, the East Coast must offer comparable rates of return to other places in New Zealand. Erosion factors, cyclones and repeated floods do not produce a particularly positive climate for such private investment. The financial viability of forestry ventures decreases with distance from the main centres and with the use of poorer classes of land.

3 **Primary and secondary benefits and costs**

A significant factor limiting land use changes is that farmers, forestry companies or regional government will examine any investment to promote change from the viewpoint of how the costs and benefits are distributed. Externalities ie benefits received and costs paid by somebody else, are not usually brought into investment decisions regarding land use charges.

4 **Intergenerational issues**

Future benefits and costs of changing to more sustainable land uses may not be as important to individual landowners as present costs and benefits.

5 **Land Tenure**

Land tenure can affect the decisions made about soil conservation programmes because of the creation of an externality where the lessee pays all the costs of the conservation work but the landowner (lessor) receives some of the benefits. This situation is perhaps more common on the East Coast than elsewhere in New Zealand because of the high proportion of Maori land held under multiple ownership. In some cases, the lessees of this land have no right to renewal or compensation for improvements. Where the land, both Maori and Pakeha, is farmed as a Trust or Incorporation, the trustees or management committee may be willing to carry out conservation programmes but lack the finance to do so.

RECOMMENDATION

Any policy development or implementation of that policy by the new Gisborne Regional Council that impacts on Maori land should involve consultation with Te Runanga O Ngati Porou and Runanga O Te Aitanga-A-Mahaki to evolve appropriate and acceptable mechanisms to help promote sustainable land use.

2. 9. 1 Incentives to promote change

There are several measures that could be adopted as practical measures of policy implementation.

1 There is, of course a policy option of "doing nothing" and letting the market operate to allocate resources for sustainable land use. While attractive to some policy makers, and easy to implement, there are major problems in that land use externalities will not be accounted for in the decision and a sub-optimum solution will be generated. When considering the scale of the externalities apparent on the East Coast, this option is not particularly attractive.

2 Direct subsidies and taxation deductibility of erosion control costs have been effective to a degree. However, it is felt that the current subsidy level, the scale of the problem and the purchasing ability (and willingness) of landowners will not accelerate the rate of land use change. For effective erosion control, large scale plantings (with subsequent silviculture costs) are necessary. These massive direct costs to landowners would have to be virtually fully subsidised to achieve rapid adoption of sustainable land use.

3 Land swapping and farm amalgamation could be an attractive proposition in this region given the serious rural debt problem and depressed sheepmeat prices. In areas where large erosion problems exist in conjunction with landowners willing to exit from farming, it is possible that the neighbours will be amenable to discretionary purchase of parts of the farm for sale. Boundaries may be re-arranged to suit both their purposes plus protection forestry. In such a case, five farms with severe erosion problems may become two farms with minimal erosion problems, while conservation forestry is established on the balance.

The problem remains in financing both the purchase of the erosion prone areas and the planting. This may be solved by the market mechanism through a discounted price or may require subsidies or soft loans to attract investors. The amalgamation approach would at least provide substantial areas of land for forestry and allow economies of scale and easier administration.

Land swapping could have a similar outcome where two or more parties agree to exchange suitably-sized areas of different land classes to effect rational land use, i. e. one party achieves a relatively large forest block by foregoing "better" land to another party who achieves a more economic farming unit.

4 There is some scope to look at alternative financing methods since there is still the problem of each beneficiary being able to finance his/her share of the costs. These could include Government loans where interest and principal repayments are carried forward to the time of harvest or where the government pays a larger subsidy but obtains a greater benefit, i. e. share in the crop's profits. This would be somewhat similar to the Land Development Encouragement Loans where there was no interest charged over the early life of the development scheme. Loans could also be made available to

regional government agencies to fund their share of costs. These loans could have interest and principal repayment deferred.

Some of the existing protection forests that do not meet their owner's objectives (e. g. Timberlands Incorporated) could be "given" to local authorities to provide a limited cashflow to enable the local region to finance its contribution.

5 Collective financing may be attractive to regional bodies and authorities. Through rating and community fund-raising, the necessary finances may allow afforestation on erosion-prone areas. The benefits would be multiple in that erosion control, flood damage avoidance and investment returns could be achieved. The communities could contribute by way of labour for establishment, releasing and pruning etc, hence minimising cash requirements. This input and the subsequent longer term forest revenues would ease the rating burden.

6 Legislative means have been used in the past to modify individual investor behaviour to suit nationally desirable goals, but has not always been successful. Despite this, it is considered appropriate to review current taxation legislation as it affects both forestry and conservation measures. It is felt that both these measures have intrinsic features of revenue flows over time and externalities that support a more favourable taxation regime, e. g. the current tax legislation contains a maximum $7,500 deductibility level for planting and tending a forest area for any farm.

At present mining companies have an obligation to restore and rehabilitate operating areas to their previous condition, more or less. A similar regulatory tool could be used in compelling those landowners who mis-use certain land areas to restore them to their previous state, or as near as possible. This, for example, would require agriculture to be a conditional land use on Class 3b, 3c and 4 areas, and any permit to depart from predominance implies a recognition of the risks involved.

Having developed and promoted suitable policies and mechanisms to encourage changes to sustainable land uses, the implementation phase should be carried out at the request of a group of landowners. These policies represent radical change to farmers and to farm management. Many farmers are more concerned at present with earning enough income to support their families and need time to consider new styles of land management. There will also need to be retraining opportunities for farming families to take full advantage of land use changes. These policies needs to be based on the principle of equity, that is the belief that progress does not produce victims. A process to manage change for farming families will be necessary.

Policy development into new ways of managing land is being undertaken in the Hawke's Bay region. A group comprising the Hawke's Bay Catchment Board, Federated Farmers and the Ministry of Agriculture and Fisheries is developing a feasibility study of a substantial land area in which the goal of sustainable land use could be achieved. The work is presently looking into the feasibility of making the changes and whether the new land management units can be made ecologically and financially viable in the long term. Measures to effect the changes have yet to be investigated but could include some of the incentives outlined in this section.

RECOMMENDATION

That the new Gisborne Regional Council and the new Hawke's Bay Regional Council, should in consultation with communities in the East Cape and in the new Hastings and Wairoa districts, develop policies for sustainable land uses in their districts.

3 KEEPING FLOODWATERS AWAY FROM PEOPLE - RIVER CONTROL AND MANAGEMENT

3. 1 Introduction

River boards and river trusts were set up, some starting as early as 1868, to prevent flood damage to lands. These early river boards were often responsible only for a particular section of river and often for only one bank of a river. Although the boards did achieve reasonable protection of urban areas subject to severe flooding, their ad hoc nature and the lack of consideration for the catchment as a whole, limited progress. The draining of wetlands has intensified flooding problems in many areas, as wetlands can "buffer" floodflows. The 1941 Soil Conservation and Rivers Control Act brought soil conservation, river control and drainage under unified control both at a national and district level.

After the passing of the 1941 Act, structural works were the main means of achieving a level of protection from flooding. This was largely due to the need for achieving immediate protection of life and property on the floodplains. From 1945 to 1985, capital expenditure of $1000 million (in 1988 dollars) was invested by catchment authorities in New Zealand on river control schemes. The current maintenance and flood damage repair costs of these schemes are approximately $6. 3 million per year. (17)These schemes give protection for up to 100 year return period floods to 50,000 ha of urban land and 754,000 ha of rural land and protect assets that exceed $9000 million in value. They also provide a level of flood protection for approximately one million people who live on floodplains.

For many years, flood hazard reduction had meant river control and later catchment control. Catchment control schemes integrated soil conservation work with river control and drainage work as appropriate. The benefits of soil conservation work were seen as a reduction in erosion and soil loss and reduced aggradation in river channels. The link between catchment control works and downstream benefits in terms of river channel stability and bed load transport was assumed in the past to apply to all types of rivers. Monitoring and observations of river systems has shown that this link is most apparent for the East Coast region rivers but is not always as apparent or important for some South Island gravel rivers.

The nature of rivers and their behaviour varies throughout New Zealand. There are braided gravel rivers in Canterbury, short steep rivers on the West Coast of the South Island and rivers of the East Coast region that transport tremendous quantities of fine sediment. River control and management is carried out for different objectives because of wide variations in the character of rivers, their response to rainfall in their catchment and their ability to transport sediment.

The actual techniques used for river control in New Zealand vary widely. There is no recognised standard or guideline for river control work, and river control engineers generally use "rules of thumb" which they have developed from experience in their locality. River control and management is expected to be one of the functions of the new resource management agencies which will be established on 1 October 1989 as part of local government reform.

3. 2 Objectives of river management

Information on the objectives and means of river control and management was requested from four catchment boards, East Cape, North Canterbury, South Canterbury and Westland. Both the North Canterbury and the South Canterbury Catchment Boards have braided gravel rivers to manage. The Westland Catchment Board's region covers 2. 3 million hectares of land on which active hydrologic and geomorphic processes occur. The Westland region has

experienced many forceable reminders of the flood risk it faces, notably the two major floods in 1988.

The East Cape Catchment Board's (1) objectives in relation to flooding are:

1 to mitigate flooding to a realistic risk level;

2 to reduce the aggradation of river beds in the established flood control schemes;

3 to establish and secure appropriate river meander patterns and alignments;

4 to establish and maintain appropriate floodways clear of obstructions and unwise developments;

5 to anticipate and/or control overflow and overland flow.

The broad objectives of the North Canterbury Catchment Board (18) in regard to flooding are:

1 to reduce flood damages (both tangible and intangible) by means as described in NWASCA's Unified Flood Loss Reduction Policy (4);

2 to achieve and maintain stable conditions concerning channel position, channel pattern and aggradation and degradation;

3 to generally maintain the waterway as an efficient conduit for both floodwaters and sediment;

4 to ensure through regular maintenance work that the performance of existing flood protection systems remains to the design standard.

The South Canterbury Catchment Board's (19) adopted aim is the wise and beneficial management of water and land resources in a manner which yields multiple, efficient, balanced and sustainable uses in perpetuity. The Board has adopted a number of objectives to achieve this aim, one of which is to minimise the adverse effects of flooding.

The Westland Catchment Board (20) has recently developed a Flood Damage Prevention Policy. The policy statement splits flood damage prevention activities into four sections viz, flood warnings, flood planning, riverbed land use controls and river control works. The objectives of each activity are stated as are the means of attaining these objectives.

3. 3 Means of achieving river management objectives

The means of achieving the East Cape Board's objectives are:

1 The location, construction and maintenance of flood retaining stopbanks, where appropriate;

2 Reduction in aggradation in river beds is achieved by the promotion and implementation of catchment control schemes incorporating sound soil conservation and macroscale afforestation. In the upper and middle river reaches, reduction in aggradation is achieved by using stopbanks which are limited in height. Floodwaters containing fine sediment overtop the stopbanks so that the overspill sediment settles out on the ground. This "colmatage" philosophy retains fine sediment in the upper reaches of a river. In the downstream scheme reaches, the promotion of a well grazed floodway maintains capacity by minimising sediment deposition on berm areas;

3 River meander patterns and alignments are established by adequate investigation and design practices and appropriate use of suitable river control works;

4 The establishment and maintenance of appropriate floodways is carried out by controlling developments through planning legislation;

5 The development and use of hydraulic computer models enables potential overflow locations and overland flow paths arising from greater than design floods to be identified. These models, as well as data on floodspread from past flood events, are used to identify potential overflow locations.

The strategies used by the North Canterbury Catchment Board to achieve their river management objectives in relation to flooding can be categorised as follows:

1 Decrease peak flows

- adjust runoff rate through e. g. land treatment, afforestation, control of development, conservation farming;
- divert flow to natural or constructed channels.

2 Decrease flood height for a given flow

- increase channel capacity;
- reduce downstream backwater.

3 Decrease the duration of flooding

- improve local drainage.

As an example of braided river management, the Waimakariri River has a long history of attempts to constrain the river rather than let it wander over old channels through and to the south of the City of Christchurch. The objectives of the 1960 Waimakariri River Control Scheme included passing the design flood safely to the sea and also dealing with the problem of aggradation in the lower reaches of the river. The design flood is accommodated by using not only the river channels but also the bermland adjacent to the channel (refer figure 3). Bank protection against erosion uses groynes, rock rip-rap, and willow planting. Stopbanks have also been constructed to contain flood flows. The problem of aggradation in the lower reaches of the river is, in part, managed through the commercial extraction of gravel. This controlled commercial gravel extraction is an important river management tool for some gravel rivers.

The major element in achieving the South Canterbury Board's objectives for gravel rivers is the provision of clear flood fairways by the removal of woody vegetation. The establishment of vegetation, usually trees, is encouraged on the fairway fringes to control erosion, encourage berm siltation and to screen debris from any flows escaping the formal river system. Stopbanking systems contribute to the flood fairway stability by maintaining its sediment transport capacity and containing floodwaters within known channels.

The Westland Board intends meeting its objective for river control and management by promoting river control works on a comprehensive basis and ensuring that any works are subject to long term economic evaluation.

3. 4 Sediment sources and sediment transport

The sediment problem in East Cape rivers, and in particular the rivers draining to the East

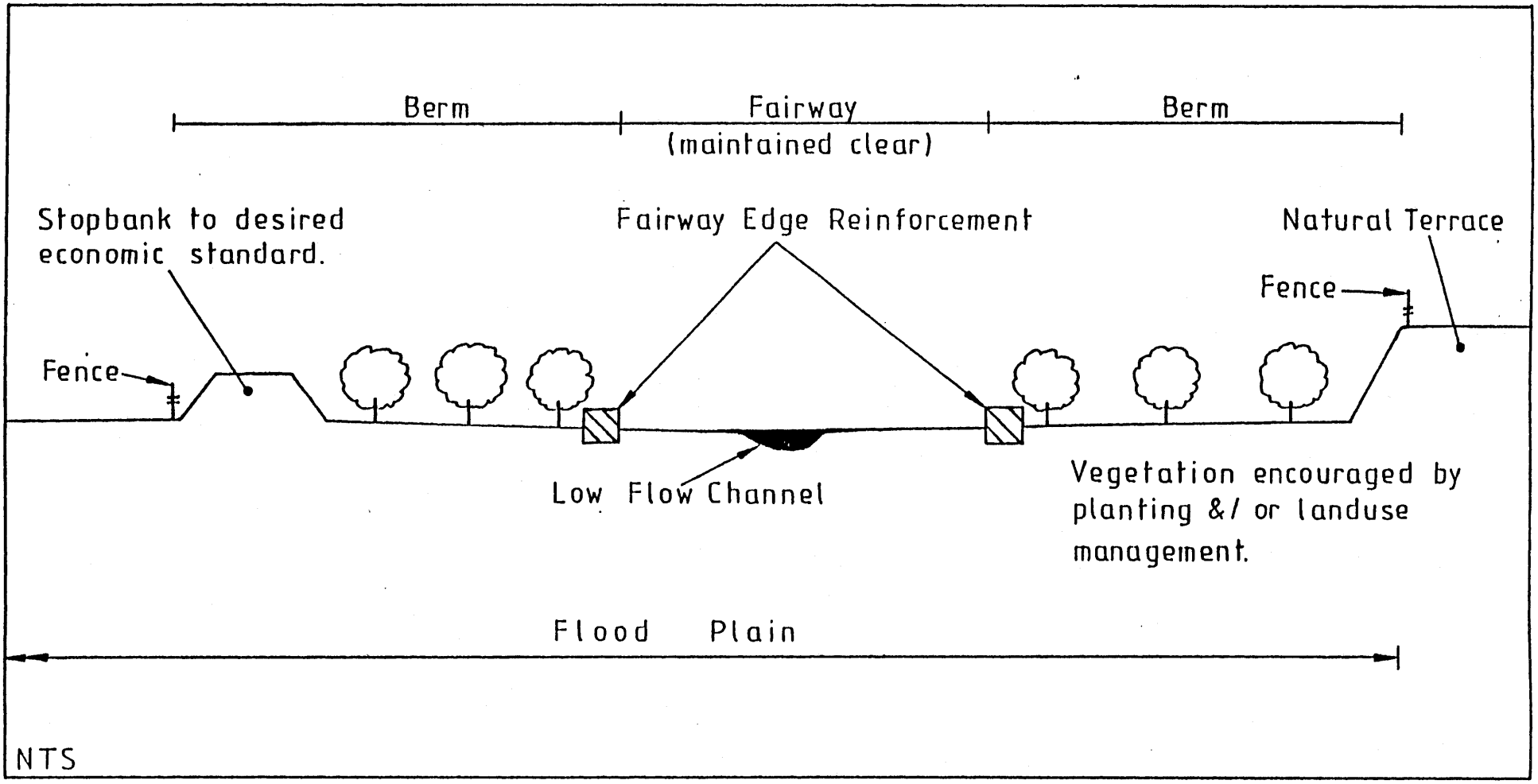


Fig 3 : Braided River

Typical Cross Section

Coast, is a major influence on river control design and management for the East Cape Catchment Board. The sediment sources for the rivers are in the upper catchment hill country areas. Changes in bed load from scour or from aggradation, affect the interpretation of data such as discharge/level relationships. These changes make modelling and therefore management of the river systems a complex undertaking. The bed load problem has always existed in the East Coast region and was made more evident by the Bola storm. More flood events since Bola have added to the problem. River control and management in this region requires the continuation of catchment surveys to detect changes in bed load, and the investigation and containment of bed load movement so as to minimise its impact in the lower reaches of the river system.

However, allowances for the changing nature of the bed load are made by anticipating that the river's ability to keep floodflows within its channel or within its floodway will reduce over time. The design of a stopbank at Te Karaka on the Waipaoa River, for example, has been derived from modelling studies under the present bed load regime. The model was also run under anticipated aggradation conditions in the river some years in the future. From these studies, the stopbank and river alignments remain unchanged but anticipated aggradation will reduce the design standard. The stopbank is constructed in such a way as to allow easy upgrading in the future.

In contrast to this, the North Canterbury Catchment Board has found that most of the gravel sediment transported in the rivers is supplied from the bed or banks. In the case of the Waimakariri River, the sediment source is mainly below the Lower Gorge. To reduce the supply of sediment, works to prevent bank erosion within the entire river system would have to be carried out. In addition to these new sediment sources, the gravel that is already in a river bed is resorted and moved downstream during each river "fresh" or flood. These changes in the existing gravel bed material, along with any new gravel supplies, alter the ability of the river channel to accommodate flood flows.

The Westland Board recognises the importance of the upper catchment areas but these factors are overwhelmed by the massive and natural geomorphic processes. Recent advances in the understanding of these natural processes is now significantly influencing the design of river control activity.

The management of gravel bed rivers, especially the designing of channels to transport sediment, is still not well understood. Although there is much information available on sediment transport in rivers, most of it relates to much finer sediment than gravels. The North Canterbury Catchment Board has, over recent years, been actively researching this topic. Partly as a result of this research, the Board has a general philosophy of minimising interference with rivers in their region, e. g. not constricting the river width unless external constraints, past decisions or objectives make it absolutely necessary.

3. 5 Effect of river management works with respect to major floods

The East Cape region has demonstrated the effectiveness of river control works many times. Since the Waipaoa River Flood Control Scheme was constructed, the Poverty Bay flats have developed from a risky, stock fattening area to one of highly developed cropping and horticultural land use with consequent benefit realised to Gisborne City and the region. Following the 1948 floods, which were the trigger to undertake the Waipaoa River Flood Control Scheme, the Poverty Bay flats have enjoyed a good level of protection from flooding. During the Bola storm the Waipaoa Scheme works ensured that the Waipaoa River was substantially contained and the floodflows passed to the sea. Silt deposition on the Poverty Bay flats came from tributary rivers that overflowed their banks. The town of Te Karaka had a partially completed flood control scheme in place at the time of the Bola storm. The

stopbanking in place prevented a major disaster, because the floodwaters ponded rather than flowed through the town.

Scheme works on the Waioeka-Otara Rivers have secured Opotiki from river inundation on several occasions. The East Cape Catchment Board is currently reviewing this scheme. The completed review is anticipated to show the requirement for continued urban protection of Opotiki and a variety of options for the scheme works protecting the Opotiki flats.

In contrast to the East Cape situation, the North Canterbury Catchment Board has little historical information about the size of floods and their effect on river management works. In the last 40-50 years, floods in the Waimakariri River and the Ashley River have not exceeded design standards. The major worry is erosion of structural works such as stopbanks and groynes, as such erosion could lead to bank failure and flood outflows. This could be induced either by a flood below the design standard or by a major flood. Only two instances of this have occurred in recent times.

In 1986 the South Canterbury Board's district experienced two floods of major proportions. One of these floods was the biggest for many catchments for more than 100 years. Despite the obvious inundation of the floodplain by greater than design floods, the established river control schemes performed very well. The vast majority of flood waters were transported safely to the sea. The extent and severity of flooding was considerably less than would have been the case without the river control schemes. The Orari River stopbank prevented total inundation of Geraldine and Temuka, along with extensive rural areas.

There are a number of reasons why river control works have afforded limited protection from flood hazards in the Westland region. One of the significant problems pertains to cultural perceptions of property rights. Surveyors more than 100 years ago had little understanding of the land forming and natural erosion processes and often delineated property boundaries in naturally active river erosion/flooding areas. Later property owners wishing to 'protect' their assets did not recognise the natural forces at work that change property boundaries and make it 'uneconomic' to protect in the long term.

3. 6 Cost/benefit analysis of the Waipaoa River Flood Control Scheme

An economic review of flood mitigation measures was part of the Terms of Reference for this inquiry. Within the resources available, a cost/benefit analysis of the Waipaoa River Flood Control Scheme was undertaken (21). The brief for the study was:

- To provide a broad appraisal of the economic efficiency of flood protection works within accepted cost-benefit analyses procedures,

- To attempt to incorporate the upper catchment works programme into the assessment of flood management, as far as practicable,recognising the integration between upper catchment erosion control and downstream flooding.

- To provide a report quantifying as far as possible the costs and benefits resulting from the flood protection works, and with conclusions regarding their long term effectiveness and economic efficiency.

The Waipaoa River Flood Control Scheme was approved in August 1952 and completed in 1984. River management works included channel training works and excavation, bank protection works, stopbanks of approximately 45 kms and berm sedimentation control. About 25 percent of the total capital costs were on berm sedimentation control. This required the Catchment Board to purchase land, within the stopbanks which is leased out for pastoral use.

The economic review has indicated that, in today's terms, the scheme has been an economic success. With an Internal Rate of Return of approximately 13 per cent, and a Net Present Value of $3,854,000 at a 10 per cent discount rate, the scheme has provided a satisfactory economic result. The Net Present Value indicates that the benefits of the scheme exceeded the costs over the 35 years since the project began. This is **especially so** when it is noted that social impacts have not been included in the calculation.

RECOMMENDATION

That the new Gisborne Regional Council should continue to maintain the Waipaoa River Flood Control Scheme and augment the effectiveness of the Scheme by integration with other flood mitigation measures.

A number of points are worth noting about the review and the results.

The assessment was a broad based exercise designed to indicate general levels of magnitude. A more detailed assessment would refine the result, but it is expected that the general indication would remain the same.

The performance of the scheme has been assessed since 1951, using costs and prices that prevail to the present day. Due to the current downturn in some agricultural and horticultural commodity prices, this has the effect of deflating the result. The actual relationship between costs and returns over the review period would favour a higher economic return than indicated. The actual land use changes that have occurred would reflect the movement in commodity prices over this time.

The capital expenditure on scheme works has been spread over 33 years. This reflects the nature of government subsidised works, with availability of government subsidy and local share limiting the speed at which work could be completed. However, when development projects such as this scheme are subjected to a 10 per cent discount rate (effectively weighting present cash flows greater than future ones), a long construction period can significantly affect the economic return.

RECOMMENDATION

That the Ministry for the Environment and the new regional resource management agencies should ensure that sufficient funding for future capital works, such as flood protection schemes and other resource management projects, is made available to complete works as quickly as possible. Delays in construction adversely affect economic viability when the project is subjected to discounting.

A major impetus for, and impact of a catchment control scheme is prevention of flood damage. These saved damages are very difficult to define as they are a function of erratic climatic events. Convention allows for the use of historical data and probability theory to calculate probable annual savings from flooding. This figure is then used in the calculation of net return. It is important to acknowledge that this is a statistical representation only. If a flood protection scheme successfully contains a series of large floods immediately on completion of works, it has instantly paid for itself many times over. If it is not tested for 50 years, it might seem of little value, in economic terms alone.

A major limitation of the economic review, and in fact of most cost-benefit analyses of flood control projects, is the failure to include quantification of the social impacts of the scheme in the calculations. It is standard practice to refer to these impacts qualitatively, but inevitably attention reverts to the quantified economic measures of Internal Rate of Return and Net Present Value. This same criticism applies to assessment of environmental values associ-

ated with conservation based projects, such as soil conservation.

In the case of the Waipaoa Scheme, and other major flood control schemes around the country, the social benefits are considerable. The initial push for protection derives as much from the wish for relief from the fear, uncertainty, upheaval and anguish as it does from financial concern. The difficulty of including a valuation of this significant impact greatly understates the real net benefit of flood protection.

Techniques are available for valuing such impacts, but they are expensive and difficult to apply. They are usually based on a survey approach to determine willingness to pay. Perhaps a more appropriate solution is to require a social impact assessment in tandem with the economic appraisal, when the scale of the project justifies the additional expense. Ultimately, the way the qualitative and quantitative aspects of the assessment are presented in the report will influence the decision-makers.

The economic review was constrained to look at the flood protection scheme only. Given further resources, an assessment of total flood mitigation measures in the Waipaoa catchment would have been more instructive and appropriate.

Of particular importance in flood mitigation in the Waipaoa catchment is control of soil erosion in the upper catchment. The unstable hill country is depositing huge quantities of material into the Waipaoa River and its tributaries. In addition to localised damage, the erosion causes a high sediment load in the river. The deposited material results in much increased damage from flood inundation and also causes aggradation of the river bed. It is expected that continued aggradation of the Waipaoa River, raising mean bed levels, will eventually compromise the integrity of the protection scheme and associated land drainage.

RECOMMENDATION

That the new Gisborne Regional Council should ensure the long term security of the Waipaoa River Flood Control Scheme by giving high priority to afforestation and other soil conservation measures in the upper Waipaoa River catchment, within best technical options.

RECOMMENDATION

That the new Gisborne Regional Council should fully appraise the commercial and conservation impacts when assessing the total worth of afforestation undertaken in the upper Waipaoa River catchment.

Erosion control proposals should not be addressed in isolation from overall catchment requirements. In the past, attempts to justify erosion control have centred on the retention of pastoral land for production. This is especially difficult when the most effective measure is to retire the land permanently from pastoral production into forestry. Forestry returns on such marginal land are unlikely to justify the expenditure in financial terms only.

The wider conservation issues associated with control of erosion must be addressed. Sustaining rural production is not the only vindication for soil conservation practices; and in fact, may not be viewed by the general public as the predominant impact. Due to the relative ease with which economists can quantify the production aspect, decision-makers have concentrated upon productive return at the expense of wider conservation impacts. The true social impacts to the nation of soil conservation include:

- retention of on-site productivity;

- mitigation of downstream impacts of erosion, e. g. on water quality, flooding;

- preservation impacts, including retention of the soil resource for future generations, thus maintaining the potential for alternative uses in the future, and satisfaction gained by the community from the knowledge that the resource is being conserved.

These latter impacts are not esoteric, throw-away concepts. They are issues that have real value to society and as such must be adequately considered when weighing up the relative costs and benefits of soil conservation. Currently this is not done. The difficulty is how to include such issues within an assessment and decision-making framework. As previously mentioned, some expensive and complex valuation techniques are available. In most cases a full qualitative description of these issues, presented in a manner that can be assimilated with quantitative data by the decision-makers, is probably adequate. Further work is necessary to define a consistent framework for presenting such data.

RECOMMENDATION

That the Ministry for the Environment should undertake research into more consistent assessment frameworks and presentation to give due account to social and environmental factors as well as financial factors.

3. 7 Future of river management works

River control systems suffer damage from time to time simply because rivers are dynamic:not only do they convey flows but they shape the boundary within which the flow is contained. Because of this, there will be an ongoing need to monitor river characteristics, develop design criteria, and estimate possible flood magnitudes as tools for river management and control. Without such development work it is likely that river control techniques will become more ad hoc and, in the absence of a national strategy and river control guidelines, more site-specific and of a "fluvial fire brigade" nature. Progress on river control will in part depend on whether guidelines on river control philosophy and river control works can be developed. There are a number of experienced people within catchment boards, or recently retired, who could contribute to this work. Experience with different river control techniques, their successes and failures, requires documenting so that river control works can be more effective in the future.

The East Cape Catchment Board has assessed the damage after the Bola storm and has found that some parts of the Waipaoa River, particularly near the railway bridge and the mouth of the river, are now unstable. Flood events since the Bola storm have further changed the river system and exacerbated the restoration problem.

Maintenance of scheme works usually involves the checking and repairing of any component of a flood control scheme. River control activities are more concerned with maintaining the overall security of a scheme. The distinction between the two kinds of maintenance is sometimes difficult to make. The provision of an adequate berm, the arrest of incipient bank erosion problems, and channel alignment works, are more river control and management activities rather than maintenance. However, both are required if river management systems are to retain their integrity and function correctly during the next flood.

The North Canterbury Catchment Board's experience is that the need for continual maintenance of existing flood protection works comprises a large component of the cost of a scheme. The integrity of flood protection works in the future is dependent on their maintenance.

The Westland Board acknowledges that maintenance of existing works takes priority over new works at present. The nature of the Westland rivers is such that planning for specific

maintenance is difficult. Most problems relate to infrequent storm events.
The ability of regions to fund both regular maintenance and disaster damage repair is a real concern to catchment boards. In the past, disaster damage has been substantially met by central government. For example, central government provided partial funding for the restoration of catchment works and floodforecasting systems damaged during the Bola storm. The Ministry for the Environment is, however, currently working on a policy regarding what constitutes a major flood and what should be the central government response. It is difficult for catchment boards to budget for disaster damage repair in the sense that it is not really feasible to carry over large sums of money from one financial year to the next. To illustrate: the damage to the Waipaoa River Scheme due to the Bola storm and to the September 1988 storm was about $3.15 million compared with annual maintenance of $100,000 to $200,000.

A region's ability to fund regular maintenance of river management works varies depending on its balance of urban and rural rating base. The Marlborough Catchment Board for example has two river control schemes, the Wairau Valley Scheme and the Kaikoura Scheme, without a sufficient rating base to maintain them. The annual income from the Wairau Valley rating district is insufficient to meet regular annual maintenance of the river management works. The annual income is quite incapable of meeting the costs of major flood damage which could amount to over $2. 5 million in one year. Recent floods in Marlborough have reinforced the knowledge that unrepaired works are very quickly damaged by further floods, thus compounding the problems (22).

Catchment boards like the East Cape and the Marlborough Boards are faced with equally unpalatable options in the short term: either to raise additional funds through rate increases in rural communities that are economically depressed, or to abandon maintenance of river management works in those areas where rate returns are low. This latter option is in effect the writing off of large central government and local share investments. Whether changes in local government organisation and financing will alleviate this concern is not clear. In the long term, a region may have to choose to abandon parts of a river control scheme and use other flood mitigation measures such as land use planning on the floodplain.

In contrast, the North Canterbury Catchment Board, with the substantial rating base of the city of Christchurch has less difficulty funding the regular maintenance of the Waimakariri River Flood Control Scheme.

RECOMMENDATION

That the new regional resource management agencies should recognise the importance of maintenance of existing river control schemes where these schemes are meeting agreed objectives for mitigation of flood damage.

New river control schemes or upgrading of existing schemes would be one of the options for flood mitigation in the future. The development of floodplain management planning could alter the previous emphasis on river control schemes to achieve a level of flood protection. The challenge in the future is to integrate existing or new river control schemes with other flood mitigation measures to achieve effective flood management (as discussed in the following chapters).

4 KEEPING PEOPLE AWAY FROM FLOODWATERS - LAND USE PLANNING

4.1 Introduction

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

The latter requires that regional schemes identify areas to be excluded from urban development because of natural hazards such as flooding. District schemes must identify areas at flood risk. Local authorities should adopt policies that avoid damage or danger by preventing flood areas being zoned for residential, industrial or commercial use, or by ensuring any development is based on sound technical advice.

The power to subdivide land or to obtain a building permit in cases of danger from hazards is more specifically regulated under the Local Government Act 1974.

Amendments to this Act in 1978 and in 1979 provided further opportunities to refuse subdivision development where land was not suitable due to flooding (s. 274) and to refuse building permits in areas where the building is likely to be subject to damage by flooding or where building would aggravate flooding (s. 641). This latter amendment was opposed by many councils and interest groups. It led to a change in 1981 which extended a council's discretion to decline a permit where a risk of damage from flooding could be foreseen. There is currently pressure from many councils to reduce these restrictions on residential permits.

From 1982 NWASCA, through its natural hazards policy, encouraged catchment boards to be involved in the district planning scheme process so that new developments were planned to include adequate safeguards against flooding.

Many catchment boards have been pursuing opportunities for involvement in district and regional scheme planning as schemes came up for review. This could include:indicative or detailed maps of where flooding will occur from a design flood, maps of flooding following major floods, and the depth of flooding. Such information can be used in district and regional planning as well as in floodplain management planning. The extent to which local authorities have incorporated information provided by catchment boards varies around the country and within regions.

The Local Government Reform and the Resource Management Law Reform will both affect the nature of planning work to be undertaken by the new resource management agencies from 1October 1989.

4.2 Flood hazard assessment

Information on flood hazard assessment and land use planning was requested from three catchment boards, East Cape, Central Districts and Southland.

The East Cape Catchment Board has actively pursued mapping of the Opotiki district flood hazard from the Waioeka-Otara Rivers system. Firstly data on aggradation in the rivers and the implications for flood hazard was reconsidered. Secondly, the flood hazard for the Waioeka-Otara Rivers floodplain and Opotiki Borough was mapped. The East Cape Board

has also completed floodspread maps of the Poverty Bay flats for the 1985 and major 1988 storms and for the Te Karaka township. An initial linkage between river overflows and building development in Te Karaka has been developed as an alternative to relying solely on stopbanking for protection. The flood hazards were mapped because of two major incentives. Firstly, the East Cape Board considered it was prudent practice and common sense to do it, in spite of the lack of interest shown by some local territorial authorities. The adoption by NWASCA of the policy on unified flood loss reduction (4) was the second incentive. NWASCA required that finance for river control works would not be given unless comprehensive studies on flood hazards and options for flood damage reduction were completed. This policy was instrumental in gaining local acceptance of the Catchment Board's proposals to review flood hazard.

The Central Districts Catchment Boards (23) have produced a report on the Palmerston North City flood risks in September 1986. Flooding in Palmerston North can arise from stopbank failure along one of the major waterways through the city or from stormwater backing up during periods of high flow in those waterways. The Central Districts Boards have, in the past, considered urban stormwater problems the responsibility of the urban territorial authority. The known stormwater ponding areas are now being mapped by the Boards and will be provided to Palmerston North City for reference when building permit applications are processed.

The incentives for the Central Districts Boards to map flood hazards were:

1 the Boards' awareness 10 years ago that even major river control schemes, incorporating stopbanking, often created the problem of flooding from water that ponded behind the stopbanks;

2 the intensification of rural development in the late 1970s. Flooding on a moderate size property may not be too damaging but on a small, 5-10 ha property it may mean there is no building site on the property that would be free of flooding;

3 section 274 of the Local Government Act has increased requests for flood hazard information from territorial authorities.

The Boards' objective was to ensure that subdivision development provided areas free from flooding for a dwelling site and buildings on all properties. This would save the Boards in the future from requests for stopbanks and for costly design, construction and maintenance of scheme works.

The Southland Catchment Board (24) has, over recent years, been collecting information on the flood hazards within Invercargill City and the surrounding floodplain as part of a major flood hazard identification for the Southland region. This study basically mapped the floodplain in an attempt to identify to territorial authorities and the public the areas in Southland where flooding from the major watercourses could be expected.

The incentives to map the hazards were two-fold. Amendments to the Local Government Act which placed responsibilities on territorial local authorities with respect to subdivisions and buildings on floodplains needed flood hazard information to fulfill these legislative requirements. The Catchment Board also saw the need to inform the public of potential flood risks as people seemed unable to recognise that sooner or later, irrespective of whether flood protection had been provided, the watercourses of the region were going to re-occupy the floodplains. The public's perception seemed to be that flood protection systems, such as stopbanks, offered an absolute standard of flood protection; and developers, in many instances encouraged by territorial local authorities, were intensively developing behind stopbanks.

The January 1984 flood was the worst flood on record in Southland and provided a practical demonstration of flood hazards. In Otautau, 190 houses and most of the businesses were flooded, as were 60 houses in Tuatapere. Invercargill had 900 houses flooded to varying depths. Following this flood, Invercargill City (25) produced hazard maps in conjunction with the Southland Catchment Board. The hazard maps were based on the areas of flooding and also provided information on minimum floor levels plus an allowance for freeboard. Southland County Council (26) has produced a "Hazard Register" in which the flood information is based on maps supplied by the Southland Catchment Board.

When flooding damage occurs, the catchment board has an opportunity to gather more information on flood hazards or to upgrade information. Flood hazard data was collected immediately after the Bola storm in the East Cape region. However, the task of interpreting the information did not start until some three months after the event due in part to not having suitable people available. Where catchment boards have insufficient people available during and immediately after a flood to collect and/or interpret flood hazard information, the help of trained people would ensure that the opportunity is not lost. Coordination of trained personnel to assist a board could be achieved through the New Zealand Catchment Authorities Association or its successor.

RECOMMENDATION

That the New Zealand Catchment Authorities Association or its successor should co-ordinate a Flood Hazard Action Team to assist the new resource management agencies if needed after a major flood. This team could be appointed on an annual basis.

4. 3 Flood hazard assessment and land use planning

Flood hazard maps are not yet incorporated into regional and district schemes in the East Cape region. Until the intention to incorporate the flood hazard information is effected, the East Cape Board has sought to ensure provision is made in scheme statements for these matters. Development proposals in flood hazard areas are also scrutinised by the Board. As part of the Bola relief payments, central government allocated some funding for river surveys and hazard assessment mapping.

The Central District Boards regard flooding and what is done about it as a landuse issue. For some 15 years, the Boards have been placing their information into District Schemes. At the same time, they have been objecting to and appealing development proposals at risk from flooding to provide some coordination on flood hazards. The Boards have also documented rural areas such as the Kairanga District which suffers serious flooding. These are included in District Schemes as zones where there are limitations to intensive farming and to buildings. The major flood in the Central Districts region, on 2-4 September 1988, illustrated that the Board's older structural river control works (stopbanks) and more recent flood avoidance procedures (hazard zones and floor levels) had limited the damage in rural areas.

A number of river control schemes have spillways situated adjacent to their stopbanking systems which allow river flows, beyond scheme design flow, to escape the stopbanked channel system to planned areas. These spillways or overflow areas are often designated in District Schemes, and development controlled accordingly.

Flood hazard information now forms an integral part of all the district schemes within the Southland Catchment Board's region. The natural hazards section of the Regional Planning Scheme (s. iv) is due to be released as a Draft Plan shortly. It is not expected that flood hazard information will be contained in this document but rather the hazard will be referred to.

Inquiries will then be directed towards the appropriate district scheme.
The hazard plans are not part of the City of Invercargill District Scheme or the Southland County Council District Scheme, but the schemes contain references to a "Hazard Register" which is a separate document. The reason for this separation is that the "Hazard Register" can be amended as information comes to hand without having to go through the scheme change procedure under the legislation.

RECOMMENDATION

That the new regional resource management agencies should produce flood hazard information, if this has not already been done, according to an agreed regional list of priority areas.

4. 4 Public availability of flood hazard information

The public availability of flood hazard information varies from region to region. A recent Privy Council decision (27) has found that catchment boards have a duty to inform the public of flood hazards.

The East Cape Catchment Board has an ongoing commitment to provide adequate hazard information in statutory planning schemes. The information on flood hazard and floodspread is made readily available to the public or interested parties. Floodspread maps have been issued to local authorities and community liaison personnel. Information on flood hazard is available in the Central Districts Boards' area in the District Schemes. Territorial authorities usually direct people to the Catchment Board for further information.

Information on flood hazards is readily available to the public in the Southland Catchment Board's region. This Board has a steady stream of inquiries regarding flood hazard, especially since the 1984 floods. Invercargill City has hazard maps available for viewing and for purchase. An updating service for purchased hazard maps is also available.

In contrast, the Thames Valley United Council (28) for example, advises that there is a tendency not to make flood hazard information public because of concern for loss of popularity of a town or suburb or loss of property value.

Public availability of flood hazard information is necessary to assist the public to assess the risks of flooding. Public perception of a 100 year return period flood is that it won't occur until some 99 years after the last one. In fact, there is a small but real chance that a flood of this magnitude could happen in the next and any succeeding year, e. g. Westland has suffered two major floods this year.

RECOMMENDATION

That the regional resource management agencies should make flood hazard information readily available to the public and other relevant regional agencies.

Flood hazard information can be most graphically conveyed by photographs. The evidence of flood risk is clearly communicated not only to decision-makers but also to the public. Many catchment boards have collections of photographs which are used not only for public advice but also in decision-making processes to support restrictions on land use planning.

Another problem in assessing flood risks is the lack of long-term data. The limitations in the practice of designating 100 year or longer return period floods based on relatively short records is illustrated by the following two examples. In Southland all the largest floods since

European occupation have occurred since 1977. This means, for example, that the 1913 Mataura River flood which was regarded as the 100 year return period flood has, since the 1978 and 1980 floods, been relegated to one with a return period of approximately 35 years. Similarly, a designated 500 year return period flood occurred in Marlborough in July 1983 and was followed by a designated 250 year return period flood within 12 months. As more information on climate, rainfall, and changes to land use in the catchment is collected, the perception of flood risks will have to take account of the changing nature of the flood hazard.

4. 5 Public perception of flood hazard

The mobility of New Zealanders can cause local knowledge of flood risks to be lost. The Southland Catchment Board's experience (24) is that when residences are flooded, very often the first owner who took the risk in building on the site is no longer the owner. Almost always the flooding risk was not known to the new occupant. For example, the 27 families whose houses were relocated after the 1984 Southland flood did not know their homes were likely to be flooded. The area had been flooded twice previously.

Even if the population is relatively stable, communities can be subject to "memory fade". Another problem is that people's perception of flood risk in general doesn't always translate to an appreciation of their personal situation. People can become indignant that a line on a map prevents them from building on a part of their property where they wish to site their dwelling. Even when minimum floor levels are provided, it has been noted by one catchment board (23) that during floods, although people's houses are not flooded, they are upset about not being able to leave their house because of water levels. In reality, people still want to build in floodable areas but are unhappy when it floods.

For people to perceive flood risk and then to take appropriate actions to minimise their risk, requires the following course of action:

1 landowners including subsequent purchasers, must have available to them sufficient information on which to make an assessment of risk;

2 landowners or an agency need to interpret this information as an expression of risk;

3 landowners must be able to interpret this expression of risk in order to try and assess the costs of ignoring the risk.

This last step is particularly difficult for natural hazards such as flooding when people may only experience a major flood once in their lifetime. In that case, it is exceptionally hard to assess the risk and the costs of ignoring the risk. Even when communities frequently suffer flooding, people may not have the money or the inclination to take avoidance measures.

The fact that the membership of elected agencies changes completely about every nine years poses another problem. The knowledge of past disasters and the reasons for restricting land uses in certain areas can decline in importance over time. This aspect is especially critical as the initially elected members of the new regional resource management agencies may not have a background in flood hazard assessment.

4. 6 The future of land use planning in relation to flood hazards

This year, both a programme of local government reform and a review of resource management statutes is being undertaken by central government. Both programmes will affect the way in which land use planning in relation to natural hazards, including flooding, is to be carried out in the future. Although details on both have not yet been made available,

there are some principles that should be incorporated into these reforms:

* there are only limited requirements in the present planning legislation for natural hazard mapping or natural hazard planning. The proposed planning legislation should ensure this is a function of regional government. Information on flood hazards should be collected, regularly updated and made available to all relevant agencies and the public;

* present land use planning controls such as s. 641 and s. 274 of the Local Government Act may need amending, but the intent to restrict unwise developments in flood prone areas should be retained in any new planning legislation;

* there is at present no provision in legislation for water and soil planning. There is some linkage of land use planning with the principles and objectives of the Soil Conservation and Rivers Control Act 1941 and the Water and Soil Conservation Act 1967. Through the Resource Management Law Reform, it should be possible to integrate water and soil management with landuse planning. One tool of such planning would be floodplain management planning as promoted by NWASCA. Regional government should be required to plan for natural hazard management. Included in this requirement is the production of floodplain management plans.

The priority to be accorded to integrating flood hazard assessment into land use planning will vary from region to region depending in part on the flood risks. However, the priority accorded within regions may depend on the structure and other functions of proposed regional resource management agencies.

For example, the East Cape region is proposing one Regional Council as best representing the nature and interests of that region. Water and soil interests are accorded high priority within all the local territorial authorities and are pivotal in the argument for a single authority for the East Cape region.

5 KEEPING PEOPLE AWAY FROM FLOODWATERS - FLOOD FORECASTING AND FLOOD WARNING

5. 1 Introduction

Forecasting is the process of identifying the potential of a rainfall event and translating the event into consequences of river flows and levels. Flood forecasting requires data sensors, a telemetry system, the processing and analysis of information to give prediction on the nature of an expected flood. Flood warning uses the results of the flood forecasting to assist emergency personnel and agencies to take actions to prevent damage, loss of life or loss of stock from occurring.

The ability to forecast potential flood events is crucial in New Zealand as many rivers have a short response time following heavy rainfall. Central government, through NWASCA, gave grants to catchment boards for the purchase and installation of flood forecasting and warning systems.

5. 2 Flood forecasting

A flood forecasting system requires the ability to monitor both the water levels of the upstream tributaries of a river and the rainfall.

The process begins with the New Zealand Meteorological Service providing timely information on weather development and rainfall potential. The Meteorological Service issues heavy rainfall "alerts" to the relevant catchment authorities. These "alerts" are either cancelled, extended or updated to a heavy rainfall "forecast" within a 24 hour period. These "alerts" are part of the "storm warning/severe weather warning service" provided by the Meteorological Service for the benefit of all sections of the community. The initial "alert" sets up predetermined procedures within catchment boards to monitor and evaluate potential flood situations. Direct contact between the duty forecaster at the Meteorological Office, the catchment board, and other relevant agencies has been a valued and effective means of exchanging information on a developing situation. This has certainly been true in the East Cape region.

The prediction of runoff from rainfall for particular catchments is a complicated task. Modelling of the available data to produce flood forecasts is at an early stage of development. However, flood forecasts based on catchment characteristics as derived from historical flood records have been shown to be effective. Continuous updating of flood forecasts can be made by using the field data from telemetered sites.

5. 3 Flood forecasting options

Over the past 10 years, and especially in the last five years, there has been a marked growth in the development and installation of telemetry equipment for hydrological data collection. Information on flood forecasting systems was requested from two catchment boards, East Cape and Otago. The East Cape Catchment Board was among the first boards to develop and install a system. The DSIR Hydrology Centre developed the Aquitel system which is used by many catchment boards and the DSIR Water Resources Survey.

The East Cape Board's system incorporates real time telemetry of rainfall and river stage from 26 sites. The field units are interrogated under computer control, and data processed by Board software provide a variety of presentations to aid decision-making.

The Otago Catchment Board operates a network of 11 telemetered water level recorders and seven telemetered automatic rain gauges giving reasonable coverage of the larger catchments on the Board's east coast area. The board's system has pre-set alarm levels for each site which will call base when alarm conditions are met until acknowledged. These alarm levels may operate either on river level or a programmable number of mm of rain in a number of hours (e. g. 50 mm in 12 hours).

The East Cape Board's systems were designed in 1978; they have been installed and progressively improved over the last 10 years. The Waipaoa catchment was the first to be serviced, shortly followed by the Waiokea-Otara Rivers catchment. Plans are in hand to extend major coverage to catchments north of the Waipaoa Basin.

Systems have been progressively installed by the Otago Board, e. g. the lower Clutha, the Pomahaka and the lower Taieri Rivers in 1982, the Kakanui River in 1983. The Electricorp sites in the upper Clutha River, run by DSIR Water Resources Survey, are due to be integrated into the Board's network this year.

5. 4 Effectiveness of flood forecasting systems

The East Cape Board considers their system has proved reliable and very effective in providing staff with field data, thus facilitating timely advice to other agencies. The system demonstrated its worth during the Bola storm and also during minor flood events.

The Otago Catchment Board is very satisfied with the improved ability to forecast timing and levels of peak floods at downstream sites from information derived up-country. The Otago Board is fortunate in that the response times of rivers in their region are generally slower than many catchments in the East Cape region. For example, Roxburgh to Balclutha on the Clutha River is about 12 hours river travel time.

5. 5 Flood warning procedures

The outcome of flood forecasting measures is advice of what may happen in respect to a developing flood situation. The responsibilities for flood warning are the subject of agreement at a national level among agencies such as catchment boards, civil defence and police. Catchment boards operating a flood warning advisory service are seen as the competent authorities to issue flood warnings. Although there is no statutory requirement for catchment boards to fulfill this role, the function is in accord with a board's responsibilities in respect of river control and hazard planning.

Flood manuals have been developed by catchment boards to detail the functions and responsibilities of their staff during a developing flood situation. Manuals also specify the links with civil defence and other emergency services.

Community awareness and preparedness in urban areas is necessary to take advantage of the flood forecasting and flood warning advisory service provided by a catchment board. At the local territorial agency level this should mean the close integration of catchment boards and the local or regional civil defence organisation so that flood warning information can be quickly disseminated to affected people. Community awareness is better developed in many rural areas where flood warning information has significantly lowered potential livestock losses.

RECOMMENDATION

That the new regional resource management agencies should ensure that the

civil defence section and the flood forecasting section of the organisation are co-ordinated so that flood situations can be identified and information disseminated in time to mitigate damage.

The flood warning procedure in the East Cape Catchment Board region is well developed and relies on maintaining continuous links with Police, Emergency Services and Civil Defence personnel. A manual of flood procedures is used by catchment board staff and outlines the actions required as a potential flood event unfolds. Procedures are predetermined through the buildup to a disaster stage where a declaration of civil emergency establishes an overall control system. Another example of good co-operation between agencies is seen in Otago. The Otago Catchment Board is involved with the South Otago Combined District Civil Defence Plan for the lower Clutha river system and has established good liaison with the United Council Civil Defence staff. However, this good cooperation is not evident in all regions.

Many catchment boards have flood warning systems for rural catchments. For example, the East Cape Board's routine flood warning operations established on its major schemes, involve an escalating round of contacts with river wardens and individuals. The Otago Catchment Board has one autodial voice synthesizer system on the Pomahaka River linked to 14 farms. This system has proved very satisfactory and the Board hopes to install more of these units if the local contribution to the cost can be found.

5. 6 Future needs

The public expectation of advice in adverse weather is much more demanding than it used to be. There are costs associated with the provision of this advice:

1 the installation of the telemetry equipment to collect rainfall and river stage information;

2 the equipment maintenance.

The New Zealand Meteorological Service is currently being restructured and retrenchment in some services has occurred. The Meteorological Service considers storm warnings to be a prime function of the Service. It is considered essential that the present services to catchment boards are maintained for the purposes of flood forecasting. Information exchange between the Meteorological Service and the catchment boards that has existed and been beneficial to both agencies should be retained.

With the variable areal and time distribution of rainfall, improved information relating to rainfall intensity and location would assist flood forecasting and hence warning time. The New Zealand Meteorological Service has been investigating the introduction of weather radar. Such systems provide real-time information which can enable flood warnings to be issued earlier than at present. Preliminary estimates for New Zealand indicate that annual savings of some 6-7 per cent of the $90 million (1988) average annual flood damage costs could be made by improved warnings assisted by radar. The Meteorological Service has a proposal before it for a network of five weather radars that could provide coverage of the entire country. With a capital cost of $10 million, this is a clear benefit to the country. But the Service cannot capture the benefits and so will not proceed.

To assist in quantifying this aspect, the Otago Catchment Board has co-ordinated a Floodwarning Response Survey with participating agencies being the East Cape, Hawke's Bay, Waitaki, Otago and Southland Catchment Boards and the New Zealand Meteorological Service. The objective of the survey is to develop stage-damage curves for New Zealand conditions and loss reduction figures related to flood warning lead time. University of Otago

consultants are analysing data from about 450 questionnaires and writing the report which is due by December 1988.

Future needs will include improvements in modelling techniques to use data obtained by the telemetry system to refine flood prediction. These techniques can not only improve flood prediction but also ensure that flood warning procedures are more effective. The need to either expand or upgrade an existing telemetry system in anticipation of or response to flood events will be recognised. For example, the East Cape Catchment Board is extending its telemetry system after the Bola storm. There is always the possibility, though, that a localised storm event will not be picked up by a telemetry network. The potential for flood damage in these situations will remain.

RECOMMENDATION

That each new regional resource management agency should consider the need to either extend or upgrade telemetry systems to ensure major catchments can be monitored for developing flood situations.

With local government reform being undertaken at present, flood forecasting and flood warning should become a regional responsibility as this is the level of government where the best and current information is required for decision-making in a storm event.

RECOMMENDATION

That the Local Government Reform should ensure that flood forecasting and flood warning become a regional responsibility and function.

At present, the DSIR Water Resources Survey collect hydrological data for certain river systems. The DSIR telemetry systems are not all integrated with catchment board telemetry systems although this integration is proceeding in some regions. There is a need to clarify the relationship of national, regional and local agencies involved in hydrological data collection and dissemination in relation to flood forecasting. This is particularly necessary in the light of the Local Government Reform and the Resource Management Law Reform.

RECOMMENDATION

That the DSIR Water Resources Survey telemetry sites should be integrated into the relevant regional resource managment agency's telemetry system.

6 FLOODPLAIN MANAGEMENT

6. 1 Introduction

The NWASCA floodplain management planning policy (4) changed the previous emphasis of relying on structural works to minimise flood loss damage to promotion of a more comprehensive approach. This approach comprises all of the options discussed in this inquiry together with civil defence planning, disaster relief and insurance.

The development of floodplain management plans is new and few have been completed. One example is the ARA Waitemata City/Henderson Borough - Opanuku Stream Catchment Management Study. Many catchment boards have been or are involved in flood hazard assessment studies which is the first part of a floodplain management planning process. In some areas, the development of a comprehensive floodplain management plan will require the availability of resources, both people and funds, in order to be undertaken.

Draft guidelines on floodplain management planning were produced by NWASCA in March 1988. The guidelines outline the elements to be included in the planning process. These are:

* setting up a floodplain management working group;
* a flood hazard assessment study;
* the selection of a flood size to be used for planning purposes;
* the evaluation of available adjustment options;
* the preparation of a floodplain management plan.

6. 2 Production of floodplain management plans

The North Canterbury Catchment Board (18) is undertaking a floodplain management plan for the Waimakariri River floodplain. The plan is being developed with the background of a lack of flood damage events in Christchurch and surrounding communities over the last 40-50 years. This will inevitably affect communities' perceptions of flood risk and may affect their responses to different options to mitigate flood damage loss. As part of the planning study, the Centre for Resource Management will be conducting a survey to ascertain people's perceptions of flood risk and their knowledge of various adjustment options.

The first part of the plan is the production of flood hazard maps indicating high risk flooding areas of Christchurch. These maps are intended to be produced in 1989. The production of the maps is to give a factual basis for future planning on the floodplain. An initial examination of adjustment options has identified the following for further consideration:

* maintain and locally refine the existing stopbank system;
* extend the present stopbank system;
* extend the flood forecasting system and evaluate the effectiveness of flood warning communication with emergency services;
* zone the highest risk areas as flood hazard zones to ensure any new development meets appropriate flood proofing standards;

* develop a technical assistance programme to advise floodplain occupiers on flood risk and damage reduction measures;

* establish an ongoing flood preparedness programme for floodplain occupiers.

6. 3 Future for floodplain management planning

Because many communities have developed on floodplains, the risk of damage occurring from major floods has to be faced. There is no one adjustment option that reduces risk to a negligible level. However, the intent of floodplain management planning is to identify the risk for different areas and, in the long term, to work towards reducing this risk. Thus a floodplain management plan for the Gisborne flats area will differ from that for Greymouth. None of the plans will start from a zero base but will have to take into account existing river management works, existing catchment management and present land uses on the floodplain. The plans will also have to consider the existing measures that minimise flood loss susceptibility during minor or the less than design floods while recognising the probability of flood loss damage by major floods.

Floodplain management planning should be undertaken on a catchment or sub-catchment basis. Addressing each of the flood mitigation measures in isolation from others is a rather ad hoc approach and will not in the future lead to the most effective mix of measures. This catchment basis for future planning has been largely recognised in the proposed reform of local government but should also be recognised in the new resource management legislation. At the same time, there must be sufficient flexibility in this approach to accommodate variations in the nature of the flood hazard in different river catchments.

RECOMMENDATION

That the new regional resource management agencies should plan and appraise future flood mitigation measures on a catchment or sub-catchment basis.

Floodplain management planning should be integrated into planning at the regional level. The present reform of the resource management statutes provides the opportunity for this policy to be implemented through legislation and for responsibilities for producing and implementing a floodplain management plan to be clearly apportioned. Floodplain management planning should be carried out under the auspices of a single authority.

RECOMMENDATION

That the Resource Management Law Reform should include in any new planning legislation, floodplain management planning as a basis for planning land uses on floodplains.

Following policy development through the Resource Management Law Reform, there will be a need for the research and development of technical tools to assist regional agencies. These tools could include:guidelines for undertaking a floodplain management planning exercise, information on river stages and damage incurred and the practicability and cost of house raising. There will also need to be a system of performance monitoring to assess the effectiveness of the plans and the policy over time. These tasks should be a responsibility of both central and regional government.

The implementation of floodplain management plans will depend largely on the degree of risk perceived by the affected community, the availability of funding from that community, and the priority of importance given in relation to other functions of regional government.

The Resource Management Law Reform is addressing Natural Hazards Reduction as part of phase 2 of the review process. From phase 1 of the process it has been agreed that Government has a role in natural hazard reduction through information provision, policy direction, disaster relief, civil defence and management where appropriate. The phase 2 study is examining the scope of government involvement and the variety of mechanisms available for natural hazard reduction.

The role of central government in assisting communities through policy development, emergency planning and disaster relief could be made more effective by bringing together the relevant agencies. Dr Neil Ericksen (29) has suggested that a co-ordinating agency should be set up to bring together all the information on natural hazards. Such an agency could collate information for householders, builders, developers and banks. If a new agency is not feasible, then a greater degree of co-ordination should be encouraged by the Ministry for the Environment.

7 INSTITUTIONAL CHANGE

7.1 Introduction

Institutional changes that affect flood mitigation measures have included the abolition of NWASCA and the Water and Soil Division of the Ministry of Works and Development. The Ministry for the Environment is now responsible for water and soil policy matters as well as some operational requirements.

The policies that were promoted by NWASCA that are relevant to this inquiry are the floodplain management planning policy and the soil conservation policy, both adopted in 1987. These policies are looking to the future and to the long term benefit of the regions. They have been reviewed by the Ministry for the Environment and will be considered as part of the Resource Management Law Reform. Future policies for floodplain management planning and sustainable land use will depend on the outcome of the Resource Management Law Reform.

One of the institutional changes arising from the abolition of NWASCA is the transfer of the MWD Science Centres specialising in water resources, soil conservation and hydrology to DSIR. With NWASCA as the co-ordinating body, the links between the Science Centres and the catchment boards meant a focussing of research work on the needs of the boards. These Science Centres under NWASCA were multi-disciplinary in nature and reflected the range of skills and expertise required for the tasks. For example, the New Zealand Land Resource Inventory land classification system is providing a nationally consistent information base for catchment boards to use in their soil conservation and land use work. The disciplines involved in this work include soil conservation, geology, soil science, plant physiology and physics.

The Ministry for the Environment, through its research function will be identifying areas of research needed for policy development and for the needs of the new regional resource management agencies for their water and soil management functions. The New Zealand Catchment Authorities Association, or its successor, can also identify the research needs of the present catchment boards. These two indirect links with the research agencies have replaced the direct link of NWASCA.

RECOMMENDATION

That the DSIR should continue to consult with the Ministry for the Environment and the NZ Catchment Authorities Association or its successor to ensure that the research needs of water and soil resource management are identified and met.

One of the important functions of the Science Centres was running training courses for catchment board staff to disseminate information on research. With the change of institutional control being so recent, it is not yet certain whether the Science Centres will be able to carry on its technology transfer role.

RECOMMENDATION

That the DSIR should be encouraged to continue to provide training in land use assessment and management to staff of the new regional resource management agencies.

RECOMMENDATION

That the NZ Land Resources Inventory land classification system should be

maintained, refined and updated when required, so as to continue to provide a sound basis for land use planning according to the capability of the land.

7.2 Funding

The effect of changes in funding of water and soil management has been particularly noticeable since 1987. This has been brought about by:

1 The removal of administration grants to several catchment boards and the partial change to 'user pays'. This has meant these boards have a reduced ability to fulfill their statutory functions through ongoing commitments and new activities. Another implication is that the ability of catchment boards to respond to emergencies, like flood events, is uneven. Some boards can cope better than others.

2 The rural economic downturn. A landowner's ability to fund water and soil management works has been severely curtailed in many regions and particularly in regions subject to the greatest risk of either soil erosion or flooding.

Uncertainty about the future functions of local and regional government and the priority to be accorded to water and soil management has meant that catchment boards are unwilling to embark on activities which have ongoing costs and benefits. To overcome this, the new regional agencies will have to address the issues of water and soil management risk, who bears the risk and also who pays to mitigate this risk.

If the level of funding of water and soil risk management activities cannot be achieved within a region, then central government may have to address the implication of activities or strategies not being undertaken to lessen risk. Targeting of preventive measures for flood mitigation or soil erosion is more appropriate than ad hoc response to disaster events.

A fundamental aspect of flood mitigation is the source and availability of funds. Fulfilling technical, social and economic criteria is no guarantee that necessary finance will be forthcoming. It is also possible that in the past the supply of money nationally may have resulted in works that would not have achieved efficiency criteria.

The continuation of government support at an appropriate level can provide the opportunity for positive actions to be taken in floodplain management. In some cases, provision of government funding for one adjustment option has been conditional on a review of all possible options being done first. This has often been sufficient incentive for flood hazard mapping to be done and the information to be incorporated in land use planning.

The funding base for water and soil management including flood mitigation is changing to reflect the greater emphasis on regions being responsible for natural resource management. Regional revenue will probably be obtained by a combination of general rating (including crown assets) and direct charging where appropriate. The emphasis will most likely be on recovering costs from users/beneficiaries. However, it is often difficult to clearly define user/beneficiaries in flood mitigation and associated conservation activities. User/beneficiaries can be separated as follows:

- on-site impacts, individual beneficiary.

- local/regional impacts, general benefits to region or portions of it;

- national impacts of interest to society as a whole, e. g. conservation issues.

Efficient resource management is assisted by ensuring that the true costs of that management are clearly placed where the benefits lie. This is not an argument for hitting easily identifiable users/beneficiaries with the total costs, e. g. implying that the full cost of erosion control should be borne by the landowner. Penalties for inappropriate land use aside, retention of the soil benefits many downstream users and many other individuals throughout the nation.

This is illustrated by the Waipaoa River Flood Control Scheme, which is funded by a rate recovered from a limited rating district classified according to "benefits". Decisions on just who "benefits" from scheme works can give rise to river flats being included and the associated hill country left out. In the case of the Waipaoa River Scheme this has meant that the known catchment threat to the Waipaoa River is financially separated from the Scheme works in the middle and lower reaches of the river.

Another example of the need for a whole catchment approach concerns a drainage district near Gisborne. In July 1985 the hill country in this catchment was severely eroded and the erosion was accelerated by the Bola storm. Attempts by the East Cape Catchment Board to introduce soil conservation works (prior to 1985) were unsuccessful, even at a 70 per cent subsidy rate, due to lack of farmer interest. Debris from a large slip from the Bola storm together with material scoured from the steeper tributary channels is now being deposited in the lower Taruhereu drainage area. This kind of problem needs to be tackled on a whole catchment basis, but this is not catered for in the normal method of funding through rating of the drainage area. The hill country farmers need to acknowledge that although they are not direct beneficiaries, they are contributing to the aggradation problem and thus severity of floods.

The obvious difficulty is in determining proportionate share of costs. Where the costs and benefits are spread throughout a wide community of interest, a government role should exist to provide a mechanism for redistributing costs and benefits associated with achieving a particular policy objective such as sustainable land use.

Provision of a mechanism will depend on having access to relevant information. A property owner should know not only the value of a particular piece of land but also the capability of that land and also the risk associated with human activity on that land. At the present time this information is scattered and not readily accessible. There would be merit in having valuation information include codes for land use capability and for erosion and/or flooding risk. This not only informs a would-be purchaser but could provide significant information to a regional authority to identify who was causing risks and who was bearing the risks. In New South Wales, any planning restrictions relating to a property are issued at the time of sale of the property. This kind of system could be explored for New Zealand.

A mechanism for redistribution of costs and benefits would need to operate over a long period and allow for variation over time, implying a monitoring function to assess the effectiveness of the redistribution mechanism. It is important that the right economic signals are given for sustainable land resource management.

A possible mechanism worthy of investigation would be a rating system based on a modified form of land valuation. Policies of 'user' and 'polluter pays' could establish criteria for valuations. The rating revenue would benefit the rate payer and the user. Costs should be borne by those who 'pollute' or generate the greatest risk to resource management. Thus land that is used for activities which increase the risk of erosion occurring could incur higher rates than lower erosion risk activities. Similarly, land with high capital investment requiring a high degree of servicing and flood protection could also incur higher rates than land with lower capital investment requiring less servicing.

Ideally notification of such a mechanism would influence changes in land use to achieve sustainable resource development.

RECOMMENDATION

That the Ministry for the Environment should undertake research into systems for allocating financial responsibility for future flood mitigation measures and for resource management. These systems would:

(a) delineate between individual, regional and national users/beneficiaries as well as risk generators and

(b) delineate between those who contribute to offsite risks and those who benefit from the protection provided.

8 SUMMARY

Because communities have been located on floodplains, the risk of flood damage occurring has to be assessed. This inquiry has discussed many of the adjustment options that are available to reduce the risk of flood damage occurring and has attempted to look at their effectiveness. There is no one adjustment option that is used to the exclusion of others within the areas serviced by catchment boards who have contributed to this inquiry. All the options have the potential to reduce the severity of flooding and to reduce flood loss damage.

Each option has its limitations, however. Stopbanks need bank protection maintenance to prevent scour damage. This is a significant ongoing financial commitment. Flood forecasting and therefore flood warning systems may not always be effective as for many rivers in New Zealand, flood development is rapid. Floodplain zoning is unpopular with existing landowners who may suffer a fall in the resale value of their land. Afforestation as a soil conservation measure takes eight to 10 years to become effective.

There has, in the past, been more emphasis on the structural options to reduce the impacts of floods as the institutional and funding mechanisms for these have been in place for many years. Alterations to both institutions and funding over the last year have provided an opportunity for change and a measure of uncertainty as to the priority that water and soil work will have in the new regional resource management agencies.

Further progress in reducing flood loss damage will come from the integration of all the mitigation measures into floodplain management planning. This planning should be undertaken at a regional level to reflect regional differences in the risk posed by flooding and the long term measures that can be put in place for each area or community. The emphasis in such planning should continue to be on preventive and avoidance measures, together with public education on perceived levels of "protection" that can be achieved. A possible effect of climate change is that cyclones in some form could pass close to New Zealand with increasing frequency (30). It may be that in retrospect the Bola storm will not be regarded as such an extreme event.

The costs and benefits of floodplain management planning will need redefining in view of the proposed changes to regional and local government agencies, the changes to resource management statutes and the changes to funding these activities.

In the past, central government policies and funding incentives played a large part in achieving flood mitigation measures. The future will see a greater emphasis on the regions assessing the water and soil management risks and ensuring that the generators of risk and the bearers of that risk are identified. Similarly the beneficiaries of risk management activities, such as flood mitigation measures, will need to be identified. The way in which funding of risk management activities is undertaken within the regions should be based on these aspects of risk. This could mean radically different regional funding arrangements.

In the interest of future generations, central government cannot allow the nation's soil resource to be degraded or the nation's floodplain land to be unwisely used. It has a role to play in dealing with the problems of soil erosion and floodplain management. The primary goal of such a role must be to conserve resources by allowing only sustainable land uses to continue. Unfortunately farming on the basis of good business can result in short term continuation of land uses which produce unacceptable rates of soil erosion and resource degradation. The need to integrate the commercial objectives of landowners, and the long term sustainability of the land resource, are fundamental to New Zealand's commitment to controlling erosion (and its causes), and conserving soil. It is also most cost effective to implement on-site soil conservation practices to retain the soil in situ than to pay the repair

costs of off-farm damage, such as flood damage. Society continues to put an ever increasing variety of demands on the land as new values and uses are recognised. Consequently, a national resource point of view, such as sustainable development,needs to be adopted when major decisions affecting natural resource use are being made.

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GLOSSARY

afforestation	conversion of pasture land or scrub land into forest
aggradation	the raising of the mean bed level of a river channel through deposition of sediment
bed load	the sediments and gravels temporarily stored in the river system
berm	land between the normal river channel and the stopbank subject to flooding
colmatage	retention of fine sediment on the ground by allowing floodwaters to overtop stopbanks at designated locations
erosion	the wearing away of the land surface by natural agents that involves the transport of debris
floodway	the area, mostly aligned with naturally defined channels where a significant passage of water flows during floods
floodway fringe	those parts of the floodplain where temporary storage of floodwaters occurs during the passage of a flood
freeboard	the difference in height between the top of the stopbank and the height of a design flood
return period	a 100 year return period flood has a 1% probability of occurring in any one year
rock rip rap	river bank protection using different size rocks
scour	the clearing action of floodwaters on riverbanks or the riverbed
siltation	deposition of material in a channel or on land surface from upstream erosion