

ECONOMIC REVIEW OF THE

WAIPAOA FLOOD CONTROL SCHEME

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1.0 DISCUSSION OF FINDINGS

The purpose of this review is to evaluate the effectiveness of the Waipaoa Flood Control Scheme in economic terms.

The Waipaoa River Catchment, and East Cape in general, suffer from a high frequency and intensity of flood events. Since the completion of protection works designed to mitigate flooding of the Gisborne Flats, peak flows have predominantly been contained within the stopbanked channel.

With a level of protection up to a 100 year return period flood, and subsequent land drainage, the scheme has precipitated an intensification of land use in the Gisborne plains, and contributed towards the wealth and stability of the Gisborne area.

In March 1987 Cyclone Bola distributed intense and protracted rainfall over the East Cape region. The Waipaoa River was subjected to peak flows equivalent to an estimated 120 year return period flow. The peak flows were also sustained over an unusually long period.

The Gisborne flats suffered significant localised flooding which overtaxed the drainage system. To this substantial flooding was added limited overflow (approximately 50 cumecs) of the scheme bank over some 100 metres.

Cyclone Bola demonstrated that the scheme has a capability beyond its original design: Damage from flooding on the Gisborne flats was greatly reduced by the protection works.

The events subsequent to Cyclone Bola have led to an investigation of the policies and mechanisms of flood mitigation. This economic review has indicated that, in todays terms, the scheme has been an economic success. With an Internal Rate of Return of approximately 13 percent, and a Net Present Value of \$3,854,000 at a 10 percent discount rate, the scheme has provided a satisfactory economic result. This is especially so when it is noted that social impacts have not been included in the calculation.

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

- 1.1 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.
- 1.2 The performance of the scheme has been assessed since 1951 using costs and prices that prevail 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.
- 1.3 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% discount rate, effectively weighting earlier cash flows greater than future ones, a long construction period can significantly effect the economic return.
- 1.4 A major impetus for, and impact of, the 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, and has little basis in reality. If a flood protection scheme successfully contains a series of large floods immediately on completion of works, it has immediately paid for itself many times over. If it is not tested for fifty years it might seem of little value.

1.5 A major limitation of this review, and in fact of most cost-benefit analyses of flood control projects, is the failure to include a 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 associated with conservation based projects, such as erosion control.

In the case of the Waipaoa scheme, and other major flood control schemes around the country, the social impacts 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 failure to include 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, when the scale of the project justifies the additional expense, is to require a social impact assessment in tandem with the economic appraisal.

Ultimately, the way the qualitative and quantitative aspects of the assessment are presented in the report will influence the decision makers. Careful thought must be given to the format of presentation. 1.6 This 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.

> Flood mitigation involves a variety of interrelated measures to minimise the effects of flood hazard. Some of these measures applied in the Waipaoa Catchment are discussed in the text, and can include, for example:

- hydrometric data collection
- telemetry systems
- meterological services
- flood warning mechanisms and procedures
- flood hazard mapping
- land use planning and zoning
- regulatory processes such as water right consents
- physical works for flood containment and soil erosion control
- insurance
- resettlement

It is the total impact of these mitigation measures that describes the effectiveness of flood control. Addressing individual components is a rather ad hoc approach to the problem. Future planning for flood hazard mitigation should address measures on a sub-catchment basis, attempting to determine the most cost effective means of achieving the objective. Obviously, capital works will be one of the more costlier options.

Combining, for example, protection works with hazard definition and land zoning would ensure that inappropriate land use is prevented on flood plains. A common problem throughout the country is the inability of the public to perceive of 'level of protection'. Flood stopbanks imply absolute protection, encouraging capital intensive development within flood plains. When the scheme design

level is exceeded, damage is excessively greater than would have occurred without the scheme. Protection must be defined, and appropriate development encouraged on the flood plain.

1.7 Of particular importance for 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 heavy sedimentation of the river water. 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.

Erosion control proposals should not be addressed in isolation of overall catchment requirements. Currently attempts to justify erosion control centre 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.

What are not being adequately addressed are the wider conservation issues associated with control of erosion. 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 fixated 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, eg. on water quality, flooding
- preservation impacts, including retention of the soil resource for future generations, 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.

In the reality of the East Cape situation, large scale afforestation is probably the only effective means of containing widespread erosion. The financial viability of forestry ventures decreases with distance from main centres, and with the use of poorer classes of land. Unfortunately, these constraints apply to the majority of the East Coast hill country.

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 good. A possible viewpoint is that if a forestry operation can at least break even financially 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 by the provision of subsidies 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.

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.

1.8 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 an oversupply of money nationally may have resulted in works that would not have achieved efficiency criteria.

The funding base for flood mitigation is changing rapidly with current local government reform and rationalisation of Government Departments. It is likely that future activities will be heavily reliant on Regional and District Authority approval and funding, moving away from hands on, central government control and finance.

Regional revenue will 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, eg. conservation issues.

Efficient resource management is assisted by ensuring that the true costs of that management are clearly placed at the source. This is not an argument for hitting easily identifiable users/beneficiaries with the total costs. An example of this is 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.

The obvious difficulty is in determining proportionate share of costs. The formula for achieving this needs further attention, possibly resulting in consistent, national guidelines for determining national share in resource management projects.

RECOMMENDATIONS

On the basis of the above discussion, the following recommendations are offered.

- A The Waipaoa Flood Protection scheme continue to be maintained and provide for protection and land use opportunities on the Gisborne flats. The effectiveness of the scheme continue to be augmented by integration with other flood mitigation measures.
- To retain the flood protection standard, afforestation and other conservation measures in the upper Waipaoa Catchment be afforded high priority within best technical options. In any assessment of the total worth of afforestation, full appraisal of commercial and conservation impacts must be undertaken.

- To assist in determining a financial base for future flood mitigation measures and more general resource management, research be undertaken by the Ministry for the Environment into means of delineating between individual, regional and national users/beneficiaries.
- D Future capital works for flood protection schemes, and other resource management projects, should be completed as quickly as possible so as to maximise economic return. Delays in construction adversely effect economic viability when the project is subjected to discounting.
- Assessments of flood mitigation measures and other resource management activities must emphasise social and environmental impacts as well as financial ones where these factors are significant. Further research is necessary by the Ministry for the Environment, into more consistent assessment frameworks and presentation to give due account to these factors.
- Future planning and appraisal of flood mitigation measures should be on a catchment or sub-catchment basis. Consideration of one component of a number of interrelated measures can be misleading.

2.0 STUDY BRIEF

The analyst is required to undertake an economic review of existing flood control measures in the Waipaoa Catchment. The review is a component of a wider investigation carried out by the Parliamentary Commissioner for the Environment. Specifically:

- Within accepted Cost-Benefit Analyses procedures, to provide a broad appraisal of the economic efficiency of flood protection works.
- As far as practicable, attempt to incorporate the upper catchment works programme into the assessment of flood management, recognising the integration between upper catchment erosion control and downstream flooding.
- Provide a report quantifying as far as possible the costs and benefits resulting from the flood protection works, and with conclusions regarding the long term effectiveness and economic efficiency.

3.0 BACKGROUND

The Waipaoa Catchment is on the East Coast of New Zealand, with the Waipaoa River running just to the South of Gisborne City (see figure one).

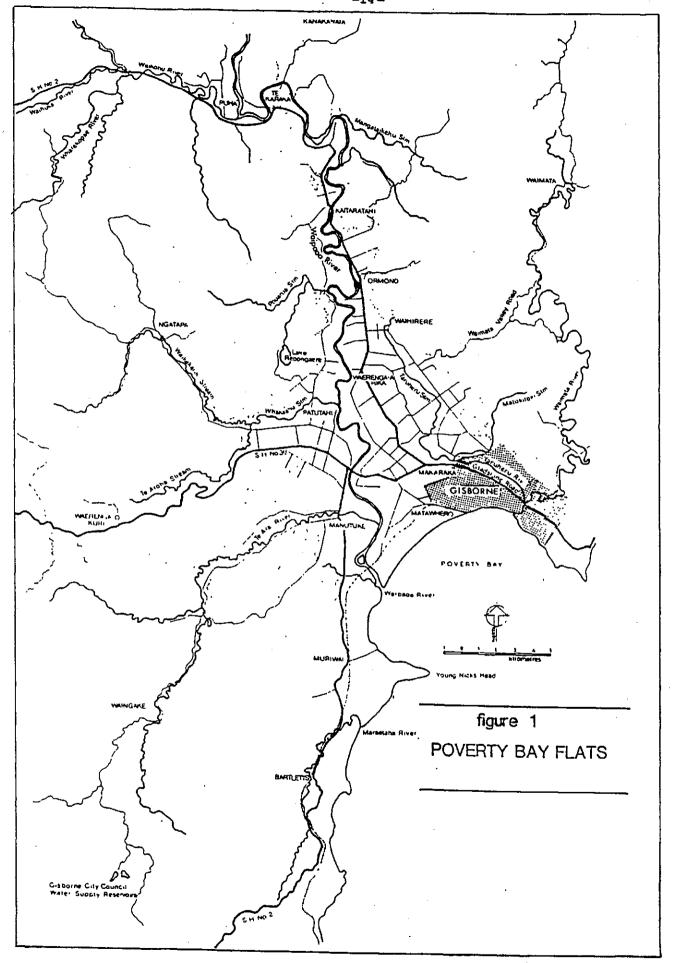
The catchment area is 217,080 ha, with a total Waipaoa River length of 108 kms. The highest point in the catchment is 1210 metres above sea level. The average annual water discharge is in excess of 1300×10^6 cubic metres, although this can vary from extremes of flooding to periods of very low flows.

The Waipaoa River flow is characterised by very high suspended sediment load due to erosion in the upper catchment. Severe aggradation is caused by erosion of primarily argillite and mudstone from the Mangatu and Upper Waipaoa Catchments.

Prior to European Settlement, most of the catchment was covered in native bush. Around the 1890's forest clearance began to move into the higher hill country, continuing for 30 - 40 years. The result of this land clearance was noted as early as 1910, and by 1920 the raising of stream beds from deposition was noticable.

The catchment was always susceptible to flooding during high rainfall. A useful description of historical flood events is contained in "Floods in New Zealand 1920 - 53" published by the Soil Conservation and Rivers Control Council (Ref 19). The Waipaoa catchment suffered from significant flooding on a regular basis, documented back as far as 1853. The floods caused widespread damage and have taken life.

1912, the Poverty Bay Rivers Board was formed with responsibilities for river clearing and flood warning. With the enactment of the 1941 Soil Conservation and Rivers Control Act, moves were made towards the establishment of the Poverty Bay Catchment Board in



1945. In 1948, following a series of almost annual floods, the Waipaoa was hit with a severe flood. A total of 8500 ha was flooded, causing damages in excess of 336,000 pounds sterling. The flood provided the impetus for the Waipaoa Catchment Flood Control Scheme, commenced in 1953. In 1956, during the early stages of scheme construction, the catchment was again badly flooded over an area of 8,000 ha, causing in excess of 86,000 pounds sterling damage to roads and bridges alone.

The protection scheme was officially declared completed in 1973, however work continued on and off until 1985. In addition to the scheme, soil conservation work and afforestation was undertaken in the upper catchment. Afforestation was part of the overall East Coast Project (Ref 5) designed to minimise erosion, reducing downstream damage and aggradation. Control of erosion by land retirement and conservation works is an integral part of the flood protection measures utilised in the catchment.

The flood protection scheme has lead to an intensification of land use on the fertile river flats around Gisborne city. The move from pastoral to horticultural land use has had a significant impact on the Gisborne area by the generation of wealth, employment and social stability.

In March 1988, the East Cape/Poverty Bay region was subjected to torrential rain from Cyclone Bola, with over 900 mm of rain falling on some hill country areas. The Waipaoa River reached the highest levels ever recorded. Large areas of the Gisborne flats were inundated from localised flooding and limited overflow from the Waipaoa River. The flood protection scheme prevented the scale of damage seen in other districts, such as Tolaga Bay. In the upper catchment widespread slipping and deepseated earth movements occurred, depositing large amounts of material into the river system. The East Cape Catchment Board and the DSIR noted that areas of afforestation and on-farm conservation works were successful in limiting erosion damage. The flood event during Bola had an estimated return period in excess of 100 years, ie. greater than scheme design levels.

As a result of Cyclone Bola's impact on the East Cape region, the Planning and Development Select Committee has requested the Parliamentary Commissioner for the Environment to undertake an investigation of flood protection measures in the East Cape. As part of that exercise, this report contains an economic assessment of the effectiveness of the Waipaoa Catchment Flood Control Scheme, and comments on other measures employed to control flooding in the Waipaoa Catchment.

4.0 FLOOD CONTROL MEASURES

Mitigation of flooding within discrete river catchments has historically been achieved by a combination of activities, primarily undertaken by Catchment Authorities. It is important to note that it is the integrated effect of flood mitigation procedures that minimises hazard from flooding. The impact of a single component such as protection works is difficult to define in isolation of other measures. For this reason, any appraisal of the overall impacts of flood control should contain a comprehensive assessment of all flood mitigation measures. However, due to resource constraints, the more detailed appraisal in this report is limited to physical flood protection works only.

The flood mitigation measures employed in the Waipaoa catchment are summarised below.

4.1 Waipaoa Flood Control Scheme

The scheme is described in more detail in Section 5. In summary, physical works comprising stopbanking, channel works, river clearing, floodgating and provision of berm areas between stopbanks are designed to protect approximately 10,000 ha from floods up to a 100 year return period.

4.2 <u>Te Karaka Flood Control Scheme</u>

The Te Karaka township is 47 km up river from the mouth of the Waipaoa. Urban protection by stopbanking was almost completed when hit with the effects of Cyclone Bola in 1988. Extensive flooding and damage occurred.

The protection of Te Karaka is necessary due to the build up in the mean bed level of the Waipaoa river. The scheme is designed to protect the township and land area of approximately 190 ha from flows of up to 4,000 cumecs (approximately 100 year flow).

The scheme cost is \$400,000 (1985), with calculated average annual savings from damage of \$114,000 (1985). The economic analysis (Ref 1) indicates an internal rate of return of 23 percent.

4.3 Stopbanking of Middle Reaches of the Waipaoa River

Approximately 40 kms up river from the scheme area, the Waipaoa River flows between terraces and hills, isolating pockets of river flats. Approximately 900 ha of these river flats have been protected with stopbanking by individual farmers. The stopbanks are generally designed to withstand flooding up to an 8 year return period, beyond which they are expected to overflow. The reasonably frequent overflow onto the flats and resulting siltation achieves two purposes:

- a the siltation raises the height of the river flats in conjunction with aggradation of the river bed, thus maintaining drainage levels;
- b siltation of the middle reaches retains some eroded matter in the flats, rather than restricting it to the river system and eventually moving downstream. It is estimated by the East Cape Catchment Board that approximately 6 million cubic metres of eroded material is currently held in the middle reaches.

4.4 Soil Conservation

The East Cape Catchment Board has undertaken works over a number of years to limit soil erosion in the Upper Waipaoa Catchment. The problem of erosion in the East Cape region are well documented, particularly regarding attempts to control it by afforestation. However, on land currently in pastoral use, some control over erosion can be obtained by site specific soil conservation works.

Erosion control is a crucial element in flood mitigation in the Waipaoa Catchment. In the first instance, silt and debris laden flood waters cause substantially greater damage, when not contained by protection works. Perhaps of greater concern is aggradation of the river bed by eroded material from the upper catchment. Continued aggradation is raising the bed level and thus water levels of the Waipaoa River.

Gradually aggradation will compromise the flood protection level provided by existing works. Ultimately aggradation may totally destroy the effectiveness of the Waipaoa and Te Karaka flood protection schemes. To spend large amounts of money on physical protection of flatlands, without a corresponding effort to contain soil erosion would be shortsighted and inefficient.

Unfortunately, it is not within the scope of this study to include the costs and benefits of soil conservation and afforestation activity in an overall assessment of flood mitigation. However, it is worth noting, in general, the impacts of soil conservation in the Catchment. Data available to date is adequately presented in the East Coast Project Review (Ref 13).

Erosion control has been addressed in the Waipaoa Catchment in two main ways:

- Farm conservation works on individual properties aimed at maintaining the productive potential of pastoral land. The works have involved open planting with poplars and willows, conservation forestry of small blocks, water control, drainage of earthflow areas, debris dams, gully planting and control works.
- b Afforestation of pastoral areas to primarily exotic tree species. This has involved commercial forestry with solely financial goals.

The impacts from these erosion control measures are outlined in detail in the East Coast Project Review report. In summary they are:

A Net increase in productive capacity of pastoral land from farm conservation practices. Over the whole East Coast Project area, an estimated 44,000 stock units productivity has been retained by farm conservation works to date. This is a mere one percent of the total carrying capacity of the region.

The economics of farm conservation work were assessed as part of the East Coast Project Review. The assessment indicated low estimated internal rates of return, based on livestock production alone.

The <u>on-site benefits</u> from farm conservation are currently not sufficient to encourage farmers to undertake works for financial return. Any justification of farm conservation works must take account of the off-site benefits discussed later in this section.

Net returns from forestry. The Mangatu forest, 13,000 ha in the upper Waipaoa Catchment, is run commercially by Forestry Corporation.

Estimated returns from Mangatu are not available due to commercial sensitivity.

Further commercial forestry may be viable on category 3a land or better, the closer to Gisborne the better. However this better land does not exhibit the major erosion problems. Further conservation forestry on more erosion prone land is necessary, and this is unlikely to be judged viable on the basis of financial return only. Additional downstream benefits need to be considered.

- c Saved Flood Damage. Control of erosion will reduce debris and silt in flood waters. This will reduce blockage of culverts and bridges causing flooding, and reduce damage from floating debris and inundation by silt laden waters.
- A major impact of erosion control in the Upper Waipaoa
 Catchment is on aggradation of river channels. A continued
 buildup of bed levels with material eroded from the
 headwaters can have a tremendous effect on flooding and
 drainage patterns on the river flats. East Cape Catchment
 Board staff estimate that there is probably around one
 million cubic metres of eroded material within the scheme
 length of the river channel, approximately 6 million cubic
 metres in the middle reaches, and 38 million cubic metres in
 the upper reaches of the Mangatu and Waipaoa Rivers.

The effects of changing land use on the Te Weraroa Stream and the upper catchment on Waipaoa River levels have been surveyed by the Catchment Board since 1948. The impact of the afforestation and farm conservation programme is evident in the upper catchment, but as yet is not obvious further down river. However, the East Coast Project Review notes that "Comparison of aggradation rates before and after afforestation suggests that sediment supply to the headwater catchments have been reduced by around two thirds". (Note: prior to Bola).

The evidence indicates that substantial afforestation would significantly reduce the rate of aggradation of the Waipaoa river. However, there is sufficient material already in the system to maintain aggradation in middle and lower reaches even if upper reaches are caused to degrade.

Erosion control is expected to reduce sedimentation input to the water courses of the Waipaoa Catchment. The resulting improvement in water quality, especially in upper catchment streams, would greatly enhance the aquatic habitat. Further downstream, horticultural expansion will place demands on groundwater supplies, requiring further abstraction from the Waipaoa River. Sediment loading causes severe problems with irrigation systems, requiring expensive filtration equipment.

Major impacts of soil conservation frequently ignored in assessments of costs and benefits are preservation impacts. These somewhat esoteric impacts are seldom acknowledged because they are usually not reflected in financial terms. However, when looking at impetus for, and benefits from conservation activities, preservation values can rate highly. They may be considered more important than production and financial return.

To clarify preservation impacts, they can be divided into three areas:

- The retention of the soil resource for possible use by future generations (bequest value);
- The retention of the soil resource maintaining the potential for alternative uses in the future (option value);
- Satisfaction gained by the community from the knowledge that a natural resource is being sustained (existence value).

Because current market mechanisms do not place monetary values on these impacts, they are often disregarded in decision making. In reality they can be significant values to individuals and the community. Broad financial valuations can be obtained using willingness to pay techniques, however these techniques are expensive and difficult to apply. Past studies, both in New Zealand and abroad, have shown that dollar valuations of preservation values can be very high, greatly outweighing the associated costs.

The prevention of soil erosion has significant regional spillover effects. Social and economic impacts are reflected in security of individual hill country farming operations, and the viability of rural communities, plus employment opportunity in farming and forestry operations.

4.5 Flood Management

The East Cape Catchment Board is actively involved in the management and mitigation of flooding in addition to scheme works. Hydrological data collection, catchment telemetry systems for early warning, meterological service reports, flood contingency plans, and civil defence response all combine to assist in flood hazard mitigation.

4.6 Discussion

Assessing flood protection in the Waipaoa Catchment, the combination of measures discussed above, and their aggregate catchment wide impact would provide the logical basis for analysis. However, the review brief and resource constraints have limited this assessment to a broad review of the Waipaoa flood protection scheme only. It should be noted that this sectionalised approach may under or overstate the actual benefits of total flood mitigation practices in the Waipaoa Catchment.

5.0 WAIPAOA FLOOD CONTROL SCHEME IMPACTS

5.1 General

The Waipaoa Flood Control Scheme was designed to protect approximately 10,000 ha of fertile river flats from flooding of up to a 100 year return period. The scheme physically constrains flood waters to a stopbanked channel over approximately 45 kms of the Waipaoa River. The confidence engendered by the scheme has permitted drainage and development of the fertile river flats with intensification into horticultural use. The potential for high productivity has attracted major processing industries.

The scheme has provided security and peace of mind to individuals who were constantly threatened by floodwaters. The social and economic growth resulting from the development of the Poverty Bay flats is a major factor in the development of the Gisborne region.

The impacts of the scheme have been assessed within a cost-benefit framework to provide a broad indication of the worth of the scheme since its inception.

5.2 Method

The study brief is to provide a broad assessment of the Waipaoa Flood Control Scheme. A discounted cash flow analysis has been applied to the impacts of the control scheme. The review has drawn heavily on a previous Preliminary Ex-Post Study undertaken by MAF in 1980, plus numerous relevant studies and reports listed in Appendix A.

The following conventions have been applied:

a The assessment has been undertaken from a national viewpoint, identifying impacts for both the with and without scheme situations.

- b Cost and prices have been adjusted to present day values (December 1987) using the Construction Cost Index, and current Product Price Assumptions.
- The study attempts to measure how the project has performed to date. The measurements of viability are made at the beginning of the project life of 37 years.
- d A 10 percent discount rate has been applied.
- The results are presented as Net Present Value, (NPV) indicating the present value of the benefits minus the present value of the costs, and Internal Rate of Return (IRR), the discount rate at which the present value of the benefits equal the present value of the costs, ie. NPV = zero.
- f Sensitivity of the results to changes in estimates and assumptions is tested in Section 5.5.

5.3 Costs (Standardised to Dec 1987, CCI 2910)

5.3.1 Scheme Capital Costs

The Waipaoa Flood Protection Scheme was approved in August 1952 at an estimated cost of approximately (\$30 million [Dec 1987] at a 3:1 government subsidy). The actual costs on total completion of the scheme in 1984 were approximately 33 million (1987) as compiled from ECCB annual accounts.

Capital works include: channel training works and excavation; bank protection works; stopbanks; berm sedimentation control; and contribution towards the construction of a new highway bridge.

The contribution towards the new highway bridge of \$1,455,000 (1987) or 40,000 pounds sterling (1953) has been removed from the calculation. The relevant costs and benefits of the bridge are outside the boundaries of the analysis.

Approximately 25 percent of the total capital costs were on berm sedimentation control. This was in fact the purchase of land within the stopbanks by the Catchment Board, which is leased out for pastoral use. This cost is treated as a transfer cost in this analysis, ie. no real resource cost, only a transfer of ownership. There may have been a reduction in productivity under the lease arrangements, but this is not considered to be a significant cost.

The land purchase cost of \$8,336,603 (1987) has been deducted from the cost flows between 1953 and 1960, at which time stopbanking and land purchases were substantially completed.

Actual, adjusted and economic capital costs are displayed in table two, over a period of 32 years.

5.3.2 Scheme Maintenance Costs

Actual scheme maintenance costs are indicated in Table Two. Continued maintenance requirements and restoration work is estimated by ECCB at approximately \$100,000 per annum.

5.3.3 Drainage Capital and Maintenance Costs

Following flood protection works, drainage of the fertile flats was possible allowing intensification of land use. Actual drainage costs were computed from the annual accounts of the ECCB as shown in the 1980 MAF Preliminary Ex-Post Study of the Waipaoa Scheme (Ref 9). These figures have been CCI updated for this analysis, and are shown in Table Two.

Total drainage capital costs were approximately \$576,000 (1987).

5.3.4 Development and Maintenance of Berm Areas

The costs of developing and maintaining the land inside the stopbanks for the dual purpose of flood channel and pastoral production are shown in Table Two. These costs were compiled from the ECCB Annual Accounts.

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	ADJUSTED CAPITAL	29876 3369562 3369562 3595401 3489530 4133105 4419821 2352103 1045816 624615 945845 459383 149206 153861 42498 0 0 101603 725205 1054584 902665 4678693 21043 21043 21043 375343 365270 157625	
	ACTURE CAPITAL	1540 185268 206234 206254 255656 282504 154382 71518 44646 69882 34730 111434 12108 3578 0 0 12100 72100 3500 4400 0 0 0 0 0 127800 701000 3500 4400 0 0 0 0 241200 252300 110500 0	
	133	150 167 167 172 186 186 191 223 223 223 223 224 225 225 226 227 227 227 227 227 227 227 227 227	
two	YEAR	1952 1953 1954 1955 1956 1960 1961 1963 1965 1970 1971 1972 1976 1976 1976 1976 1986 1985 1985	
Table			

5.4 Benefits

5.4.1 Saved Flood Damage

The Waipaoa Flood Protection scheme is designed to protect an area of approximately 10,000 ha from flood events of up to 100 year return period. Gisborne city is not subject to significant flooding from the Waipaoa River and as such is not protected by the scheme works. Urban flooding as seen in 1985 was the result of localised rainfall for which no protection exists.

The nature of the Waipaoa Catchment is such that high rainfall events combine large scale erosion in the upper catchment with surface flooding in the flatlands. The flood waters are heavy with silt and debris, causing severe damage to pasture, crops and infrastructure.

Total damage from flooding is a function of areas flooded, depth of water, land use, quality of flood waters, period of inundation and the speed of the water. Recent data suggests that duration of flooding may dominate depth as the most significant damage factor.

The Waipaoa has suffered a series of damaging floods over the years. The regularity of major flooding over recent years is demonstrated in Table Three. Some historical information exists on damage from these floods, although the estimates are usually conservative, concentrating only on stock losses and roading repairs. The publication "Floods in New Zealand 1920-53" by the Soil Conservation and Rivers Control Council (Ref 19) provides a useful description of Waipaoa River floods. Information from the 1948 flood is especially detailed.

More recently, Cyclone Bola and subsequent flooding in the Waipaoa catchment has provided more data on actual and potential impacts of flooding in the region.

estimated at 336,356 pounds sterling (approximately \$20 million in 1987 values). The flood had an estimated return period of 57 years.

The July 1950 flood had a peak discharge of 3200 cumecs, with an estimated return period of 20 years. The flood inundated approximately 6400 ha of rural land causing damage to crops and infrastructure, although stock losses were light. Damage to roads and highways was estimated at 86,000 pounds sterling. Damage to crops, pasture and farming infrastructure is conservatively estimated by the analyst at approximately \$500,000 (1987) or 20,600 pounds sterling in 1950 (based on MAF working papers). Total estimated damage 106,000 pounds sterling (\$2,500,000 in 1987 values).

In November, 1950, the Waipaoa River peaked at approximately 1500 cumecs at Kanakanaia Bridge. Flooding was not serious, but damages to county roads during October and November totalled 21,200 pounds sterling.

In 1951 the Waipaoa River peaked during a flood event at approximately 1400 cumecs at the Kanakanaia Bridge. Generally, little damage was caused.

In March 1987, Cyclone Bola caused widespread flooding throughout the East Coast region. The Waipaoa Catchment suffered localised flooding plus limited overflow from the Waipaoa River. The scheme prevented all but 50 cumecs of Waipaoa River flood waters from inundating the flats, at which time overburdened drainage and flows from adjacent upland areas had already flooded large areas. The peak discharge for the flooding was 5300 cumecs, corresponding to a flood event in excess of 100 year return period (design flood discharge). A factor of the storm event was the long rainfall period and corresponding duration of peak river flows.

Although the Gisborne flats suffered major damage from the flooding, very little damage could be attributable to discharges from the Waipaoa River. As a result, the Gisborne flats were not subjected to large quantities of fast flowing debris and silt laden flood waters from the greater Waipaoa catchment. The reduction in damage from scheme protection is highlighted by the much greater, long term damage incurred by the Tolaga Bay area, without protection works.

The calculation of damages prevented by a flood control scheme is extremely difficult. Convention provides for a statistical calculation of probable damage prevented, using historical damage figures and flood event return periods based on peak discharges. The resulting estimate of damage saved per year is merely a statistical probability. In reality floods occur in a random manner. For example, the Waikato region suffered three major floods of around 100 year return period magnitude during the 1950's. The Waipaoa Catchment has already been subjected twice this year to peak flows up to and in excess of 100 year return period.

However, the use of probability calculations does allow the analyst to make a broad estimate of average savings from flood protection, acknowledging the limitations of the technique.

Table Three provides historical data on flood events in the Waipaoa catchment, with estimates of with and without scheme areas flooded.

The limited historical damage information has been updated to 1987 values, and used to estimate probable damage levels in the absence of protection works.

Estimates of saved flood damage from a number of different size floods is sufficient to allow a broad statistical calculation of annual benefit. The flood information used for this analysis was from the 1944, 1948, 1950, 1951 and 1988 floods.

The 1944 flood had a peak discharge at the Kanakanaia Bridge of 2846 cumecs and flooded approximately 5,600 ha. Crop losses were heavy, but stock losses were minimal. Damage to roads and county works were considerable. Damage from the flooding was estimated at 87,906 pounds sterling (approximately \$5 million in 1987 values). The flood had an estimated return period of 15 years.

The 1948 flood was the largest on record prior to Cyclone Bola. The flood had a peak discharge of 3,964 cumecs and flooded approximately 8,500 ha. Damage was widespread, with heavy stock losses and damage to fences, buildings and roads. Total damage was

estimated at 336,356 pounds sterling (approximately \$20 million in 1987 values). The flood had an estimated return period of 57 years.

The July 1950 flood had a peak discharge of 3200 cumecs, with an estimated return period of 20 years. The flood inundated approximately 6400 ha of rural land causing damage to crops and infrastructure, although stock losses were light. Damage to roads and highways was estimated at 86,000 pounds sterling. Damage to crops, pasture and farming infrastructure is conservatively estimated by the analyst at approximately \$500,000 (1987) or 20,600 pounds sterling in 1950 (based on MAF working papers). Total estimated damage 106,000 pounds sterling (\$2,500,000 in 1987 values).

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In 1951 the Waipaoa River peaked during a flood event at approximately 1400 cumecs at the Kanakanaia Bridge. Generally, little damage was caused.

In March 1987, Cyclone Bola caused widespread flooding throughout the East Coast region. The Waipaoa Catchment suffered localised flooding plus limited overflow from the Waipaoa River. The scheme prevented all but 50 cumecs of Waipaoa River flood waters from inundating the flats, at which time overburdened drainage and flows from adjacent upland areas had already flooded large areas. The peak discharge for the flooding was 5300 cumecs, corresponding to a flood event in excess of 100 year return period (design flood discharge). A factor of the storm event was the long rainfall period and corresponding duration of peak river flows.

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In the absence of the protection works, it is estimated that land use on the Gisborne plains would not have changed significantly from the 1950's, that is, mainly pastoral and cropping (see Section 5.4.2). It can reasonably be assumed that, without the scheme, a flood of the magnitude of the 1988 event would have caused more damage than the 1948 flood. In order to provide a broad estimate of likely damage, it is assumed that damages would increase above 1948 levels by at least the factor of increased areas inundated. ECCB estimated that the 1988 flood would have covered approximately 9700 ha of the plains, as compared with 8500 ha in 1948, ie. an increase of 14 percent. Therefore estimated without scheme damage from a flood event of the size of the 1988 flood, at 14 percent greater than 1948 damages, is \$22,800,000 (1987). In fact damage would have exceeded this level due to the long duration of peak flows.

The actual damage from flooding during Cyclone Bola differs substantially from the hypothetical 'without scheme' situation. Damage was predominantly caused by localised flooding, but effected capital intensive rural properties developed in response to perceptions of Waipaoa River flood protection. A breach in the stopbank near to the Waipaoa River outlet resulted in the loss of several hectares of horticultural land, and damage to the railway bridge.

Considerable data exists on damage from Cyclone Bola. MAF Tech have published an assessment of damage for the East Cape, Gisborne and Wairoa area (Ref 11). Actual damage for the Gisborne Flats is more difficult to define, and would require a detailed appraisal of records. As an indicative estimate of damage, the short term reduction in base land values provides a broad quantification. John Fitzharris, MAF Tech, Gisborne (pers comm) notes that average base land values on the flood plain have dropped approximately 10% from \$11,000/ha, ie. a reduction of \$1,000/ha. Obviously this will vary significantly from property to property depending on damage. This factor is used as an indicator of damage, giving a total estimate of damage of \$10 million over the 10,000 ha of the flood plain of the Gisborne flats.

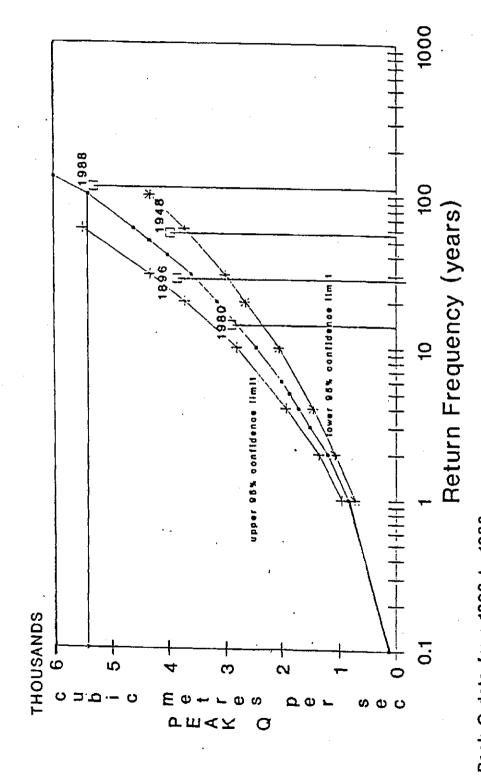
To facilitate the calculation of annual damage, it is further assumed that a flood event significantly larger than the 1988 flood would cause increased damage at least by a factor of increase in peak flow. For example, a 200 year flood would result in peak flows approximately 40 percent higher than the 1988 flood (see figure Two). Therefore it is assumed that damage would be 40 percent greater.

To calculate expected benefit of saved flood damages, it is necessary to calculate damages likely to occur without the scheme, and damages likely with the scheme. The net difference is the benefit to the scheme.

Tables Four and Five show probability calculations whereby different sized floods and corresponding damage figures are presented as a probable annual damage estimates. This is a means of showing individual flood damages as a probable average annual figure. These are summed to give an estimate of a total yearly damage. As previously mentioned, the calculation is a statistical representation only. Obviously if several major floods hit in rapid succession following completion of a protection scheme, the actual benefits would be much greater than indicated by this analysis.

WAIPAOA FREQUENCY PLOT Waipaoa @ Kanakanaia Br.

FIGURE 2



Peak Q data from 1896 to 1988 Derived by ECCB & RWB

TABLE FOUR: CALCULATION OF EXPECTED ANNUAL FLOOD DAMAGE WITHOUT SCHEME SITUATION

Return Period (Years)	Probability	Damage (\$)	Probability Interval	Average Damage (\$)	Expected Annual Damage (\$)
1	. 1	0			
			0.5	0	0
2	0.5	0			
			0.16	254500	40720
. 3	0.34	509000			
•			0.28	2812564	787518
15	0.06	5116129			
			0.01	5128564	51285
20	0.05	5141000			
	_		0.033	12358460	407829
57	0.017	19575919			
			0.008	21037959	168303
112	0.009	22500000			
			0.009	22500000	202500
			1.00	· .	1658155

TABLE FIVE: WITH SCHEME SITUATION

1	1	0			
80	0.0125	0	0.9875	0	0
	0.0125	Ū	0.0035	50000000	17500
112	0.009	10000000	0.004	12000000	48000
200	0.005	14000000	0.004.	12000000	
			0.005	14000000	70000
			1.00		135500

The damage calculations provide a broad estimate of without scheme damage of \$1,658,155 per annum, and with scheme damage of \$135,500 per annum.

The net damage savings attributable to the flood protection scheme are \$1,522,655 per annum.

The estimate is a statistical and somewhat arbitrary one. The influence of saved flood damages on total scheme viability is tested in section 5.5.

The annual saved damage is assumed to apply from 1960, at which time stopbank construction was substantially complete.

5.4.2 Land Use Changes

The Waipaoa flood protection scheme provides a level of security from flood hazard that has resulted in land drainage and intensification of land use on the flood plains. The perception of protection on fertile river flats lead to the establishment of Watties Canneries in the district. Watties Management confirmed in 1977 that the cannery would not have been established in Gisborne in the absence of the scheme (Ref 9). It is also likely that two major wineries would not have established in the area without the guarantee of flood protected grape supply.

The combination of flood protection, drainage and demand for process crops lead to changes in land use from predominantly pastoral and mixed cropping to more intensive cropping and horticulture. A breakdown in landuse in the area from 1954 to 1978 is provided in the 1980 MAF Study (Ref 9).

More recently, the Gisborne flats have been extensively developed into grapes, kiwifruit, subtropicals, pip and stone fruit, sweetcorn, tomatoes, vegetables as well as maize and pastoral use. A breakdown of land use on the Poverty Bay flats in 1978 and 1988 is shown on Table 6 (Source MAF Tech, Gisborne).

TABLE SIX: LAND USE POVERTY BAY FLATS

·	на 1988	На 1978
Total area	20242	20242
Kiwifruit	772	54
Citrus	374	231
Subtropicals	135	84
Pip and Stone Fruit	136	. 96
Grapes	934	725
Sweetcorn	235	1740
Tomatoes	350	180
Squash	· 134.	29
Vegetables	1669	1014
Maize	2576	3481
White Straw	207	818
Pastoral	9275	8794
Non Productive	3445	2996

Land use changes within the scheme area that are directly attributable to scheme protection and subsequent drainage are difficult to define accurately. However, it is unlikely that any significant intensification of land use would have occurred without protection and drainage. Following discussion with local experts, the 1980 MAF Review concluded that "... without the Waipaoa Flood Control Scheme and the associated Drainage Schemes, land use on the plains today would not be greatly different than in 1950, apart from on the flood free soils".

Land use on the flood plain in the 1950's was predominantly mixed crop (primarily maize) with prime lamb production and finishing.

The net returns from land use intensification are seen as net benefits to the nation. The argument that land intensification would have developed elsewhere without the scheme is not considered valid. Land use intensification appropriate to market forces will occur where possible, assuming land is available for transfer. As such, land changes on the flood plain are a net increase in national productivity.

The 1980 MAF Review used survey data to estimate actual land use changes in the scheme area. This data has been combined with the data from table six to provide an estimate of net land use changes in the scheme area attributable to the flood protection and drainage. Scheme area is defined as areas of benefit classified A-E, totalling 9696 ha. Where the two sets of data are inconsistent, the more conservative estimate has been used. Areas of subtropicals have been deleted from the model due to difficulties in determining actual crops grown.

The net changes in land use attributable to the scheme are shown in Table seven.

The model has assumed all process crops grown in the area are a scheme benefit. Without the cannery there would have been no demand. Consistent with the 1980 MAF Review, 70 percent of grape production is also seen as a direct scheme benefit.

Following the approach used in the 1980 MAF Review, the areas in process crops have been multiplied by gross margins supplied by MAF Tech, Gisborne (see Appendix B).

The net returns for the horticultural crops of grapes, citrus, pipfruit, stonefruit and kiwifruit have been calculated as shown in Appendix C. To simplify the analysis an initial establishment cost followed by an average gross margin has been applied (see Appendix B, information supplied by MAF Tech, Gisborne). This is a simplification of a varying costs and return flow over a number of years.

	KIWIFRUIT	00000000000000000000000000000000000000
LAND. DATA	STONEFRUIT	115 0 116 117 117 118 118 118 118 119 119 119 119 119 119
ы	PIPFRUIT	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
FILE	CITRUS	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
	GRAPES	555 555 654 654 654 654 654 654 654 654
BENEFIT (HA.	PEAS	168 341 109 109 121 121 227 227 227 400 409 353 369 369 449 449 449 274 274 274 274 274 274 274 274 274 274
DIRECT SCHEME B	BEANS	16 0 16 15 23 23 24 24 112 113 114 115 115 115 117 117 117 117 117 117 117
	TOWATOES	33 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3
LAND USE CHANGES	SWEETCORN	405 217 217 218 308 316 316 97 166 401 656 1108 1108 1108 1109 1104 1124 1138 1138 1138 1138 1138 1138 1138 113
Table 7	YEAR	1951 1952 1953 1954 1955 1956 1957 1961 1963 1965 1965 1970 1971 1972 1974 1972 1974 1976 1976 1976 1977 1978 1978 1978 1978 1978 1978 1978
-		

Production foregone by development from pastoral production/cropping to horticultural use has been calculated on the basis of 20 stock units per ha, with a sheep gross margin of \$19.61 per SU.

The net cash flows from land use intensification are summarised in Table 8.

5.4.3 Value Added by Processing Firms and Fishing Industry

Watties have indicated that they would not have established processing operations in the Gisborne area without the crop protection afforded by the scheme. It is also unlikely that the Watties fishing industry would have developed in Gisborne without the processing base. Similarly, two major wineries would most likely not have established in the area without the additional flood protected grape growing areas.

This assessment is from the national viewpoint. If these major developments could have been directed to another region, the direct benefits of the scheme are limited to the net savings from operating in Gisborne compared to another district.

Alternatively, if the developments would not have occurred in alternative sites, the value added to the product by the processing is a direct scheme benefit.

Due to difficulties in determining alternative options for these processing developments, and commercial data concerning value added to product, assessment of these scheme benefits has not been attempted. However, it should be noted that value added benefits of this nature are potentially large: Influence on the scheme economics could be significant.

5.4.4 Security and Peace of Mind

A major initiating factor in flood control works, beyond any perception of financial loss, is the fear of flooding. The physical dangers associated with flooding are obvious, with well documented

·	TOTAL	121500	90300	126090	-4576062	1469500	1511154	152020	1553200	\$1000CT	1500958	1217398	1466492	1569042	1598274	1544518	1704250	1756962	1823942	1887702	1337730	1405954	1644772	2191702	2458552	2704124	3056768	3244332	3620526	2768574	1970634	2726516	2838886	3252632	3674166	4108162	4559548	5040924	5298188	
	KIWIFRUIT	0	٥	0	0	C	, C	•	> <	> •	ɔ '	0	0	ó	0	0	0	Ċ	0	0	0	0	0	0	0	0	0	0	0	-321800	-260064	47040	388536	695640	1037136	1344240	1685736	2057200	2226736	
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	PIPFRUIT	0	0	0	-919940	749560	749952	720074	##76C/	000001	/1/878	667302	699426	744692	766108	787524	808940	843498	841064	862480	883896	905312	926728	948144	969560	926066	1040244	997804	955240	601484	233142	243850	254558	265266	275974	286682	297390	308098	318806	
LAND, USE	CITRUS	0	0	0	-1171352	ACAST F	360956	200000	261930	#00000 #00000	369172	386544	383220	370890	358572	345856	311112	306456	318780	331104	343428	355752	97764	196356	294948	393540	672340	700548	908496	686664	353560	369444	415180	443936	459820	492684	538420	554304	587168	
	GRAPE	0	0	0	0	· C	-	•	> <	.	0	0	0	0	0	0	0	· C	0	0	-670242	-688088	-312100	-30680	155030	325740	415740	584592	761728	757160	698882	772740	875882	962882	1036740	1139882	1213740	1316882	1403882	 - -
CHANGES	PEAS	0	25200	51150	18600	16250	18150	00000	24050	05040	42150	34650	55350	61350	52950	55350	56700	60000	74550	89250	87900	00069	63150	67350	49650	25050	41100	41100	41100	37650	34200	30600	27150	23700	20250	16800	13350	0066	6450)
· ł	BEANS	0	0	4640	2610	1250	4350	טריי פריי	1250	007/	0969	7830	12760	15660	25230	27260	39440	54810	33060	37990	32480	38570	67860	71050	77720	76270	56260	56260	56260	51040	vo	409480		31030		20880	15660			! !
CASH FLOWS	TOWATO	0	0	70300	86950	0000	000/5 1005/0		008200	DCOOK	107300	29600	136900	138750	138750	125800	140600	103600	138750	144300	123950	146150	112850	153550	159100	185000	229400	262700	297850	333000	364450	395900	427350	458800	490250	521700	553150	584600	616050	,
	SWEETC	121500	65100	0	20100	45600	86700		92400	00056	29100	49800	120300	162300	164400	93600	153300	183900	202500	196800	300000	332400	313200	433800	423600	401400	312600	382200	452100	522000	476700	431700	386400	341400	296100	251100	205800	1,60800	115500	; ; ;
Table 8	YEAR	1921	1952	1953	1954	1000	1956	0000 F	1050	OCAT .	1959	1961	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	!

examples of loss of life. The uncertainty associated with flood events places great stress on individuals within a flood plain. This uncertainty and fear, for example, of losing irreplacable items or watching stock perish is not fully relieved by insurance coverage, and hence is not wholly financially based. The social impact of security and peace of mind of residents in a protected area is a significant, if uncalculated, benefit of any flood mitigation measure.

5.4.5 Regional Stability

The Waipaoa Flood Control Scheme has provided security to the rural community that has allowed intensification of land use as a direct benefit. A secondary benefit of the scheme is the social and economic impacts on the region as a whole. The generation of wealth in the district, with resulting impacts on the business community, schooling, social services etc, has contributed greatly to the standard of living in the region. These aspects must not be disregarded when judging the true economic impacts of the scheme.

5.5 Results

The costs and benefits of the flood protection scheme have been quantified and a discounted cash flow analysis undertaken over a period of 36 years. The net cash flow is shown in Table 9.

The Internal Rate of Return over the 36 year life of the project is approximately 13 percent. The Net Present Value at a 10 percent discount rate is approximately \$3,854,000.

NPV 0.5 percent = \$20,735,000

NFV @ 15 percent = \$1,273,940

It should be noted that this is a conservative estimate of net benefit as the calculation does not include estimates of some beneficial social and environmental impacts.

FLOW. DATA				
FLC		SAVED DAMAGES	0 0 1387155	
, SCHEME	BENEFITS	LANDUSE CHANGE	121500 126090 126090 1469500 1511154 1539280 1511154 1511154 1560958 1217398 1217398 1217398 1217398 1217398 1217398 1217398 1217398 1217398 1223942 1337730 1405954 1644772 2704124 3620526 2704124 3620526 2704124 3620526 2704124 3620526 2704124 3620526 2768574 1970634 2726516 2726516 2726516 2726516 2726516 2726516	
WAIPACH FLOOD CONTROL SCHEME		DEV/MAINT BERM	51379 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	
CASH FLOWS		. D MAINTENANCE	19706 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	· ·
ð	I	DRAINAGE CAPITAL 1	25214 5479 140847 207139 160632 160632 185825 254503 342103 342103 129207 129207 129893 461978 146898 146898 146898 146898 146898 146898 146898 146898 146898 146898 146898 146898 146898 146903 353724 311955 83313 0 0	ı
rable 9		CHEME CAPITAL MAINTENANCE	0 0 0 0 0 0 0 0 0 0 0 130785 2977863 2977863 2977863 2977863 152872 152872 178697 178697 17646 83663 103592 91805 55860 87300 98193 65439))))
Ĥ	COSTS	SCHEME CAPITAL 1	29876 694815 2293903 2226356 2636964 2819892 1500666 667241 398511 945845 42498 0 0 101603 725205 1054584 902665 4678693 21043 21043 21043 21043 315343 365270 0 0	•
	୪ _.	YEAR	1952 1953 1953 1953 1955 1955 1960 1963 1965 1975 1975 1975 1976 1976 1978 1978 1988 1988 1988	> 1

5.6 Sensitivity Analyses

The analysis of the impacts of the Waipaoa Flood Control Scheme was, of necessity, based on a broad appraisal of the costs and benefits. The results have indicated that the scheme has been effective in achieving a satisfactory level of economic return over its life.

Due to the uncertainty associated with some assumptions and estimates used in the analysis, it is useful to re do the analysis with variations on the key assumptions. This is designed to indicate areas that have a significant impact on the result.

The sensitivity analyses are summarised in TABLE 10.

5.6.1 Land Use Changes

The major financial benefit from scheme protection is from increased returns from intensification of land use. Accurate estimates of land use benefits that are directly attributable to the scheme are very difficult. Also the use of current product price assumptions, during a period of deflated commodity prices, to describe past returns somewhat deflates the true benefit.

To test the impact of variations in land use and net returns, the analysis was re-run with the land use change cash flows increased and reduced by 20 percent.

A 20 percent increase in net returns lifts the IRR to 14.5 percent, whilst a 20 percent reduction in net returns drops the IRR to approximately 12 percent. The analysis is reasonably robust to moderate variations in changing land use benefits.

5.6.2 Saved Flood Damage

The estimate of annual saved flood damage used in the analysis is a statistical calculation. As explained in the text, convention allows for its use in describing saved flood damage, but it has

little basis in reality. For this reason, the impact of the estimate on the result is tested by including no allowance for saved damages in the analysis, followed by a doubling of the estimate.

No allowance for saved flood damage reduces the IRR to approximately 7 percent, whilst doubling the estimate raises the IRR to approximately 18 percent.

Again, the analysis is reasonably robust to variations in this estimate.

TABLE 10 : RESULTS OF SENSITIVITY ANALYSES

Anal	ysis	NPV @ 10%	IRR
1	Base	3854090	13.1
2	20 percent reduction land use benefits	1920780	11.7
3	20 percent increase in land use benefits	5758410	14.5
4	No allowance saved flood damage	-2756640	7.4
5	Doubling allowance saved flood damage	10464800	17.6

5.7 Discussion

Conclusions and recommendations from the study are presented at the beginning of the report, Section One, Discussion of Findings.

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IE Jones, Ex-Chief Engineer, East Cape Catchment Board, Gisborne

Dave Peacock, Deputy Chief Engineer, East Cape Catchment Board, Gisborne

Dr Craig Trotter, Soil Conservation Centre, Aokautere, Manawatu

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APPENDIX B : ESTABLISHMENT COSTS FOR HORTICULTURE

AND GROSS MARGINS, GISBORNE FLATS

(Source : MAF Tech, Gisborne, August 1988)

ESTABLISHMENT COSTS:

Grapes		\$15,750/ha	
Kiwifruit		\$12,480/ha	
Pipfruit		\$12,750/ha	
Citrus		\$12,480/ha	
Stonefruit		\$22,330/ha	
GROSS MARGIN FOR:	,		
Grapes	\$ 3,000/ha	Goats	\$27.43/SU
Kiwifruit	\$ 9,040/ha		
Citrus	\$ 4,500/ha	Deer	\$43.13/SU
Pipfruit	\$11,100/ha	•	•
Stonefruit	\$ 2,500/ha	Cattle	\$11.41/SU

Tomatoes	\$ 1	,850/ha	Sheep	\$19.61/SU
Sweetcorn	\$	300/ha		
Maize	\$	250/ha		

\$ 1,750/ha

Barley	\$	150/ha
Peas	\$ *	150/ha
Beans	\$	290/ha

Squash

APPENDIX C HORTICULTURAL CASH FLOWS

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TABLE C2

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