

TECHNICAL REPORT

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## POVERTY BAY FLOOD HAZARD MAPPING

### TECHNICAL REPORT

#### 1.0 Introduction :

Following the completion of the Waipaoa River Flood Control Scheme in 1973, the Poverty Bay flats were generally considered to be flood free. However, the localised storm on the 25th and 26th July 1985 caused extensive flooding over the eastern Poverty Bay flats and also in the Ngatapa and Waingake valleys. Less than 3 years later Cyclone Bola struck the district and on the 7th March 1988 the Waipaoa river overflowed the scheme stopbanks for the first time, and together with floodwaters from the Taruheru river flooded extensive areas of the Poverty Bay flats.

Following the devastation of Cyclone Bola, Government funds were made available to the former East Cape Catchment Board for flood hazard planning, but first priority was of course given to repairing the flood control scheme and the drainage network on the flats. However these funds were eventually transferred to the District Council and have been used to finance this work.

This study has assessed the flood hazard on a major part of the Poverty Bay floodplain from Kaiteratahi to the coast, but excludes Gisborne City.

#### 2.0 SUMMARY

The first and most fundamental requirement when undertaking flood hazard mapping is to select an appropriate "flood standard" or "designated flood". The Australia merit based approach which balances social and economic consideration against the consequences of flooding, has generally been followed for this study. The flood standard we have adopted therefore takes into account the frequency of flooding, changes in frequency over time, the expected "life" of a dwelling or development, floodwarning time and the social and economic impact on the community. While each of these factors can be debated extensively the selection of the flood standard is ultimately based on experience and professional judgement. We have therefore come to the conclusion that the appropriate flood standard for the Waipaoa river is the "Bola + 10%" flood; a flood which has a magnitude 10% greater than the Cyclone Bola flood throughout its duration. It is considered that with respect to the steady aggradation of the Waipaoa river and uncertainties due to the "greenhouse effect", it would be most shortsighted to select a lower flood standard.

The Bola + 10% flood has been modelled in the Waipaoa river using the "Latis" computer model. This model identified both the location and magnitude of the overflows to be expected under these conditions. The "Latis" overflows onto the floodplain have been combined with tributary flows which could reasonably be expected under these extreme conditions; for instance the July 1985 flood in the Taruheru has been combined with the Bola + 10% overflow from the Ford Road area.

Floodspread maps and data from the July 1985 and March 1988 (Bola) floods have been used to calibrate larger floods, and a combination of empirical and (simplified) theoretical methods have been used to assess the extent, depth and velocity of the flood standard in each of a number of sub-areas. The overall accuracy of this process was restricted mainly by the accuracy of the contours on the aerial photo prints used for the base maps, but to improve accuracy at "control" sections a number of road profiles were accurately surveyed.

The hydraulic analysis together with consideration of the likely effects on housing and development has resulted in the recommendation of five distinct flood hazard zones. For each of these zones we have suggested a number of restrictions on building and developments. Other factors such as town planning and Civil Defence requirements will obviously need consideration before final conditions could be adopted for each of the five zones, but this is outside the scope of this report.

It is believed that the proposed flood hazard zoning is the most detailed of any zoning on a major floodplain in New Zealand. While it is essentially an extrapolation of the July 1985 and Cyclone Bola floods, it does not allow for a "breach" of the main Waipaoa River Scheme banks, which although most unlikely, could result in a markedly different floodspread. For this and other reasons, it is considered that no part of the floodplain could be considered completely flood free.

### **3.0 The Area Under Study :**

The area included in this study is the Poverty Bay floodplain from the sea to the upstream end of the Flood Control Scheme at Kaiteratahi, bounded by the hills on both sides of the floodplain and the Karaua Stream to the south-west. Also included in the study are the eastern ends of both the Waingake and Ngatapa valleys. Figure 1 shows the study area.

Gisborne City is excluded from the study area and will be the subject of a separate report.

The ground elevation of the area under study varies gradually from 27 m above sea level at the northern end to sea level at the coast, a distance of about 23 kms. The land is generally flat with average slopes on the floodplain in the range of

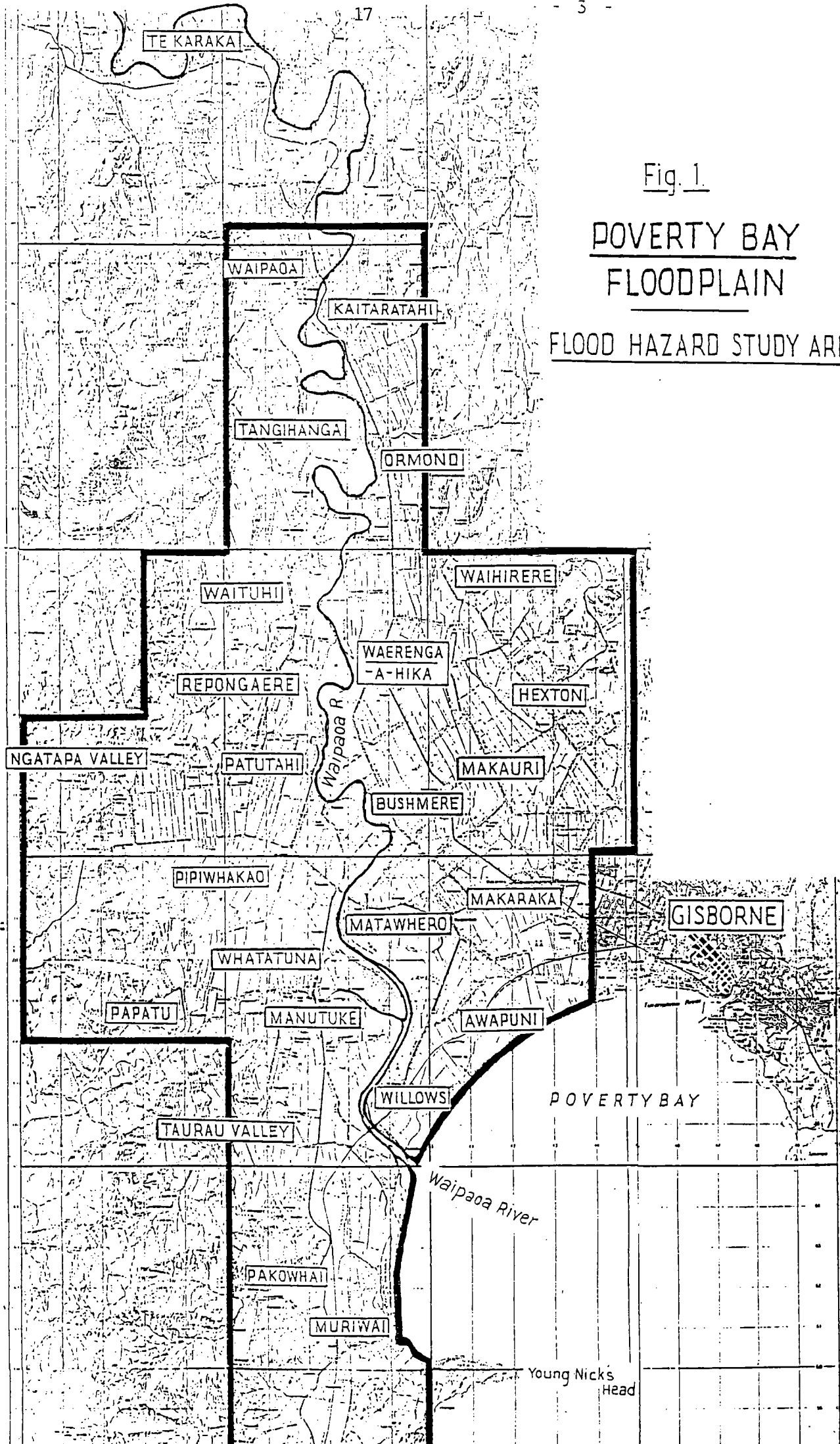


Fig. 1

POVERTY BAY  
FLOODPLAIN

FLOOD HAZARD STUDY AREA

0.5 to 1%. The land is cultivated with horticultural crops such as grapes, kiwifruit, apples. Maize and sweetcorn are also cultivated in the area, but there are also areas in pastoral farming.

The population is generally concentrated in small townships and villages such as Waipaoa, Ormond, Patutahi, Manutuke and on the fringes of Gisborne City to the south-east.

The area is drained to the Waipaoa and Taruheru Rivers by a well maintained network of drains and streams. Flood gates are provided at the drainage channel outlets.

A system of well maintained sealed roads is connected to State Highway 2 traversing through the eastern Poverty Bay flats. The formation levels of the roads are generally 300 to 400 mms above the natural ground level. Culverts and bridges provide access over the numerous drains and streams.

#### 4.0 Factors to be Considered When Setting a "Flood Standard" :

Setting a "flood standard" or a "designated flood" is one of the earliest tasks when embarking on a flood study. It is also an important and fundamental decision as the standard is the reference point for the preparation of flood hazard plans and eventually floodplain management plans. In effect it determines the area of land that should be subject to flood related development and building controls. The Australian "merit" approach (NSW Govt., 1986) which we have generally followed, is inherent in the selection of the flood standard. It involves balancing social, economic and ecological considerations against the consequences of flooding, with a view to minimising the potential for property damage and the risk to life and limb. If the adopted standard is too low, new development in areas above the flood standard may be inundated relatively frequently and damage to public services will be greater. Alternatively, adoption of an excessively high standard will subject land that is rarely flooded to unwarranted controls.

The flood standard we have adopted therefore takes into account the following factors :

- (i) The statistical odds or frequency of flooding over each distinct area.
- (ii) Changes in this frequency over time (due to external events such as the aggradation of the Waipaoa river and possible future changes in the weather pattern due to the greenhouse effect).
- (iii) The average "life" of a dwelling or development.
- (iv) The flood warning time and Civil Defence preparations.
- (v) The social and economic impact of the effects of a specified flood standard on the community.

The above items are discussed in more detail as follows :

#### 4.1 Frequency and Area of Flooding

The frequency of flooding obviously varies greatly from place to place over the floodplain. However it is possible to define specific areas subject to flooding from the same source and then attempt to calculate the flood frequency from recorded flood events.

The Waipaoa river has a long record (in NZ terms) of annual flood peaks, from 1938 to 1990, and it is possible to "synthesize" an annual record as back as far as 1886. However for the purposes of this study the 50 year record (1938 to 1989) has been used to derive flood frequencies using the Gumbel annual exceedance method. The largest recorded flood, the Cyclone Bola flood of 7th/8th March 1988, is thus accorded a 200 year return period with respect to the 50 year record, but the variance suggests a return period, between a 90 and 400 year event. In statistical terms a 50 year record is too short to extrapolate to a 100 year event; in fact it is generally recognised that to accurately calculate the 100 year event 300 years of record are required.

The actual peak discharge of the Cyclone Bola flood at Kanakanaia (5300 cumecs) has only been assessed, (not directly measured) and is subject to considerable error. Therefore the "return-period" calculations are at best a "guesstimate" and should not be quoted or used except in a general sense. We do know however that the Cyclone Bola flood was the biggest to date this century and as such serves as a "benchmark" flood, but not the flood standard as will be explained later.

The other river to cause extensive flooding over the floodplain is the Taruheru, but unfortunately river stage records are too short to be of any use in deriving flood return periods for the larger events. The July 1985 flood which was slightly larger than the Cyclone Bola flood in the Taruheru has been taken as a "benchmark" flood.

In the various tributaries (Waikakariki, Te Arai, Muhunga) the largest recorded flood (which has been either the 1985 or 1988 flood) has been adopted as both the benchmark and the flood standard for these confined valleys.

As mentioned earlier, adopting a flood standard is subject to items (i) to (v), and the actual flood standards adopted are as in Chapter 5.

#### 4.2 Changes in Flood Frequency with Time

The frequency of flooding (overtopping of the scheme stopbanks) of the Waipaoa River can be expected to increase with time as confirmed in report no. GDC 91/225, "Waipaoa River Flood Control Scheme : Aggradation Study". In this report it is suggested that at the critical 19 mile section some 500 cumecs

of capacity has been lost over the past 25 years. Some if not all of this "lost" capacity could be restored by raising of the scheme banks at the Waituhi overflow, but it is possible (if not likely) that a further loss of 500 cumecs could occur over the next 25 years due to aggradation of the bed and berms over the period and it may not be economically feasible to restore this loss in capacity at a later date. A Cyclone Bola flood (of 5500 cumecs) in 25 years time may then have the same impact as a "Bola + 10% flood (ie. an additional 500 cumecs) would have on the scheme at the present moment.

The other unknown which must be considered is the effects of the so-called "greenhouse effect". Although global temperature rises this century have been small (but measurable), there is no doubt about the increase in carbon dioxide and other greenhouse gases will have an impact on the weather and there is now a widely held view amongst atmospheric scientists that we should expect the weather to be more unpredictable and with increased storminess. Thus it is important to err on the side of caution when adopting a flood standard because it does set the standard for developments on the floodplain for a long time to come.

#### 4.3 Average Life of Dwelling or Development :

Most houses built today are expected to last a "lifetime" (70 years), and in fact because of the use of decay resistant materials where these are in contact with the ground or weather we should expect substantially more than this.

There are many houses older than this existing today without the advantages of tanalised timber. We must therefore expect the "flood standard" to accomodate the likelihood of flood events over at least the next 100 years. If our statistical base was to remain constant over the next 100 years we could than expect a 63% chance of a "100 year" flood in this period of time. But, as outlined in paragraph (4.2), the statistical base is changing and the chances are expected to be much higher than this.

#### 4.4 Floodwarning and Civil Defence Preparedness

The former East Cape Catchment Board developed a comprehensive telemetered floodwarning system for the Waipaoa Catchment, which proved to be invaluable during Cyclone Bola in showing the rainfall pattern and intensities over the catchment and the passage of the floodwave as far as Te Karaka. There are now 11 remote telemetered raingauges and 6 telemetered river level gauges in the catchment giving real-time data in the District Council offices. In addition to this there is a "rainfall-run-off" model under development which will assist with predictions of flood levels within the scheme from real time rainfall and run-off data in the upper catchment.

These two systems will be able to give reasonable forewarning of flood hazards from the Waipaoa River. However there will be only a short warning time for flash floods from the smaller catchments such as the Taruheru, Te Arai etc. The flood hazard plans are a combination of both short high intensity floods (eg. 1985) and long duration floods (Cyclone Bola), and although these maps show the extent of likely flooding they do not indicate the speed or the sequence in which the floodplain is inundated during a flood.

The Civil Defence organisation in this District has the benefit of the experience of two recent states of emergency. The lessons learnt from 1985 and 1988 together with the flood hazard plans which show areas which are likely to require evacuation and traffic routes which are likely to be severed, will be invaluable when Civil Defence is confronted with another emergency situation. However, how prepared Civil Defence will be when confronted with another flood emergency is outside the scope of this report.

The selection of the flood standard must therefore be of at least sufficient magnitude to cover the full extent of all the historic floods, and preferably larger, so that the implications regarding evacuation routes under extreme conditions can be examined beforehand.

#### 4.5 Social and Economic Impact of the Effects for Specified Flood Standard on the Community :

As stated earlier, if the adopted standard is too low, new developments in areas above the flood standard may be inundated relatively frequently and damage to public services will be greater. The adoption of too low a flood standard would not only be short-sighted but could lead to expensive litigation against Council.

When members of the public are given mandatory floor levels for new dwellings they do not expect to get flooded except perhaps in some disaster of unimagined proportions. They would certainly expect to be protected from another Cyclone Bola and probably against something larger.

On the other hand, adopting too high a flood standard would subject land to unnecessary controls and increase building costs.

In Australia the 1% (100 year) flood was widely adopted as the flood standard by most states, but in 1984 New South Wales adopted a policy to abandon the 1% flood as a mandatory statewide standard, in favour of Councils becoming responsible in their areas, for the determination of a flood standard based on social, economic and ecological, as well as flooding considerations. The flood standard adopted in NSW is therefore variable.

In the USA, some states around the Gulf of Mexico have adopted a 0.2% (1 in 500 year) flood for planning purposes. The situation in New Zealand is similar to that in New South Wales, with each District or Regional Council choosing a flood standard appropriate to the flood plain and the level of development already existing.

The Poverty Bay flats are relatively "undeveloped" in terms of building density and are not expected to be highly developed in the future because of restrictions on the minimum size of subdivision on the better quality land. Fortunately most of the land available for "life-style" blocks is on high land not so susceptible to flooding. Comparison of the Cyclone Bola floodspread and 1985 floodspread map of the Poverty Bay flats with the Bola + 10% floodspread shows an increased area of some 1200 hectares which would be subject to infrequent flooding and would therefore be subject to minimum floor level requirements. In addition, the areas already inundated by the 1985 and Bola floods could be expected to be flooded to a greater depth in a Bola + 10% flood; therefore building heights in these areas would generally be a little higher. The economic impact therefore of using a Bola + 10% flood standard is not expected to be at all excessive in Poverty Bay.

A Bola + 20% floodspread has not been done because of the high cost of the hydraulic analysis. It is considered that the economic impact of a flood of this magnitude could still be acceptable, but of course the probability of such an event would be correspondingly smaller.

## 5.0 The Adopted "Flood Standards" :

### 5.1 Waipaoa River

Consideration of all the factors discussed in the foregoing paragraphs has led to the adoption of the "Bola + 10%" flood as the flood standard in the Waipaoa river. The "Bola + 10%" flood has also been taken as the same shape as the "Bola" flood hydrograph, since a flood of this magnitude is likely to be generated by a similar long-duration Cyclonic storm. Fig. 2 shows graphically the Bola and Bola + 10% hydrographs at Kanakanaia.

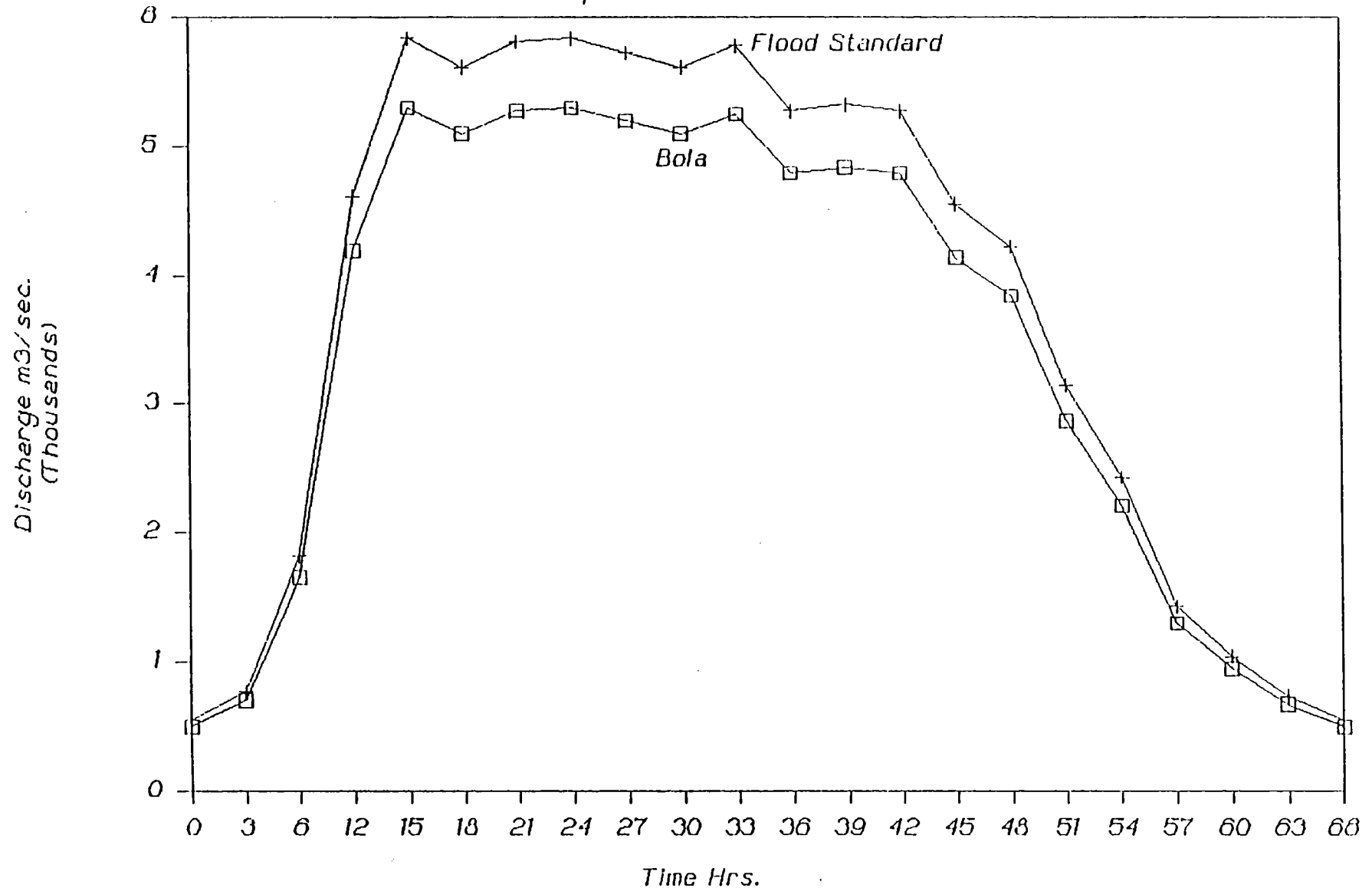
While we have adopted the Bola + 10% flood standard for the Waipaoa river, the flood standard varies over the Poverty Bay flats because of the effects of tributary streams.

### 5.2 Taruheru River

When the Bola +10% flood overtops the Waipaoa River Flood Control scheme stopbanks downstream of Ormond and flows overland it will eventually combine with the Taruheru River. Similarly, a flood standard equal to the record July 1985 flood has been adopted for the Taruheru river, to which is added the overflow from the Bola + 10% flood. This is a very reasonable supposition, as during Cyclone Bola the discharge in the Taruheru was only slightly less than in the 1985 flood.

# Fig. 2 Flood Hydrographs

Walpaoa River at Kanakanaia



### 5.5 Te Arai and Whakaahu Streams

The Te Arai and Whakaahu streams flooded during July 1985 and March 1988. Flood spread maps are available for both events with more area being flooded during 1985.

The peak discharges in these two streams have been assessed for the "Bola" event and a comparison of the "Bola" flows with those calculated using empirical methods is given below:

	<u>"Bola" Estimate</u>	<u>TM 61</u> ("100 yr")	<u>RFE</u> ("100 yr")
Te Arai m <sup>3</sup> /sec	600	460	334
Whakaahu m <sup>3</sup> /sec	300-500	347	247

According to above the "Bola" flood peaks are of the magnitude of a "100 year" flood or more.

The flood spread maps show that the effects of the July 1985 event are more severe than that of "Bola". Therefore the flood occurring during July 1985 in the above two streams was taken as the flood standard. The peak discharges in the two streams adopted for the flood standard are shown in Figure 3.

Note that the peak discharge of 600 cumecs in the Te Arai (Fig. 3) is the same as for the "Bola" flood. This is because the Te Arai overflows near the end of Papatu Road, and the remaining flow downstream of this point is relatively constant. However the overflow at the end of Papatu Road has been assessed at approx. 175 cumecs at the peak of the 1985 flood (as adopted for fig. 3) compared to approx. 150 cumecs at the peak of the Bola flood.

### 5.4 Muhunga Stream

During the peak of the Cyclone Bola Flood, floodwaters from the Muhunga stream could not discharge into the Waipaoa river as the Waipaoa river was at a higher level sufficient to keep the flood-gates on the SH 2 culvert closed. Water therefore overtopped the return banks. The peak discharge in the Muhunga stream was calculated using available data, (49 cumecs) and this figure was also used for the flood standard.

## 6.0 THE FLOOD STUDY

The flood study was carried out to determine the maximum velocities, flood levels and depths of water in the flood spread area for the "standard" flood. For the purpose of the study the total area was divided in to smaller sub-areas based on hydrological, topographical and man-made (eg. Road) boundaries.

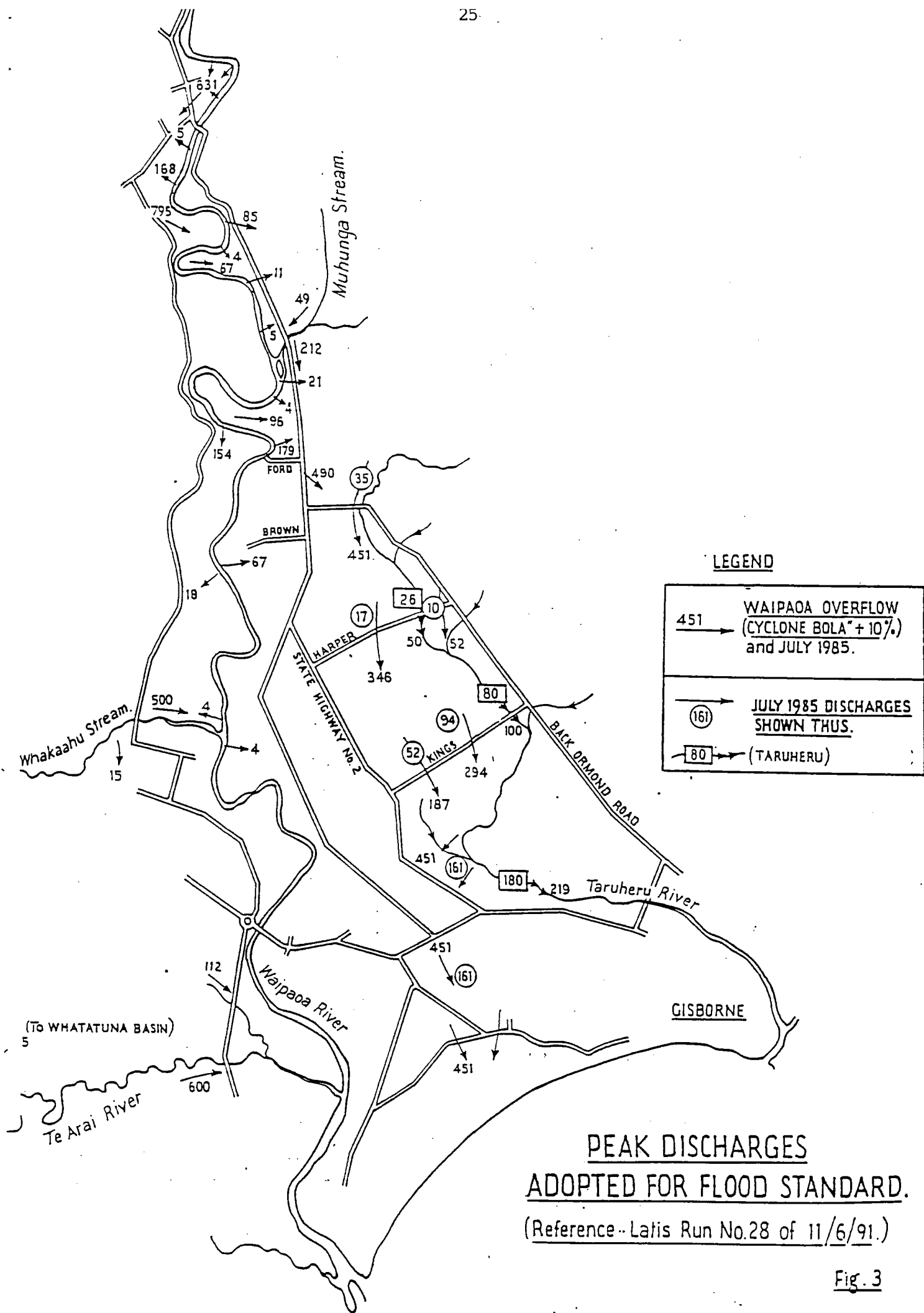


Fig. 3

The inflow, flow characteristics within the sub-area and the outflow were calculated for each sub area. The depths and velocities of overland flow will depend on land slope, vegetative cover, obstructions such as shelter belts, fences and trellis and their orientation to the direction of flow, spacing of trees in orchards, presence of buildings and many other factors resisting the flow of water. The flood water flowing into an area will fill all small and large depressions in the area before flowing out. If the depressions are comparatively large they will reduce the flood peak and delay the time of occurrence.

The roads constructed across the sub areas are generally 30 to 40 centimetres above the natural ground level and when they are crossing the flood paths these roads act as hydraulic "controls".

At an early stage it was decided not to attempt to model the overland flow using the "Latis" computer model. It was considered that the disadvantages of using a mathematical model would outweigh the advantages, and this decision in retrospect has found to be justified. Mathematical modelling could possibly have been justified if more accurate survey base plans had been available, but even if these had been available the amount of work required to set up the model to make full use of the increased number of survey points would have been enormous.

The survey information available was a series of 1:10,000 scale aerial ortho-photos flown in September 1988 (after both the "Bola" flood and the 1st September flood) which show spot heights and 1 metre contour lines. (Accurate mathematical modelling would require much closer definition than this).

Surveys of the July 1985 and "Bola" floods spreads carried out by the former East Cape Catchment Board (14) had defined the major flow paths on the floodplain, and provided a fairly reliable hydraulic "data base" which could readily be extrapolated for the specified flood standard by the empirical means described below.

The 1985 or 1988 peak flows as defined on the floodspread maps were "calibrated" at various sections on the floodplain and then using the same calibration factors (eg,. roughness co-efficient "N" for channel flow, or the discharge co-efficient "C" for weir flow) the flows were then extrapolated for the flood standard.

It is important to note that the absolute values of the 1985, 1988 and flood standard discharges are not important, rather the relative differences between the calibrated flood and the flood standard will determine the increase in levels and therefore the increased flood hazard.

It is not practically possible to model the overland flow to represent all the conditions prevailing in a sub-area and therefore three types of flood flow were selected to represent the overland flow in each area, as follows :

- (i) Broad-crested weir type flow.
- (ii) Wide channel flow.
- (iii) Routing through basins.

These flow types are discussed in detail in Appendix I, and summarised as follows :

- (i) Flows over roads or any high embankment were categorised under broad crested weir flow, where the discharge is related to the upstream water surface elevation.

A formula has been used (Appendix I) which corresponds to the hydraulic conditions where water flows over a roadway, allowing for up to 80% submergence. Accurate surveys had to be carried out along road centrelines where these were considered to act as "controls", and these surveys have been recorded on drawings. By entering the road profile data on spreadsheets, the increased head due to a range of flows could readily be calculated.

- (ii) The flow over the gently sloping land was categorised as wide channel flow and an empirical method (the Mannings equation) was used to determine the velocities and depths. This is a gross simplification of the real situation, which is described in more detail in Appendix I. A Mannings "n" or roughness co-efficient of 0.05 was used for overland flow calculations. The water surface slopes were assumed parallel to the Bola flood slopes. In this case the energy gradient is assumed parallel to the water surface.

- (iii) Where there were extensive depressions or basins, eg. Muhunga basin, flood routing was carried out to determine the maximum depths of water and the peak outflows.

The calculations were carried out for each sub area as briefly described below :

### 6.1 Waipaoa District

The total flow into the area consists of the overflows from the Waipaoa River and the contributions from minor catchments. The total flow from the river has been assessed as 804 m<sup>3</sup>/sec. (Fig. 3). Flood velocities and heights were determined by applying the weir formula for flow over SH 2 and wide channel flow to the rest (if over land flow). Ponding up will take place before the water will return to the river and flood routing was carried out to determine the maximum depth. (elevation 25.5 m R.L.).

## 6.2 Muhunga Basin

The flood water over topping the left bank of the Waipaoa river ( $172 \text{ m}^3/\text{sec}$ ) will combine with the flood waters of the Muhunga Stream to fill up the Muhunga basin before overtopping the Muhunga stop banks near the road crossing to reach the Ormond township. The total inflow was routed through the Muhunga basin, where the water will rise to a peak of 22.00 m R.L. The peak out flow from the area is  $212 \text{ m}^3/\text{sec}$ .

## 6.3 The Ormond Township and the Ormond Dip :

The flood waters overtopping the Muhunga stop banks (Peak  $212 \text{ m}^3/\text{sec}$ ) will flow through Ormond township to combine with the water overtopping the Waipaoa Banks between the "island" and Ford Road (Peak  $300 \text{ m}^3/\text{sec}$ ) to fill the Ormond dip and then escape to the Taruheru basin over SH 2. The velocities and depths of flood flow in the Ormond township and Bruce Road area were determined using wide channel flow. The peak flood level in the Ormond dip area came to 20.6 m R.L. after routing. The peak outflow to the Taruheru basin was estimated as  $490 \text{ m}^3/\text{sec}$ . The water overtopping SH 2 will spread southwards past Brown Road and flow towards Snowsill Road running parallel to the Taruheru River.

## 6.4 Taruheru Basin

The flow into the Taruheru Basin as calculated using results of "LATIS RUNS" 8 and 28 are given below.

Run No.	8	$304 \text{ m}^3/\text{sec}$
Run No.	28	$490 \text{ m}^3/\text{sec}$

The earlier run (No. 8) was modified by Run No. 28 to allow for more overflow nodes. However this modification was done after the Taruheru basin hydraulic analysis was complete and therefore flood spread mapping in the Taruheru Basin was carried out on the basis that the peak outflow from the Waipaoa ( $304 \text{ m}^3/\text{sec}$ ) will reach the basin when at the peak of the July 1985 flood. No allowance was made for the attenuation of flood peak as it travels downstream along the Taruheru. Fig. A1 of the Appendix shows the discharges along the Taruheru used for mapping purposes.

The discharges along the Taruheru resulting from an inflow of  $490 \text{ m}^3/\text{sec}$  at July 1985 flood peak, when allowed to attenuate as it flows along the Taruheru are shown in Fig. 3.

The effects of new discharges on flood spread mapping already done were checked at three key locations and the results are given below.

Snowsill Road flow Parallel to Taruheru	10 cm increase in depth
--	-------------------------

Harper Road flow over Road	6 cm increase in depth
Kings Road flow over Road	2 cm increase in depth

The above increases are well within the proposed free board of 300 mm above the "Bola + 10%" levels and therefore the flood spread maps were not revised.

The overland flow near Snowsill Road during the 1988 flood was calculated using recorded flood levels (35 m<sup>3</sup>/sec). This was combined with the 304 m<sup>3</sup>/sec coming from the Waipaoa and the depths and velocities were calculated for the peak discharge. It was found that the overland flow will be confined between the Taruheru stop banks and the rising land on the west of Snowsill Road. The area on the east of Snowsill Road and along the Taruheru stop banks is classified as a high hazard zone as the velocities and depths are high.

The flood flow across Harper Road for the 1985 event was estimated using the recorded levels (54 m<sup>3</sup>/sec). The possible flood levels along Harper Road and in the Taruheru river were calculated for the combined discharge of 359 m<sup>3</sup>/sec. The estimated peak discharge over the right bank section of the Harper Road is 282 m<sup>3</sup>/sec and that for the left bank section is 20 m<sup>3</sup>/sec. The river will carry a discharge of 57 m<sup>3</sup>/sec at the peak.

The major overland flow is concentrated on the right bank of the Taruheru confined between the river stop banks and the old disused railway line embankment and will flow towards Kings Road.

The flood flow across the Kings Road for the 1985 event was estimated using an inclined water surface and weir flow. The flow through the river at Kings Road bridge was estimated using the contracted opening method. The estimated peak discharges are at

Fenton's Drain	52 m <sup>3</sup> /sec
Tuckers Road Intersection	94
River	80
	<hr/>
	226 m <sup>3</sup> /sec.

Then flood levels were determined for a combined peak discharge of 530 m<sup>3</sup>/sec.

#### 6.5 Taruheru Basin & State Highway 2 Makaraka

A major portion of the designated flood consisting of overland flow over the Kings Road at Tuckers Road and Fenton's drain will flow straight to the Pilmers Road area. The river combined with the flood discharge in the Waru Stream will flood in

to the same area before turning towards Gisborne City. As the water level rises near the Pilmers Road area flood waters will escape over the ridge and travel in a southward direction over the State Highway to reach the Awapuni Lagoon.

Using the studies previously done for the Taruheru and the recorded flood levels the peak discharges along the Taruheru and over the S H 2 were calculated and found to be :

Along Taruheru	180 m <sup>3</sup> /sec
Over S H 2	161 m <sup>3</sup> /sec
	<hr/> 341 m <sup>3</sup> /sec

This was combined with the Waipaoa Overflow of 304 m<sup>3</sup>/sec and the peak discharges along the river and across the road were calculated.

Along River	219 m <sup>3</sup> /sec
Across S H 2	451 m <sup>3</sup> /sec
	<hr/> 670 m <sup>3</sup> /sec

The velocities and depths for these floods were calculated using parallel slopes, weir formulae and back water profiles.

#### 6.6 Awapuni Lagoon

The flood water crossing the S H 2 will fill the drainage system leading to Waikanae Creek and then cross Awapuni Road to reach the Awapuni Lagoon. The flow along the Waikanae Creek is limited due to restrictions in culverts. The Awapuni lagoon drains to the Waipaoa river but again the capacity of the drains and the outlet culvert to the Waipaoa river is limited. A flood routing was carried out for the Awapuni lagoon and a peak flood level of 3.06 m was calculated.

#### 6.7 Whatatuna and Opu Basins

The July 1985 flood spread has been used as the standard for mapping the Whatatuna and Opu Basins. (See Chapter 5.3).

The Flood water over topping the left bank of the Te Arai near Papatu Station (assessed to be about 175 m<sup>3</sup>/sec) will flow over land to reach the Whatatuna Basin. The flood water overtopping the right bank of the Whakaahu stream upstream of Creek Road (Patutahi) (assessed to be about 15 m<sup>3</sup>/sec) will also find its way towards Whatatuna basin. These combined with the contribution from its own catchment (50 m<sup>3</sup>/sec) will pond up behind State Highway 2. It is estimated that about 112 m<sup>3</sup>/sec will flow over State Highway 2 at the peak with a pool elevation of approx. 6.0 m R.L.

The flood water flowing along the Whatatuna drain and water overtopping S H 2 will pool up in Opu basin before discharging into the Te Arai River through the Whatatuna flood gates. The pool will reach a peak elevation of about 5.80 R.L.

## 6.8 Patutahi (Whakaahu Stream) and Lavenham Basins

The July 1985 flood spread and the Waipaoa River outflows for the standard flood have been used for mapping Patutahi and Lavenham basins.

The flood water overtopping the Whakaahu left bank and flowing along Knight Road and the Waituhi drain system overflows will pond up on the West of the Lavenham Road.

The water overtopping the Waipaoa on its right bank and falling into the East Lavenham basin will reach a peak of 22 m<sup>3</sup>/sec. This water will flow southwards and pond up behind the return banks of Whakaahu Stream to reach a peak level of 13 m R.L.

It should be noted that in floods greater than Bola + 10%, there is the potential for floodwaters to pond to a much greater depth in this basin adjacent to the Whakaahu Stream return bank.

## 7.0 FLOOD HAZARD ZONES

Flood hazard zones were based on the NSW Flood Plain Development manual, modified to suit local conditions.

Flood hazard lines, based on the flood standard for each sub-area, were drawn on 1:10,000 scale contoured orthophoto prints. Contours derived from aerial photography are only accurate to ±1 metre hence this had limited the overall accuracy of the flood hazard lines. However sections of road acting as "hydraulic controls" have been accurately surveyed so that reasonable accuracy can be assumed at these critical areas. Further discussion of methods used to define the flood hazard lines may be seen in Chapter 6 and the Appendix. It is important to note that these maps reflect the terrain contours and levels of stopbanks, roads etc, as they exist at the present time. Any changes to levels over hydraulically sensitive areas will necessitate review of the maps in these areas.

Five zones have been identified on the maps, and for each zone suggestions have been made as to the restrictions to be imposed so that hydraulic conditions are not unduly compromised. Note that these restrictions are to apply to proposed developments, not to what is existing at present. There will obviously need to be some sort of "existing use" criteria to allow for structures, buildings, earthworks etc; which at present contravene the suggested restrictions in a specific flood hazard zone.

The five zones are outlined as follows :

### 7.1 Zone 1 : Floodway Areas (coloured blue on map)

This zone includes all watercourses, and adjacent berms subject to fairly regular flooding (in the case of the Waipaoa river this has taken as approx. "5 year" frequency or more often).

Floodway areas are areas which, even if only partially blocked, would cause a significant re-distribution of flood flows.

Suggested Restrictions :

- (i) Watercourses to be kept clear of obstructions and well maintained at all times.
- (ii) No buildings permitted whatsoever.
- (iii) Stopbanks or earthworks likely to obstruct or divert floodwaters, structures or shelter belts not permitted on berm areas.
- (iv) Permanent fencing not permitted on berm areas except at property boundaries.
- (v) No crops on berm areas within this zone except where expressly permitted for the purpose of improving pasture condition.

7.2 Zone 2 : High Hazard Areas (coloured pink)

Flow in "high hazard" areas would normally be associated with flow over stopbanks, roads and deep overland flow confined to narrow valleys. In high hazard areas floodwaters could cause structural damage to buildings and in extreme cases light framed houses could be swept away.

Three separate criteria have been used to identify these areas:

- (a) The product of depth of flow (metres) times the velocity (metres per sec.) is equal to or greater than one.  
( $v \times d \geq 1.0$ )
- (b) The product of depth times velocity may be less than one, but the area is isolated by floodway (zone 1) areas or subject to very heavy silt and/or debris deposition.
- (c) Areas within a nominal 50 metres of where overflows would be expected over stopbanks or higher ground during flood standard conditions.

Suggested Restrictions

- (i) No permanent dwellings within this zone. Conditional approval for all other buildings.
- (ii) Earthworks, structures or shelter belts likely to significantly obstruct or divert floodwaters not permitted.  
(Note : water right procedures may need to be used in cases where there is doubt about interpretation of the word "significantly").
- (iii) No permanent horticultural crops permitted within this zone. Other crops to require permits.

7.3 Zone 3 : Flood Ponding Areas (Red cross-hatching over green)

There are low lying areas or basins subject to relatively deep flooding. These areas have all been flooded in 1985 and/or 1988 but are expected to be even more deeply and extensively inundated under flood standard conditions.

In most cases floodwaters in this zone would be slow moving or stationary. At the peak of the flood standard, two sub-zones were identified :

Subzone 3A : Depth equal to or greater than 1 metre  
Subzone 3B : Depth equal to or greater than 2 metres.

Suggested Restrictions :

Zone 3A

- (i) Conditional approval for dwellings in this zone; with minimum floor level requirements. (Minimum floor level requirement suggested is 300 mm above estimated flood standard level for dwellings). If basement type construction is to be used, no habitable downstairs rooms.
- (ii) Filling of large areas subject to approval.
- (iii) Stopbanks or earthworks likely to obstruct or deflect floodwaters subject to water right procedures.
- (iv) Permanent horticultural crops not recommended.

Zone 3B

- (i) Dwellings not permitted in this zone. Conditional approval for all other buildings.
- (ii) As for items (ii), (iii) and (iv) in Zone 3A.

7.4 Zone 4 : Areas Liable to Flooding (coloured green)

These are areas which could be expected to be flooded several times during a normal life-time (viz. 70 years). They are defined as the areas on the floodplain which have previously been flooded by the July 1985 and/or the March 1988 ("Bola") floods.

Suggested Restrictions

- (i) Conditional approval for all dwellings, commercial or industrial buildings in this zone; together with minimum floor level requirements.
- (ii) Stopbanks or earthworks likely to obstruct or deflect floodwaters subject to water-right procedures.

7.5 Zone 5 : Flood Fringe Areas (coloured yellow)

These are the areas which are outside both the July 1985 and the "Bola" floodspread, but are expected to be flooded under flood standard conditions. Generally water in these areas would be shallow and slow moving.

Suggested Restrictions

- (i) Minimum floor level requirements on dwellings, commercial and industrial buildings.
- (ii) Stopbanks or earthworks likely to obstruct or deflect floodwaters subject to "waterway approval".

## 7.6 Floodplain Outside Hazard Zones (not coloured)

Under flood standard conditions there is still a considerable area of the Poverty Bay floodplain not covered by any of the above hazard zones. This does not imply that flooding will never be experienced in these areas.

In a number of situations flooding could occur, as follows:

- (i) Local stormwater overflow due to drain and/or culvert blockage.
- (ii) Floods greater than the flood standard eg. a particularly intense but localised storm.
- (iii) Failure of the Waipaoa River main scheme stopbanks.

The above items are for the most part unpredictable, therefore it would not be prudent to allow dwellings with floors at ground level anywhere on the floodplain. It is recommended therefore that a minimum level of 300 mms above natural ground level is adopted for all dwellings on the remainder of the floodplain. Recommendations as to minimum floor levels (but not necessarily mandatory requirements) could be made for commercial or industrial buildings also.

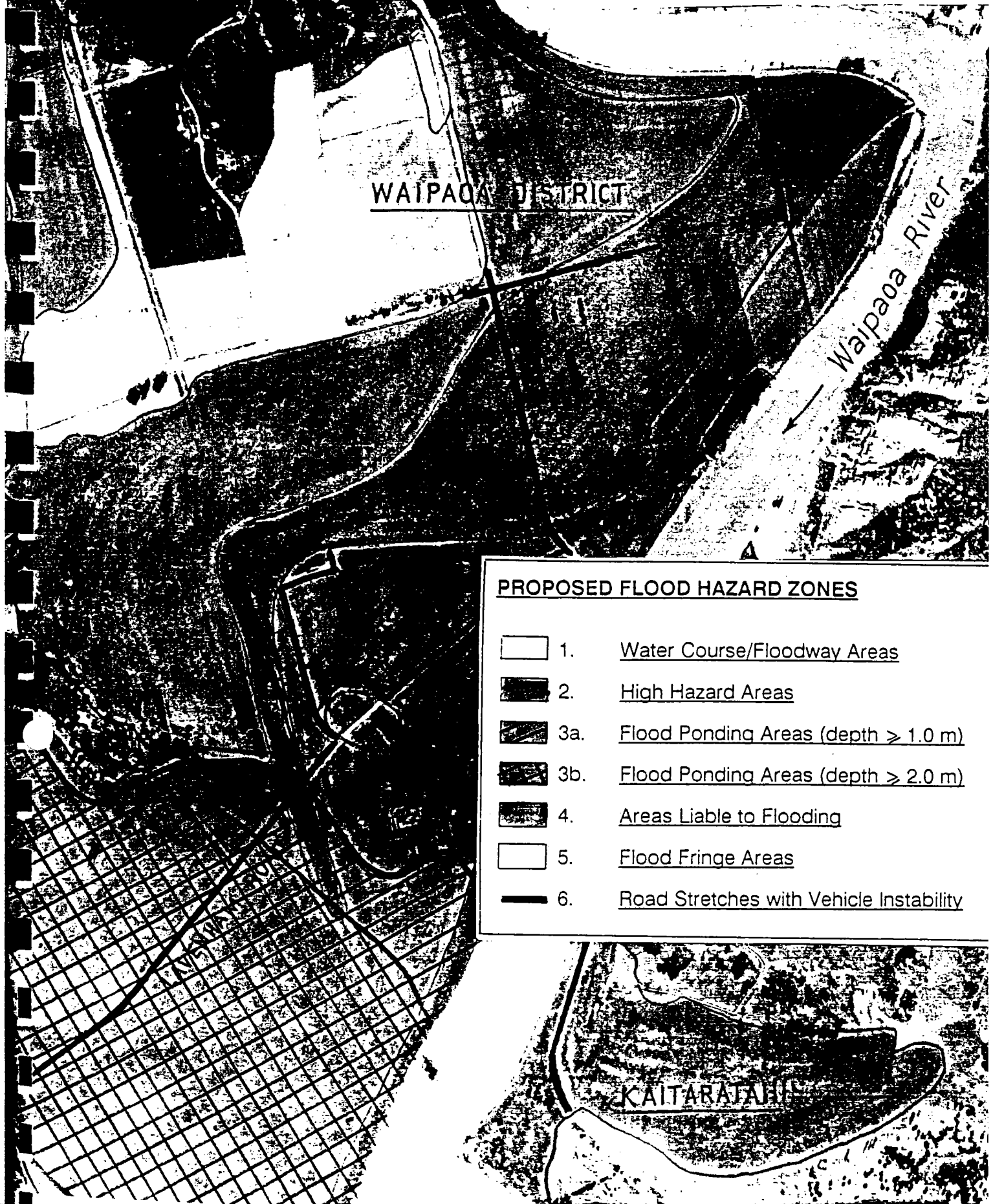
## 7.7 Vehicle Instability

In addition to the above flood hazard zones, sections of roads where "vehicle instability" could be expected under flood standard conditions have been marked on the maps. Vehicle instability is initiated by bouyancy and will occur when the depth of (still) water is over 30 centimetres, or at shallow depths with high velocities (eg. 20 centimetres @ 1.5 metres/sec).

This information is expected to be mainly of use for Civil Defence Planning.

SAMPLE  
FLOOD HAZARD MAP  
WAIPAOA DISTRICT

(Approx. Scale 1:10 000)



8.0 References

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