WORKSHOP SERIES No 17

Workshop on the Impacts of Flooding

Proceedings of a Workshop held in Rockhamptori, Australia, 27 September 1991.

Edited by G.T. Byron

Queensland Department of Environment and Heritage

Great Barrier Reef Marine Park Authority

ISSN 0156-5842
ISBN 0 624 12044 7
Published by GBRMPA April 1992

Queensland Department of Environment and Heritage

P.O. Box 155
North Quay,
Queensland 4002

Great Barrier Reef Marine Park Authority

P.O. Box1379
Townsville
Queensland 4810

TABLE OF CONTENTS — PAGE

PREFACE		iv
EXECUTIVE SUMMARY		v
PART A: FORUM PAPERS		
Jim Pearce MLA	Opening Address	1
Peter Baddiley	Fitzroy River Basin Rainfalls and The 1991 Flood Event	3
Mike Keane	Assessment of the 1991 Fitzroy River Flood How much water?	16
J.P. O'Neill, G.T.Byron and S.C.Wright	Some Physical Characteristics and Movement of 1991 Fitzroy River flood plume	36
PART B: WORKSHOP PAPERS		
GROUP A - WATER RELATED'ISSUES		
Jon E. Brodie and Alan Mitchell	Nutrient Composition of the January 1991 Fitzroy River Plume	56
Myriam Preker	The Effects of the 1991 Central Queensland Floodwaters around Heron Island, Great Barrier Reef	75

G.T.Byron and J.P.O'Neill	Flood Induced Coral Mortality on Fringing Reefs in Keppel Bay	76
J.S. Giazebrook and R. Van Woesik	Effects of low salinity on the tissues of hard corals Acropora **spp.,** Pocillopora sp and Seriatopra sp from the Great Keppel region	90
M. Coates	Effects of the January 1991 Fitzroy Flood on Intertidal Invertebrate Communities of Keppel Bay	91
Grahame Byron	Fisheries and Flood	92

GROUP B - LAND RELATED ISSUES

D.G. Chapman	Erosion Observations and Land Management Recommendations for the Floodplains following Cyclone Joy Floods in January 1991	94
G.S. Knight	Land Information - A vital resource before, during and after floods	97
John McCabe	Rockhampton Flood Management	100

GROUP C - PEOPLE RELATED ISSUES

Barbara Webster	The 1918 Flood - Nature, Effects and Community Response	119
Lex Burgess'	Involvement of Department of Family Services in Flood Response, January 1991	124

PART C - WORKING GROUP REPORTS

Synopsis of Group A Workshop Sessions 132"
Water Related Issues - M. Coates and J.P. O'Neill

Synopsis of Group B Workshop Sessions , 138
Land Related Issues - D. Crossman and A. Kay

Synopsis of Group C Workshop Sessions 144
People Related Issues - L. Steadman and D. Marshall

APPENDICES

Appendix 1
Working Group - Guidelines for discussion 152

Appendix 2
Workshop Nominees and Participants 153

Appendix 3
Program 155

PREFACE

The Workshop Coordinator gratefully acknowledges the effort and contribution made by the participants.

The findings of this workshop are directed to managers, policy-makers and planners to ensure appropriate consideration of flood potential in planning processes. The proceedings provide a solid information base for future investigations and decision making.

The Coordinator would especially like to recognise the assistance of the working group leaders, Dr Mike Coates, Mr Doug Crossman, and Mr Laurie Steadman in maintaining group direction towards objectives. The rapporteurs Mr Paul O'Neill, Dr Alice Kay and Mr David Marshall for their thorough and accurate recording of group discussion and resolutions. Mrs Tracey Brown for her logistical support for the workshop and typing of manuscripts.

Further information on any aspect of these proceedings, or of the workshop generally may be obtained from:

The Regional Director
Department of Environment and Heritage
PO Box 3 130
Rockhampton Shopping Fair
ROCKHAMPTON QLD 4701

or

The Assistant Executive Officer
Research- and-Monitoring-Section
Great Barrier Reef Marine Park Authority
PO Box 1379
TOWNSVILLE QLD 4810

EXECUTIVE SUMMARY

In January of 1991 Severe Tropical Cyclone Joy crossed the eastern Australian coast near Ayr, Northern' Queensland. Subsequently the cyclone turned into a rain depression, causing widespread flooding throughout various sections of the Fitzroy River catchment. Over 1000mm was recorded in the headwaters of the Connors River.

Extensive flooding occurred throughout the region and mom than 18.5 million megalitres of runoff escaped down the Fitzroy River and into Keppel Bay.,

In response to this major environmental perturbation the Queensland National parks and Wildlife Service undertook an extensive monitoring program to evaluate the impact of flooding on the marine environment.

During the development of this project it became clear that other individuals and organisations were also monitoring the effects of this event.. Some were involved in estimating the effects on agricultural production, others the costs of additional welfare or emotional support, whilst others were considering personal impacts.

In an endeavour to consolidate this information and establish an overall measure of the impact of flooding the Queensland National parks and Wildlife Service organised this Workshop which was held in Rockhampton on 27 September 1991.

At the workshop consideration was given to the impacts of the floods on social, economic, physical and biological parameters.

Fifteen papers were presented in the morning session for the information of all participants. In the afternoon session, participants divided into three working groups to discuss the specific impacts on the aquatic, terrestrial and human environments. Each working group was requested to consider similar matters and report back to the forum in the late afternoon.

As you might expect, all groups were readily able to identify negative impacts of the flood. A few. positive impacts were however recorded in the aquatic environment, with the opening of migratory pathways and the expansion of available breeding sites being suggested as likely outcomes., Many of the impacts were the direct result of the physical actions of the mainstream flood flow. Loss of soil, estimated to be about 18 million tonnes, and damage to riparian vegetation were considered to be the most serious loss to the terrestrial system, whilst the final deposition of these same materials caused the major impact *on the* aquatic environment.

All groups identified effective transfer and availability of information as the key to minimising the future impacts of major flooding events such as this. In particular, it was noted that there was a general lack of baseline data against which comparisons and evaluations could be made. It was considered important to establish these baselines and develop appropriate long-term monitoring strategies for thorough evaluation and assessment of impacts.

Modelling studies were seen as desirable to indicate the range of impacts and areas of effect that could be expected in any given circumstance. These models and the baseline data could then be utilised to develop appropriate response kits for management agencies, landholders and other individuals likely to be effected.

It was noted that the Emergency Services of the region have already prepared such plans, however continued evaluation of these plans was necessary to ensure minimise risk to life and property.

In summary, the participants agreed that the process of managing an emergency such as this flood event can be divided into a number of phases:

a) **Prevention**
Whilst it is not possible to control the forces of nature it may be possible to prevent or reduce future impacts by improved planning and management, and in some cases changes in land use practices.

b) **Preparedness**
An improved information network should enable managers, landholders and individuals to be more prepared. With response plans available there should be no confusion as to the appropriate course of action for each situation.

c) **Response**
The response plans should facilitate more efficient and effective responses to flood situations, thereby minimising impacts.

d) **Recovery**

This phase should also be considered in the development of the response plans. The' objective of the first three phases should be to minimise this phase, so that conditions may return to 'normal' in the shortest possible time.

PART A

FORUM PAPERS

OPENING ADDRESS

Mr Jim Pearce, MLA

Ladies and Gentlemen, welcome to the University of Central Queensland. I am pleased to be here today to officially open this workshop on the effects of the 1991 Fitzroy River flooding.

The flood experienced in Central Queensland early this year was the third largest this century, and in this region flooding is not an uncommon occurrence.

The impacts of these floods were felt in all aspects of everyday life a&throughout the range of my electorate.

Many people and'industries suffered hardship during and after the flood, and for some it was more than could be endured. In particular the impact on the grazing and small cropping sector were quite substantial.

People in this region generally accept the effects these irregular disasters bring, however this does not mean we should sit back and accept the consequences.

I was pleased to see the recent announcement of a State and Federal Government initiative to instigate a Rockhampton Flood Management Study. The study is to be supervised by the Water Resources Commission and undertaken by the consultants Camp, Scott and Furphy, and is a positive attempt by Government to identify ways to better manage future floods and to lessen the impacts on the Rockhampton community.

It is important to realise the overall effects of flooding and this workshop should start this process of understanding.

I am sure that the spirit of cooperation engendered by the floods earlier this year will continue with you today, and result in a very positive outcome.

No doubt today you will add to the already expanding knowledge base of the effects of flooding in the region .

I congratulate the Queensland National Parks and Wildlife Service and the University of Central Queensland for their initiative in formulating this workshop. I wish you well in **your** deliberations today, and look forward to the outcomes of your discussions.

I am advised that the **proceedings** from this workshop will be documented and I assure you that copies will be provided to the relevant government Ministers for their information and consideration.

FITZROY RIVER BASIN RAINFALLS AND THE 1991 FLOOD EVENT

Peter Baddiley
Queensland Regional Office, Bureau of Meteorology
Brisbane

Abstract

The arrival of Cyclone Joy during late December 1990 heralded the commencement of a period of severe flooding along Queensland's central and north coast. One of the worst affected areas was Rockhampton and its surrounding districts where flood levels in the Fitzroy River were the third highest since records began in 1860. Flood rains associated with Cyclone Joy occurred along the central Queensland coast between Townsville and Rockhampton from about 23 December 1990 to 7 January 1991. The'highest rainfall totals of 1000 to 2000 millimetres for this period fell in the Connors River headwaters, a northern tributary of the Fitzroy River. This discussion primarily focuses on the distribution and intensity of rainfall in the Fitzroy River watershed during late December 1990 and January 1991, with comment on the predominant weather patterns active during the period. Some comparison with the rainfalls which produced the Fitzroy floods of 1918 and 1954 is also presented. The flooding caused high damages in both the urban and rural sectors and required prolonged counter disaster activities to assist the communities and landholders. The flood warning system for the Fitzroy River basin which plays a part in these activities is very briefly described.

Introduction

Most of the estimated $300 million damage attributed to Cyclone Joy resulted from the high intensity rainfalls along the Central Queensland coast and the subsequent extensive flooding of river systems between Ingham and Rockhampton.

High level flooding of the Mackenzie and Fitzroy Rivers in particular caused high rural damages during the last week of December and the first week of January. The flooding at Rockhampton during the second week of January was the third highest since records began in about 1860. About 260 homes were flooded and all road, rail and fixed-wing air transport links to and from Rockhampton were cut,

Six lives were lost in the aftermath of Cyclone Joy.

FLOOD WARNING SERVICES

The Flood Warning Centre in Brisbane issued 192 flood warnings during December and January. Many of these were for flooding of river systems on the north and central Queensland coast affected by Cyclone Joy and its rain depression. Flood warning services progressively widened to include other areas of the State by the end of January as conditions continued to deteriorate in the Gulf rivers and inland river systems.

Flood warnings were provided for coastal streams between Cooktown and Ingham from 23 December 1990, as this part of the coastline came under the influence of Cyclone Joy. Warnings for coastal streams between Townsville and Mackay commenced at 8pm on 25 December, and for Mackay to St Lawrence at midnight on 26 December.

Flood warnings were provided for the Tully, Herbert, Haughton, Burdekin, Don, Pioneer, Connors, Isaac, Mackenzie and Fitzroy Rivers and Funnel Creek in the weeks following Cyclone Joy's crossing of the coast near Ayr on 26 December.

River height predictions were provided for a number of key locations including Mackay and Rockhampton. Services for these areas are discussed in more detail later in this report.

FLOODING

Main flooding and damage was in coastal streams between Townsville and Rockhampton, where rainfalls exceeded 500 millimetres in the period 23 December to 7 January. In the Bowen to St Lawrence area, rainfalls for the same period totalled 1000 to 2000 millimetres, with rainfall stations in the Mackay hinterland and in coastal districts immediately to the south of Mackay recording over 2000 millimetres.

Johnstone Rivers (Innisfail)

River levels in the North and South Johnstone Rivers peaked below minor flood level on 24 and 25 December.

Tully River

River levels in the lower Tully River around Euramo initially peaked near minor flood level on 25 December. Flooding recommenced in the Tully River in the week commencing Friday 10 January. Several moderate flood peaks occurred in the Tully River between 10 and 15 January, with water levels slightly above the Bruce Highway at Eurarno.

Herbert River

The' Herbert River peaked below minor flood level around 'the Christmas period. More serious flooding developed in the Herbert River from 10 January. Three flood episodes occur-ted between 10 and 15 January, causing near major flooding at Ingham'and major flooding downstream at Halifax and neighbouring communities. The highest peak at Gairloch was 11.32 metres on Saturday 12. Floodwaters entered the main street of Ingham which required the commercial area to take precautions, but was mainly restricted to flooding of house yards in low lying residential areas.

The Hinchinbrook Shire Council provide a local Flood Information Service during flood events which is closely coordinated with the Bureau's service.

Haugh ton River

The town of Giru on the lower Haughton River floodplain was inundated several times during December and January. Four major flood peaks were recorded up to 17 January. The highest was 2.40 metres on Friday 4 January. Further flooding of Giru occurred in early February.

Burdekin River

Minor flooding persisted in the lower Burdekin River and its tributaries until mid January. A series of peaks were recorded at Inkerman Bridge between Ayr and Home Hill.

Severe flooding of the lower Burdekin River followed in the first week of February.

The Burdekin Shire Council closely monitored the recently installed ALERT system in the lower Burdekin catchment, and provided detailed flood warnings for their area. The ALERT system'is a joint project between the Bureau and the Council, and was installed only a few weeks before Cyclone Joy. The Bureau Flood Warning Centre maintains close contact with Council officers during operational flood warning periods.

Don River

The Don River near Bowen responded to bursts of heavy rain throughout the period from 26 December (when Cyclone Joy crossed the coast) until 4 January. Flood peaks at the Bowen Rump Station were generally about 5 metres, which causes moderate flooding of farming lands in the Don River delta. Higher floods occurred in the first week of February. Close contact was maintained between the Bowen

Shire Council and **Bowen** SES. These organisations were using real-time information from the Don River ALERT system installed in cooperation with the Bureau.

Proserpine River

River rises in the lower Proserpine River were below minor flood level because the new Peter Faust Dam was near empty at the start of the event.

Pioneer River

The Pioneer River at Mackay had a series of sharp river rises and flood peaks during the period 27 December to 4 January in response to periods of heavy rain in the Mackay hinterland. Main flood peaks recorded were:

Thursday 27 Dec	1100	**6.95** metres	(Moderate)
Saturday 29 Dec	**2000**	**6.90** metres	(Moderate)
Sunday 30 Dec	1100	**7.60** metres	**(Major)**
Thursday 3 Jan	1400	**7.40** metres	**(Major)**
Friday 4 Jan	1500	**7.00** metres	(Moderate)

The higher peaks occurred with the high tide. Flood levels were below the levee protection for Mackay, although the 7.6 metre peak caused some 'street flooding of the Cremorne area. A flood level of 7.8 metres at Mackay starts to cause more serious flooding. There was obviously severe local and drainage problem flooding throughout the period at Mackay, and considerable attention was placed on the high risk of serious flooding from the Pioneer River.

Flood warnings were current for the area almost continuously from 25 December. Warnings were updated at about 3 hourly intervals during critical periods. Forecast heights/times were given for the river level at Mackay, and these were accurate within about 0.2 metres. The largest prediction error was an over-estimate of 0.4 metres (predicted 7.4m, peak was about 7 metres).

The Bureau Flood Warning Centre worked in close consultation with Ulman & Nolan engineers who provide advice to Mackay City Council as to detailed flood effects and preventative actions.

THE ROCKHAMPTON FLOOD

In the days and weeks following the coastal crossing of Cyclone Joy near Ayr on 26 December, the City of Rockhampton experienced its most damaging flood in thirty seven years. The Fitzroy River at Rockhampton finally reached a peak of 9.3 metres on Saturday 12 January which is the third highest , since records began in about 1860.

The Fitzroy River basin covers an area of some 140,000 square kilometres to the east of the Great Dividing Range in central Queensland. Its major tributaries are the Nogoa, Comet, Isaac, Connors, Mackenzie and Dawson Rivers.

As was the case for the Cyclone Charlie flood almost three years ago, the 1991 flood at Rockhampton was primarily caused by high rainfalls and flood runoff from the Isaac-Connors system to the north of Rockhampton, together with lesser flows from the Mackenzie, lower Dawson and the Rockhampton area.

Fitzroy Basin Rainfalls

Flood rains were recorded along the central Queensland Coast between Townsville and Rockhampton from about 23 December to 6 January, caused by Cyclone Joy and its continuing rain depression after crossing the coast near Ayr on Boxing Day. The attached table shows 24 hourly rainfalls (to 9am) for key stations in or adjacent to the Fitzroy drainage basin.

Within the fortnight of rain in the area, two periods of heavy rain occurred which contributed significantly to the Rockhampton flood. The first period was from 27 to 30 December where rainfalls were typically 150 to 250 millimetres per day in coastal areas from Rockhampton northwards. The highest one day total reported from within the Isaac-Connors system was 458 millimetres at Blue Mountain (30 kilometres inland from Sarina) for the 24 hours ending 9am, 30 December.

Three day totals (to 9am Sunday 30 December) in the Isaac-Connors River system included Blue Mountain 831 millimetres, Nebo 366 millimetres and Carfax 297 millimetres. The Rockhampton district also recorded very high rains in the same period with totals including Rockhampton 495 millimetres, Yaamba 627 millimetres and Mt Morgan 5 14 millimetres.

The second burst of heavier rain was from 2 to 5. January with Blue Mountain recording a four day total of 717 millimetres. Rockhampton received a further 192 millimetres in the four days to 9 am Saturday 5 January. Showers and thunderstorms persisted for the next week.

Local flooding at Rockhampton

Severe local flooding was generated in the areas of heavy rain. The Fitzroy River at Rockhampton rose quickly during Saturday 29 December and overnight to reach 7.45 metres by late Sunday. This was primarily produced by high runoff from the local streams flowing into the Yaamba to Rockhampton reach of the Fitzroy River. A river level of 7.3 - 7.4 metres was maintained at Rockhampton until Thursday 3 January when slow rises commenced with the arrival of the leading edge of the upstream floodwaters.

First flood peak at Rockhampton

The first period of heavy rain in the coastal districts between Rockhampton and Mackay caused river levels in the upper Connors River and Funnel Creek to rise rapidly to major flood levels during Thursday 27 and Friday 28 December. The Connors River at Cardowan peaked at 16.8 metres during the morning of Sunday 30 which is about 2.3 metres less than the Cyclone Charlie flood of March 1988.

Peak flows from the Connors-Isaac system extended to the Mackenzie River at Tartrus during Sunday and Monday. The peak flood level at Tartrus was 18.1 metres early on New Years Day (Tuesday). At this station, flood levels had exceeded the March 1988 flood by 0.2 metres.

The flood peak travelled down the Mackenzie during the first few days of January to reach the Fitzroy River at Riverslea overnight on Thursday 3 January. Combined flows from the lower Dawson River and the Mackenzie River produced a flood peak of 27.2 metres at this station. This peak extended to Yaamba by Sunday 6 January (16.5 men-es), and Rockhampton recorded its first peak of 9.15 metres on Monday 7 January. By this time, all road and rail links to Rockhampton were cut, and several hundred people had been evacuated from residential properties. The Rockhampton airport was closed from Saturday 5 January.

Second flood peak at Rockhampton

Rockhampton's second flood peak was again generated in the Connors and Isaac River system. The renewed onset of very heavy rains in this area during 2-5 January resulted in high volume flood runoff from the upper Connors River with levels slightly higher than those experienced five days earlier. The Mackenzie River at Tartrus peaked at 18.0 metres on Sunday 6 January, only 0.1 metres below its first peak.

The Fitzroy River at Riverslea had fallen less than 1.5 metres when it began to rise again early on Monday 7 January. The final peak at Riverslea was 28.04 metres on Tuesday night. Major flood levels downstream at Yaamba and Rockhampton remained almost steady in the days following their first peak before commencing very slow rises with the second floodwaters. Yaamba finally peaked at 16.65 metres on Thursday 10 January. .At Rockhampton, flood levels peaked for the second time at 9.30 metres 'on Saturday, 12 January, fifteen centirnetres higher than the Monday peak.

By 9am Monday 14 January, water levels at Rockhampton had fallen about half a metre and clean-up operations were well underway.

Comparison with previous floods at Rockhampton

The Rockhampton flood peak of 9.3 metres was the third highest since records began in about 1860. The highest on record is the January 1918 flood of 10.11 metres, followed by the 9.40 metre flood of February 1954. (See attached figure showing a plot of the river heights recorded in each of these events).

In terms of duration of flooding, the 1991 Rockhampton flood is similar to the 1954 flood. For example, the 1954 flood and the 1991 flood remained above 8 metres for about 13 days. Whilst this is a significant period for flood operations, it is worth noting that the 1918 flood remained above 8 metres for 26 days, and above 9 metres continuously for 13 days.

Fitzroy River Flood Warning System

The Bureau of Meteorology provides flood warning services for the Fitzroy River basin. A network of volunteer rainfall and river height observers provide reports to the Bureau computer systems via a terminal connected to the observers' telephones. The river height reports arc collated automatically into bulletins which are sent to police, radio stations, State Emergency Service and local authorities.

The rainfall and river height data is analysed by the Bureau's Flood Warning Centre in Brisbane. Flood warnings for the Fitzroy River and its tributaries are issued to the authorities active in flood operations, including those listed above. River height predictions are given for the Fitzroy River at Rockhampton.

The Bureau works closely with the Rockhampton City Council and the State Counter Disaster Organisation during flood periods. (For further details, refer to the Bureau of Meteorology booklet 'Fitzroy Flood Warning System').

Bureau river height predictions for Rockhampton

A summary table of predictions made for Rockhampton is given. The warning of 1645, 31 December provided approximately six days warning (to the Rockhampton peak) that a flood was expected with flood levels possibly higher than the March 1988 (8.4 metres). This was issued before key upstream stations had peaked. At this stage, the timing of the flood was estimated to be about Wednesday 9 January.

Subsequent predictions for Rockhampton were made difficult by the continuing rain in the catchment area (see Table 1), and were updated as the situation changed and upstream river station peaks were recorded. Considerable pressure was placed on the Bureau predictions in the days leading up to the first peak, with other predictions being generally at the 1954 flood level (9.40 metres), and higher.

The first quantitative prediction was given at 8.8 metres on Tuesday 8 or Wednesday 9 in the warning of Tuesday 1 January. The warning of Wednesday brought the timing of the peak forward to Monday or Tuesday. The Thursday warning (1630 hours 3 January) updated the peak to about 9 metres with a 3 to 4 day lead time. The Saturday 5 January prediction was updated to about 9.2 metres with a lead time of 1 to 2 days.

The river level at Rockhampton peaked at 9.15 metres overnight Friday and remained steady during Monday.

In the warning of 1030 the next day (Tuesday), a prediction that Rockhampton would commence to rise during Wednesday or Thursday and be ten to twenty centimetres higher that the 9.15 metre peak during Friday night and Saturday. The final flood peak was 9.30 metres early Saturday morning.

Interaction with External Organisations during Fitzroy Flood

Bureau flood warning staff provided regular briefings and information directly to Rockhampton City Council, Queensland Railways, Capricomia Electricity Board and State Emergency Service in addition to the flood warning and river height bulletin distribution.

A number of live or taped interviews were given to ABC Rockhampton (radio) in particular. The Bureau of Meteorology office at Rockhampton handled numerous enquiries throughout the flood period. Flood warnings and predictions were also available through the Bureau's telephone recording service (1190 in Brisbane, 1196 in Rockhampton).

SYSTEMS PERFORMANCE

The Bureau's Flood Warning Service is based on a range of different data collection and communication systems. The rainfall and river height data is processed by the Flood Warning Centre in Brisbane which formulates and issues the flood warnings and forecasts to the media, Police, State Counter Disaster Organisation/State Emergency Service, and local Councils, and several other organisations. Flood ALERT systems have been installed in the Johnstone Rivers (Innisfail), lower Burdekin River and tributaries (Ayr), and the Don River (Bowen). In each case, the ALERT system is jointly operated by the Bureau and local Shire Council. These systems automatically provide real-time rainfall and river height data through radio communications to a base station computer located at the Council offices. During the flooding associated with Cyclone Joy, the ALERT systems proved to be of tremendous value to the Councils and the Bureau. Overall the ALERT systems functioned well, although there was a number of station failures which are being investigated.

In the other river basins, the primary data is obtained from a volunteer rain and river observer network. maintained by the Bureau. This &vice, known as a ROT (Remote Observer Terminal), connects to the observer's telephone and enables direct transmission of reports to the Bureau computer. This system' functioned without fault, apart from the odd failure of individual ROT's.

Some key river height information is also obtained through Water Resources Commission gauging stations which have a telephone-telemetry capability. For these, the Bureau computer telephones a device at the WRC Station and collects the current river height. These stations are proving to be a valuable contribution to the flood warning service. Most operated continuously through the floods, although there were a few individual station failures.

All of the above systems rely on Telecom telephone communications to the Bureau's Flood Warning Centre. In this event, telephone services remained reliable.

River height bulletins (up to 5 times daily) are automatically prepared and despatched via telex and facsimile by the Bureau's regional computer system (AROS).

This system enables river height and bridge level details to be received by the police, SES, media and local Councils within one hour of the Bureau receiving reports. AROS also handles the dissemination of cyclone and flood warnings, and the routine weather forecast products. AROS enabled a timely and effective information flow between the Flood Warning Centre and the organisations involved in the flood warning and response system.

FITZROY BASIN RAINFALLS

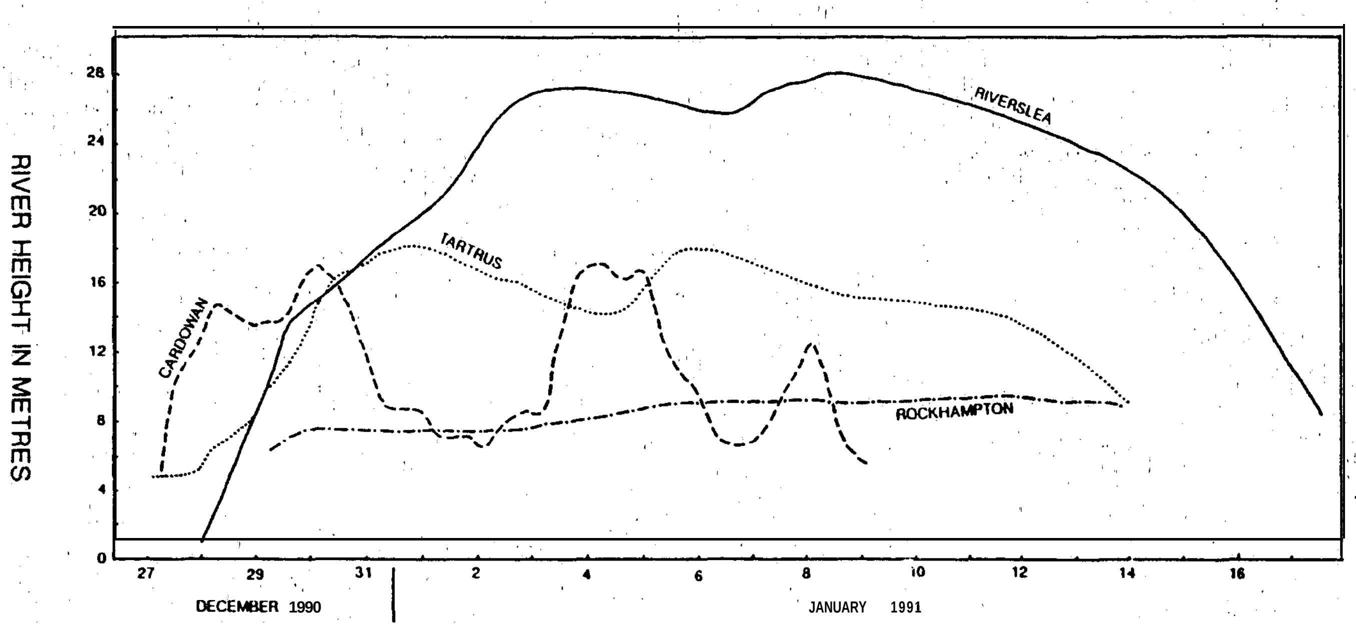
Station	Daily Rainfall (millimetres)									
	27/12	28/12	29/12	30/12	31/12	1/1	2/1	3/1	4/1	5/1	6/1
Marlborough	242	125	171		812		112	11	66	105	
Byfield	12	208	183	165	31		48	17	100		11
Yaamba	7	256	237	134	23	5	7	8	83	66	4
Yeppoon	9	136	147	195	44	14	14	11	90	21	16
Rockhampton	7	163	192	140	20	12	18	40	77	57	5
Mt Morgan	8	169	241	104	14	4	10	10	71	94	8
Sarina	347	261					1052^{4}	136	268		
Blue Mountain	281	206	167	458	82	71	108	124	295	190	69
Nebo	1232	70	29	267	38	20	41	60	131	33	
Carmila	122	193	192	205	83	61	44	66	410	29	5
Carfax	23	73	47	177	19	2	4	11	100		9
Moranbah	59	55	29	84	3		4	5	6		1
St Lawrence	37	152	232	90	73	9		21	100	75	22
Emerald	1	25	46	122	0.2		2	5	15	19	20
Clermont	18	94	52	14	2	2	2	8	29	4	12
Capella	7	55	50	17			82	4	28	452	45

Notes:

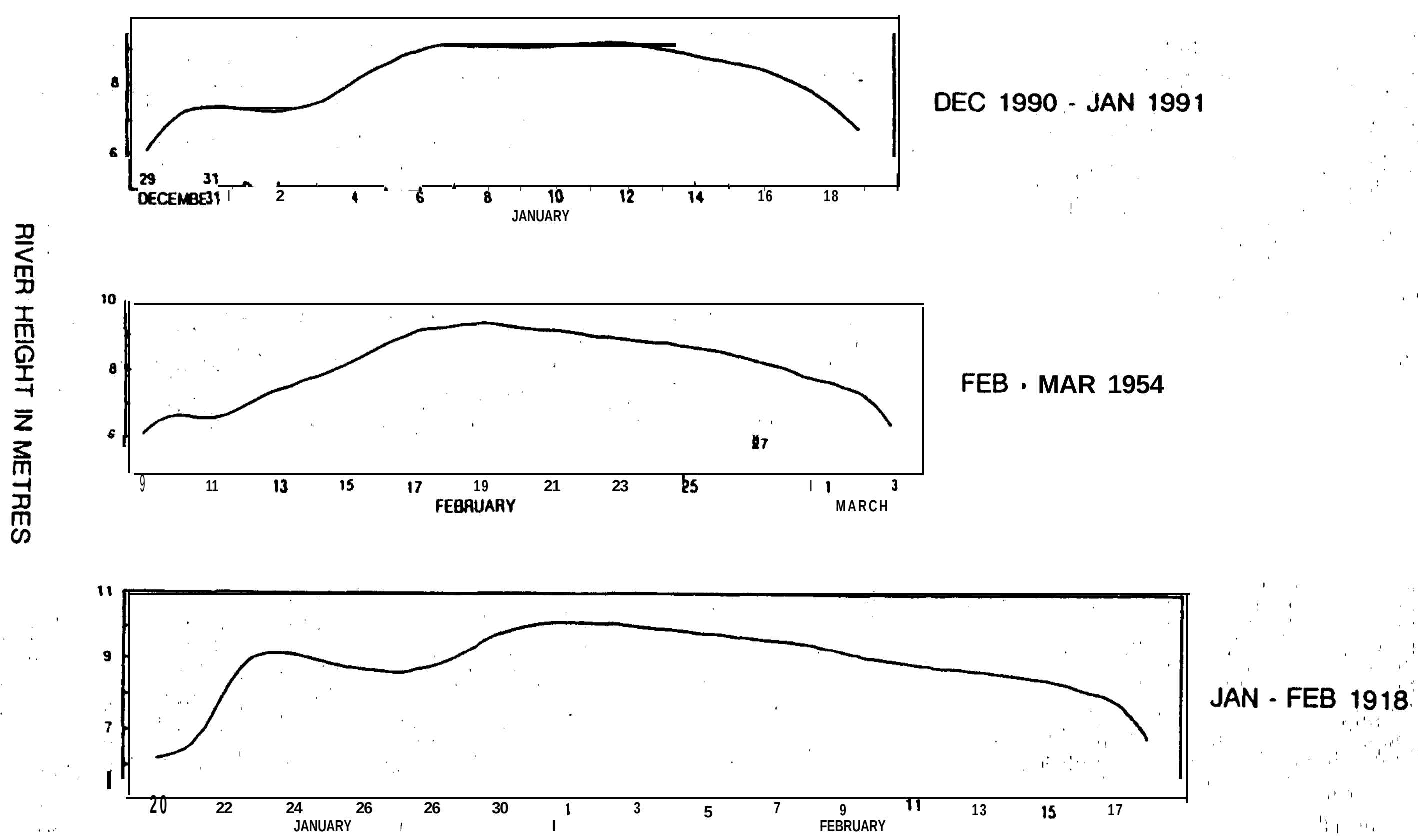
1. Subscript used where rainfall total is for more than one day. For example, ^{2} indicates that rainfall is for 2 days.
2. Gaps can be either zero or NO REPORT.

FITZROY RIVER BASIN

FLOOD HYDROGRAPHS - DEC 90 - JAN 91



ROCKHAMPTON - RECORD FLOODS



FITZROY RIVER - DECEMBER 1990/JANUARY 1991
KEY RIVER HEIGHT PREDICTIONS FOR ROCKHAMPTON

Issue Date & Time		Rockhampton Prediction
31.12.1990	MON 1130	Expected to be similar but possibly higher than March 1988 8.40 metres by Wednesday 9.1.1991
01.01.1991	TUES 1130	Approximately 8.80 metres by 8 or 9.1.1991 (Reach 8.00 metres during Saturday 51.1991)
02.01.1991	WED 1130	Approximately 8.80 metres by 7 or 8.1.1991 (Reach 8.00 metres by late Friday 4.1.1991 or Saturday 51.1991)
03.01.1991	THUR 1200	Approximately 8.80 metres by 7.1.199 1 (Reach 8.00 metres by late Friday 4.1.1991 or Saturday 51.1991)
03.01.1991	THUR 1630	Approximately 9.00 metres by 7.1.1991 (Reaching 8.50 metres by Friday 4.1.1991)
04.01.1991	FRI 1130	Approximately 9.00 metres overnight Sunday 6.1.199 1 or Monday 7.1.1991
05.01.1991	SAT 1115	Approximately 9.20 metres overnight Sunday 6.1.1991 or Monday 7.1.1991
06.01.1991	SUN 1115	Close to its peak at 9.00 metres, slight rises of about 0.10 metres possible with high tide this afternoon. Floodwaters currently in the Mackenzie River will reach the Rockhampton area late this week. These floodwaters are not expected to cause renewed rises at Rockhampton, but will prolong major flooding into next weekend.
06.01.1991	SUN 1700	Close to its peak at 9.05 metres - generally remain steady overnight tonight and during Monday.

06.01.1991	**SUN 2145**	Steady at 9.12 **metres - close** to peak **generally remain** steady **although** slight rises may continue through until Monday afternoon.
07.01.1991	MON 1700	**Steady** after peak of 9.15 metres today. Floodwaters not expected to cause renewed rises but will maintain major flooding into this weekend. Flood levels **expected to remain** generally steady this week
08.01.1991	**TUES** 1030	**The** Rockhampton **river** level is expected to be about- **10** to 20 **centimetres** higher **than** the Monday peak of 9.15 metres during Friday night and Saturday.

ASSESSMENT OF THE 1991 FITZROY RIVER FLOOD
HOW MUCH WATER?

Mike Keane
Water Resources Commission
Rockhampton

1. Introduction

1.1 Why measure floods?

As the water agency for Queensland, the Water Resources Commission manages water in this state. The Commission is responsible for assessing the surface water available, so it is important to quantify the volume of flood runoff. This is emphatically so in Central Queensland, as the climate here has a marked annual variability in the rainfall and runoff of wet years compared with dry years. The runoff of a major flood can exceed the average annual flow several times over for most Central Queensland streams (Fig. 2).

2. Fitzroy River Basin

With a catchment area of over 140 000km^2, the Fitzroy basin is the largest outflowing along the east coast of Australian and nationally is exceeded in area by only the Murray-Darling system. The Fitzroy basin comprises six major river systems:

Nogoa, Comet, Mackenzie, Isaac-Connors, Dawson and Fitzroy.

The Nogoa and Comet join to form the Mackenzie. The Connors flows into the Isaac, which in turn flows into the Mackenzie. The Mackenzie and Dawson join to form the Fitzroy, which flows through Rockhampton and into Keppel Bay (Fig. 1).

This large basin experiences heavy rainfall from a range of synoptic processes and atmospheric conditions. Major flooding is usually associated with tropical cyclones and easterly trough lows which cause heavy rainfalls sometimes over large areas. The area prone to the heaviest rainfalls is the upper part of the Isaac-Connors sub-catchment, inland from Sarina. Each of the major river systems have had major floods in the past.

2.1 Stream gauging stations

The Commission currently has 50 automatic river gauging stations located in the Fitzroy basin. These continually record the prevailing stream level. Flow volume measurements taken at these stations over the range of flows have established the relationship between stream level and stream flow at these sites. This allows for the accurate **assessment** of stream flows in the basin.

These gauging stations were installed over the past 25 years and some stations now allow direct interrogation and data downloading via telephonic links. The continual record of stream flows built up over this time has established an understanding of the stream flow behaviour of the Fitzroy basin.

2.2 Historical floods

A long and well documented history exists of major floods occurring throughout the Fitzroy basin. The 1991 Fitzroy **flood** peak has only been exceeded by the 1918 and 1954 floods, since records were kept and hence is the largest flood to be measured by the Commission's **automatic** gauging stations.

The records available for these earlier-major floods consist at best of the manually read river heights during the flood. Gauge boards to record river level **were generally** installed at locations along the river systems close to settlements. In the Fitzroy system, long term river level records are available at a number of locations, including:

- Fitzroy River at Rockhampton - for flood levels only in this tidal section
- Fitzroy River at Yaamba - for flow records and flood levels in this section just above the tidal limit
- Fitzroy River at Riverslea - for flow records and flood levels
- Mackenzie River, at Tartrus - for flow records and flood levels

2.3 Limitation of earlier flood records

To accurately assess the total volume of Fitzroy flood flow, it is especially important to assess flow near the flood peak, as major 'Fitzroy floods are **characterised** by remaining at near peak flows for many days (Fig. **3**).

The gauge locations above share a common problem, with part of the peak flow spreading across a wide floodplain at all these sites (Fig. 4). So while providing a valuable record of historical flood levels, these locations are less than ideal for quantifying peak flood flows.

Quite a number of factors make'it difficult to have a consistent measure of flood flow across a floodplain. Local topography, including hollows, old flood channels and rises affect flow patterns. Vegetation, including trees and dense seasonal crops, can cause eddies and waves, affecting flow levels and velocities. The efforts of man and changing land use between floods also affect flood flows through a floodplain. Debris gets caught on stock fencing and roads, bridges, culverts and local landfills impact on flood flows. All these factors increase the possible errors in assessing flow across a floodplain.

Flood breakouts over a floodplain also reduce the sensitivity of flow measurements there. A small rise in flood height over a wide breakout can greatly increase the flow rate, comparedwith a site where high flows are totally confined by high banks.

2.4 Flow gauging at The Gap

The installation of an automatic gauging station at The Gap site in 1964 has overcome the problem of measuring peak flows that occurs at the other sites. This site consists of a stable section of the Fitzroy some 90km upstream of Rockhampton. The site commands 97% of the Fitzroy catchment within high banks.

Numerous stream gaugings there during the 1978, 1983 and 1988 floods achieved consistent readings for flows up to 9 500m3/s, while even higher flows are still contained by the high banks there (Fig. 5). This site has allowed a reliable relationship to be established between river height and flow for the full range of flows experienced in the Fitzroy.

2.5 Reassessment of historical flood flows

Once a reliable height-flow relationship was established at The Gap, this allowed cross-checking of the height-flow relationships at other sites, as for most floods the total volume of flow can now be ascertained with some confidence for various locations along the river system. This capability has resulted, for instance, in reducing the assessed 1918 flood peak at Yaamba from 32 500 m3/s down to 18 000 m3/s, and the total assessed runoff in 1918 from 50 million Ml down to 32 million Ml.

This, overestimation of the 19 18 flood flows resulted from 'over-estimating the flow velocities, over the floodplainat the Yaamba site for the 1954 flood. The river height-flow relationship so obtained for Yaamba from the 1954 flood was then extrapolated to estimate the higher 1918 flood flow. Flood flow velocities are often over-estimated. The highest flood velocity measured in the Fitzroy through Rockhampton, for instance, has been just 4m/'s (14.4 km/hour). Many people estimate flood velocities in this high energy section of the Fitzroy are much faster than this.

3. 1991 Fitzroy flood flow records

Based on the records and experience gained from previous floods, and having a network of gauging stations in place, the Commission was therefore in a good position to quantify the 1991 Fitzroy system flood flows and to establish which tributary river systems this rimoff'came from.

3.1 Flow records from periphery of Fitzroy, Basin

Looking firstly at the records obtained from gauging stations in December 1990/January 1991 on the various tributary and major river systems draining the periphery of the Fitzroy basin; a pattern for the 1991 Fitzroy flood emerges. The various gauging stations discussed are shown on Fig. 1, while the flow volumes are summarised in Table 1.

3.1.1 Funnel Creek

Funnel Creek drains the north east comer of the Fitzroy basin, inland from Sarina, and flows into the Connors River. The daily runoff totals for Funnel Creek at Main Road gauging station show very high runoff occurring in two distinct events (Fig. 6).

The upper catchments of Funnel Creek, the Connors River and their tributaries are located on the inland side of the coastal Connors Range. This area can receive very high rainfall, especially when tropical cyclones cross the coast in this region. This occurred with Cyclone Joy in late December 1990. A second period of very heavy rainfall occurred in the Connors sub-catchment in early January 199 1.

The total runoff from the 1075km2 upper Funnel Creek catchment in December 1990/January 1991 was 1450mm.

The Braeside gauging station on Denison Creek, a tributary just to the west of Funnel Creek, recorded **1169mm** of runoff from its **775km2** catchment over this period.

3.1.2 Connors River

The recording apparatus at two gauging stations just to the south along the Connors at Gins Leap and Pink Lagoon were both inundated at the peak of the flood flows there. River flows at these stations for this period have therefore been estimated using the available data. This includes the stream level record available before the recording equipment was inundated, the manually read river heights from a nearby flood warning gauge, the known behaviour of previous floods at these stations, rainfall records and the volume of flow required through these stations to obtain the water volumes recorded at downstream gauging stations.

The gauging station at Gins Leap covers the **1320km2** upper catchment of the Connors. The estimated runoff from this catchment was **1409mm.**

The downstream station at Pink Lagoon captures most of the Connors sub-catchment, including tributary flows from Funnel, Denison, Nebo and Bee Creeks. The estimated runoff from its **8675km2** catchment was 898mm.

3.1.3 Upper Isaac River

Just to the west, the Deverill gauging station covers the **4155km2** upper Isaac catchment, being the inland part of the Isaac/Connors sub-catchment. Thisstation recorded much reduced runoffs and flows compared with **catchments** nearer the coast (Fig. 7).

3.1.4 Mackenzie River

The Mackenzie River at Bingegang gauging station captures a large 50 790km2 catchment, which comprises the western part of the Fitzroy basin, including the Nogoa and Comet sub-catchments. The runoff flows recorded through Bingegang mostly came from the north-east part of this sub-catchment (Fig. 8).

The 16 **720km2** sub-catchment of the Nogoa above Emerald flows into Fairbaim Dam. With a storage capacity of 1440 00 Ml, or some 3 years average annual flow for the Nogoa, Fairbairn was Queensland's largest storage when completed in 1972. All'the runoff from the Nogoa sub-catchment due to Cyclone Joy rainfall was contained in Fairbaim's storage.

There were some minor flows from the 17 225km2 Comet sub-catchment due to Cyclone Joy' rainfall. This came from the south-western highland rim of the Fitzroy basin and these flows were largely confined within the Comet system itself.

3.1.5 Dawson River

The recordings for the Dawson at Woodleigh gauging station show that there was virtually no runoff from the large 28 440km2 upper Dawson sub-catchment (Fig. 9).

3.1.6 Don River

Returning closer to the coast, the results from the Don at Kingsborough gauging station show that them was still reasonable runoff here (Fig. 10). This 610km2 catchment is on the inland side of the coastal ranges, south of Rockhampton.

3.1.7 Neerkol Creek

In 1987 a gauging station was installed on Neerkol Creek near Stanwell township, just west of Rockhampton. This will be used to monitor cooling water discharges from the Stanwell Power Station. This site recorded very high flows from this small 510km2 catchment, particularly in the late December period when Cyclone Joy was initially crossing the coast (Fig. 1'1'). These records show the high runoffs experienced on the coastal side of the ranges.

3.2 Summary of tributary and river system flows

The flow records of the tributary streams and river systems detailed above show that very high runoffs were experienced in the Connors sub-catchment, while quite high runoffs were also experienced from the more coastal ranges in the Rockhampton area.

Runoffs decreased generally as you proceeded from north-east to south-west across the Fitzroy basin, that is away from the influence of Cyclone Joy. This runoff pattern is in complete agreement with the rainfalls recorded over this period.

3.3 Initial Fitzroy flood flows

Heavy local rainfall in the Rockhampton region due to the influence of Cyclone Joy from 27 to 29 December, 1990 caused the initial stream rises in the Fitzroy. This resulted in moderate flooding in Rockhampton. Local tributary streams experienced very high flood flows from thii rainfall. These tributaries flow into the Fitzroy downstream of the Mackenzie-Dawson junction, from where the main river becomes the Fitzroy. These local tributaries include Neerkol-Scrubby, Alligator, Princhester, Marlborough and Gogango Creeks.

While individually these local tributaries are considered minor compared with the Fitzroy, they have a total catchment of over 10 900km2. Aside from the coastal portion of the Connors sub-catchment, the Rockhampton region is the next wettest area of the Fitzroy basin.

The two main tributaries in the immediate Rockhampton area, Alligator and Neerkol-Scrubby Creeks, have catchments in the higher rainfall coastal area. These tributaries join the Fitzroy downstream of The Gap gauging station and both would have contributed significant inflows to the Fitzroy in the December 1990/January 1991 flooding. The broad floodplain topography along the lower sections of both these tributaries would limit sudden stream rises in the Fitzroy from these catchments.

The runoff from these local tributaries maintained moderate flood rises in the Fitzroy until the main flood flow came down from the northern Connors sub-catchment.

3.4 Main volume flood flow

The main volume of the 1991 Fitzroy flood came from the Connors sub-catchment. This was supplemented by inflows from the other river systems (Isaac, Mackenzie and Dawson) and smaller tributaries as it flowed through the Fitzroy system and out into Keppel Bay and the Pacific Ocean beyond.

This large flood volume was recorded on its passage to the sea at the following gauging stations:

3.4.1 Isaac River at Yatton

This gauging station is located just downstream of the Connors confluence with the Isaac. The record of flows here show two distinct flood peaks which correspond to the two periods of very high rainfall received along the coastal ranges (Fig. 12). The initial flood peak recorded at

Yatton was higher than the second peak. The total flow past Yatton during this flood was over 12 million Ml.

3. 4.2 Mackenzie River at Tartrus

This gauging station also recorded two distinct flood peaks of near equal level (Pig. 13). The inflow through Tartrus, in addition to the Isaac-Connors flow recorded through Yatton, included runoff from the 52 595km2 Mackenzie sub-catchment, as recorded at Bingegang. Over 13 million Ml was recorded as flowing past Tartrus.

3.4.3 Fitzroy River at Riverslea

This gauging station recorded the flood flows through Tartrus, but with the additional contribution from the Dawson catchment of 50 830km2 and the adjoining tributary streams (Fig. 14). The volume of flow recorded past Riverslea was over 16 million Ml.

Much of this additional inflow came from the lower Dawson tributaries, including the Don and Dee Rivers and Mimosa Creek. The local Fitzroy tributaries, including Gogango Creek, would have contributed to the initial flood rises. The second flood peak was higher at Riverslea than the first peak.

3.4.4 Fitzroy River at The Gap

The records of this gauging station are the linchpin on which the assessment of the major Fitzroy' peak flows, including those of upstream gauging stations, are based (Fig. 15). The distinction between the two separate major flood peaks was less pronounced, having been largely dampened out at The Gap. The second peak at The Gap was higher than the first peak.

The initial stream rises at The Gap would be due to local rainfall, including flows down Marlborough and Princhester Creeks, which enter the Fitzroy from their near coastal catchments just upstream of this station.

The total flow recorded in the Fitzroy at The Gap gauging station from 26 December 1990 to 31 January 1991 was over 17 million Ml.

3.4.5 Summary of river flow volumes

A summary of the volume of flow recorded at all the gauging stations mentioned above is given in Table 1 below.

Table 1

Summary of 1991 Flow Volumes for Selected Gauging Stations in Fitzroy Basin from 26.12.1990 to 31.01.1991

Stream	Gauging Station	Flow Volume	Catchment Area	Runoff
Funnel Creek	Main Road	1 558 000 Ml	1075 km2	1 450mm
Denison Creek	Braeside	906 000 Ml	775 km2	1 169mm
Connors River	Gins Leap	1 860 000 Ml	1 320 km2	1 409mm
Connors River	Pink Lagoon	7 787 000 Ml	8 675 km2	898mm
Isaac River	Deverill	548 000 Ml	4 155 km2	132mm
Mackenzie River	Bingegang	1 348 000 Ml	50 790 km2	26mm
Dawson River	Woodleigh	72 000 Ml	28 440 km2	2mm
Don River	Kingsborough	138 000 Ml	610 km2	225mm
Neerkol Creek	Capricorn Hwy	2 14 000 Ml	510 km2	419mm
Isaac River	Yatton	12 140 000 Ml	21 200 km2	573mm
Mackenzie River	Tartrus	13 360 000 Ml	75 445 km2	177mm
Fitzroy River	Riverslea	16 545 000 Ml	132 090 km2	125mm
Fitzroy River	The Gap	17 148 000 Ml	135 860 km2	126mm

Note that the above stream flow figures are based on the best information available at present. Additional stream flow measurements in the future may well result in some alterations to the above figures.

4. Character of Fitzroy River floods

Major floods in the lower Fitzroy are characterised by the long time they remain at near flood peak. They therefore involve very large volumes of runoff from part of this 140 000km2 catchment.

Attenuation of 'Fitzroy flood peaks,' or reduction of the peak level while extending the flooding time, is, a pattern common to flood flows through all long river systems. It also takes time for the runoff to flow through such a lengthy drainage system as the Fitzroy's.

4.1 Extent of Fitzroy, flooding

The earlier 1988 Fitzroy flood provided some graphic evidence of how the Fitzroy system behaves. Tropical Cyclone Charlie'dropped heavy flood rains along the coastal ranges inland from Sarina over just a few days. Rainfall in the rest of the Fitzroy basin was limited.

The extent of the lands flooded from this heavy rainfall occurring in just the Connors sub-catchment was later graphically captured by **LANDSAT** imagery, recorded as the flood peak reached Rockhampton 10 days after the rainfall.

These satellite imagery pictures showed where the floodwaters had spread to as the flood peak passed along the lower Connors, lower Isaac, lower Mackenzie and Fitzroy Rivers. In places these floodwaters spread across floodplains 10 to 15km wide.

Floodwaters flowed back up the broad floodplains along the Mackenzie above its confluence with the Isaac and over the lower Dawson floodplain above its confluence with the Mackenzie.

4.2 Constrictions along Fitzroy system

At sections along this river system, the floodplain narrows where it is constricted by hills. The river is particularly'constricted in the 170km reach from where the Mackenzie and Dawson Rivers join (to form the Fitzroy) to downstream of The Gap. This section acts as a choke on flood flows, along with other constrictions upstream on the Mackenzie. Like water, flowing out the plug hole of a bath tub, it takes time for the water stored across the broad floodplains above these constrictions to get through the opening available.

The corollary to this is that for large flows in the Fitzroy, very large volumes of runoff are required to fill these floodplains and allow the water level (which equates with the flow rate) to rise downstream.

4.3 Flood volumes of major Fitzroy floods

The relationship between major floods and flood volumes in the Fitzroy is shown in the data on the four largest Fitzroy floods, as given in Table 2 below.

Table 2

Details of Major Fitzroy Floods

Year of Flood	Peak Flow	Flood Volume	Rockhampton Flood Gauge Max-Level	Rockhampton Flood Gauge Time over 8.0m
1988	9 500m3/s	5 million Ml	8.4m	3 days
1991	14 500m3/s	17 million Ml	9.3m	13 days
1954	14 750m3/s	21 million Ml	9.4m	13½ days
1918	18 000m3/s	32 million Ml	10.1m	26 days

In summary, major floods in the Fitzroy are the result of very large volumes of flood runoff occurring somewhere in the very large Fitzroy basin. So while the 1918 flood peak flow was over twice the 1988 flood peak flow, the 1918 flood volume which produced that peak flow was over six times that in 1988.

4.4 Source of major Fitzroy floods

The two most recent Fitzroy floods in 1988 and 1991 were due largely to very heavy rainfall in the Connors sub-catchment, which comprises only some 7% of the Fitzroy basin. Rainfall records for 1918 and 1954 show that the heavy rainfall which caused major flooding then was much more widespread. The Nogoa and Comet sub-catchments both had very high rainfalls then.

The pattern of heavy rainfall which results in major Fitzroy floods will vary with each event. The choking of Fitzroy flood flows through The Gap section though does make the behaviour of major floods in the lower Fitzroy predictable, no matter where the runoff comes from in the Fitzroy basin. Heavy local rainfall in the Rockhampton area though, when the Fitzroy is peaking here from upstream runoff, can have some affect on the actual Fitzroy levels experienced in Rockhampton.

5. Uses of flood data

5.1 Allocation of water

The accurate assessment of flood flow **quantities** allows the Commission to better manage **the** water resources **in** the Fitzroy basin. A principle use 'of stream **flow** records is for the responsible allocation of the water available for urban, industrial and agricultural **purposes,** while allowing for **instream** demands. Stream flow records also allow assessment **of** the water available for existing and possible future storages under various management **strategies.**

5.2 Major works on Fitzroy River and floodplain

The volume of the 1991 Fitzroy flood could not now be practically utilised. This flood volume far exceeds the capacity of all existing Queensland dams. There is still **value** in measuring these peak flood flows. Large infrastructure works along the Fitzroy and its floodplain, such as the Fitzroy **barrage,** the rail and road crossings over Yeppen and Rockhampton airport require a flood risk analysis to determine the appropriate level of flood protection. This flood **flow** data is also of use to private developers.

5.3 Flood studies

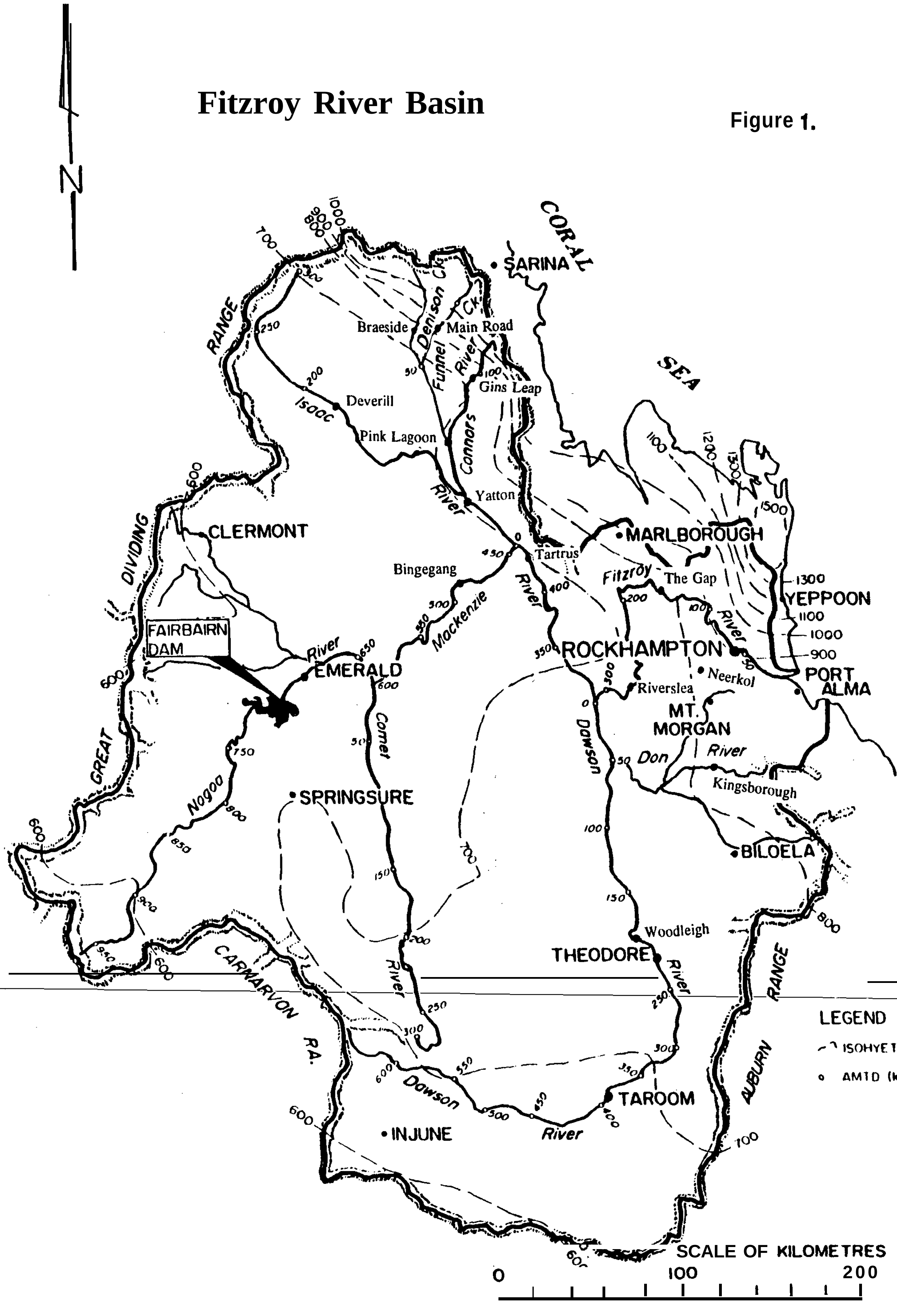
A major flood management study is currently being carried out on the causes and impacts of flooding along the lower Fitzroy. This study, which the Commission is overseeing, is to look at ways to **best** manage future flooding in the Rockhampton area. The study involves consultation with the wider community to assess the impacts of flooding here and the possible measures available to alleviate these impacts.

The extensive flood flow data now available for the Fitzroy system 'provides a firm foundation for this study. This then allows the costs and benefits of the many options available to be reliably evaluated.

The author would like to thank the Commission's **hydrographic** staff at **Rockhampton** for their assistance in providing the data presented in this paper and their many **advices** on Fitzroy basin stream flows.

Fitzroy River Basin

Figure 1.



Annual Discharge - Fitzroy River.

Figure 2.

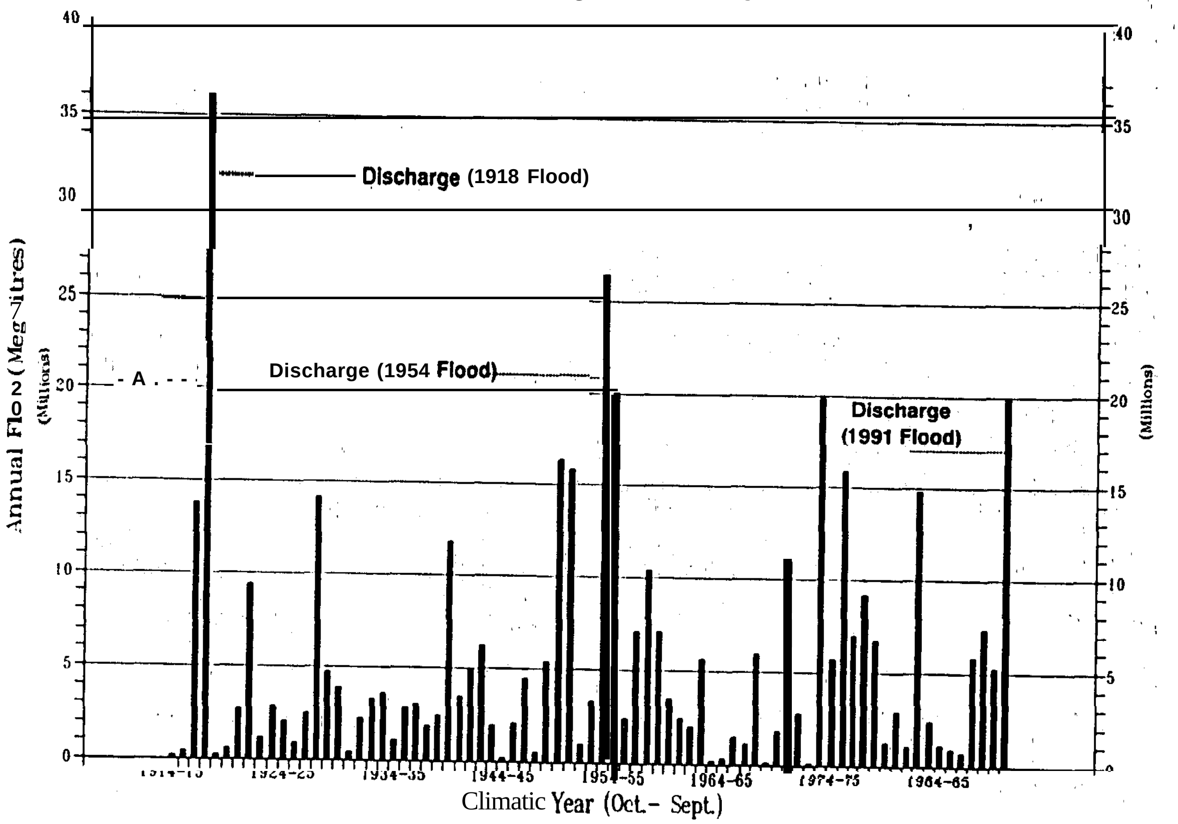
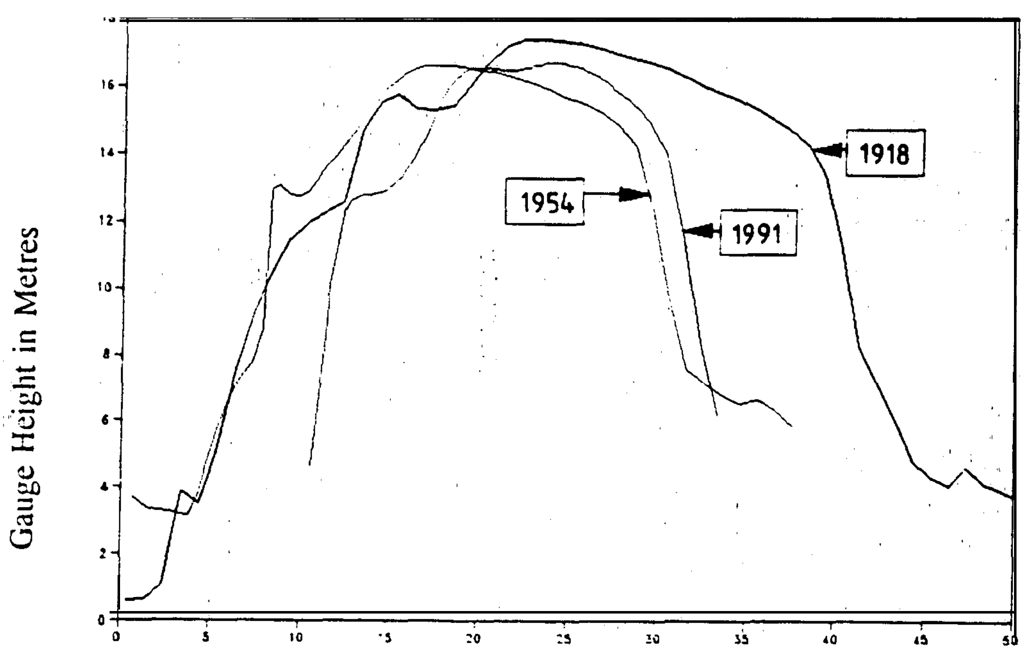


Figure 3.



Flood Heights - Fitzroy River at Yaamba

Figure 4.

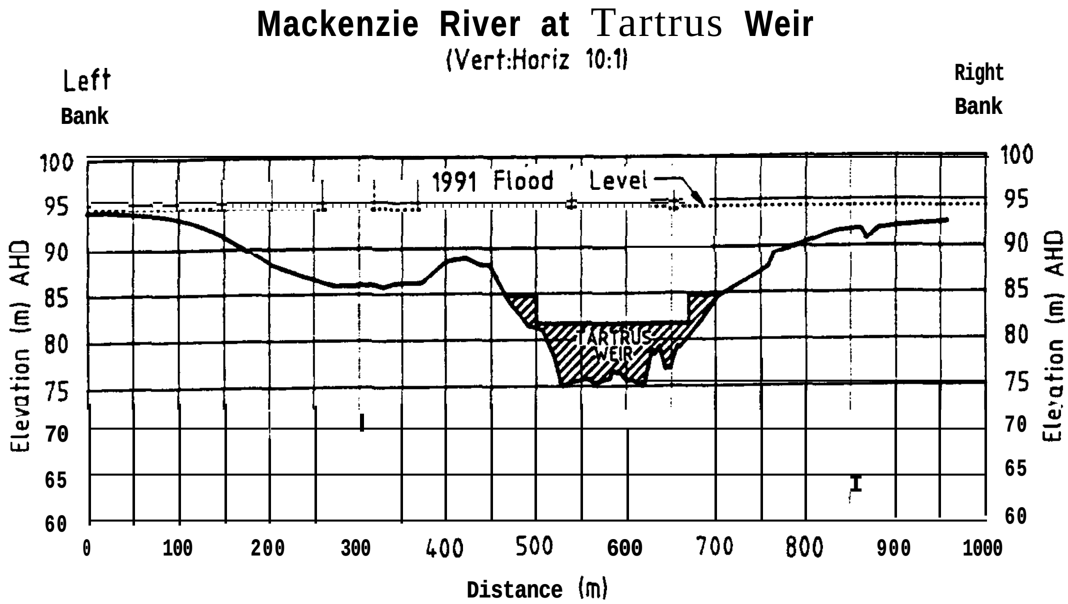


Figure 5.

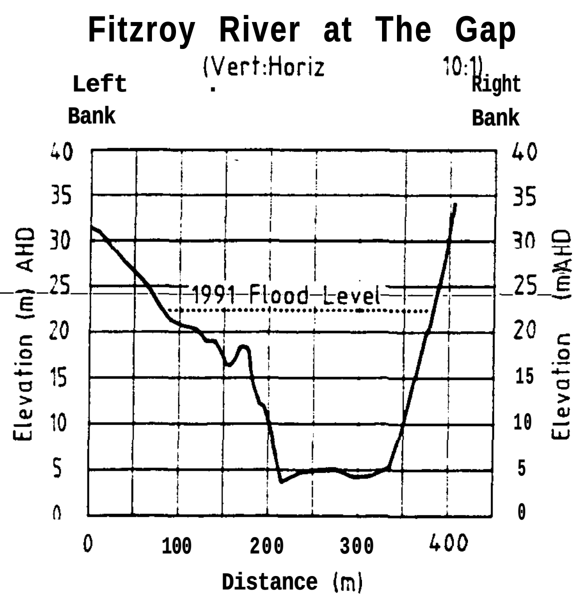


Figure 6.

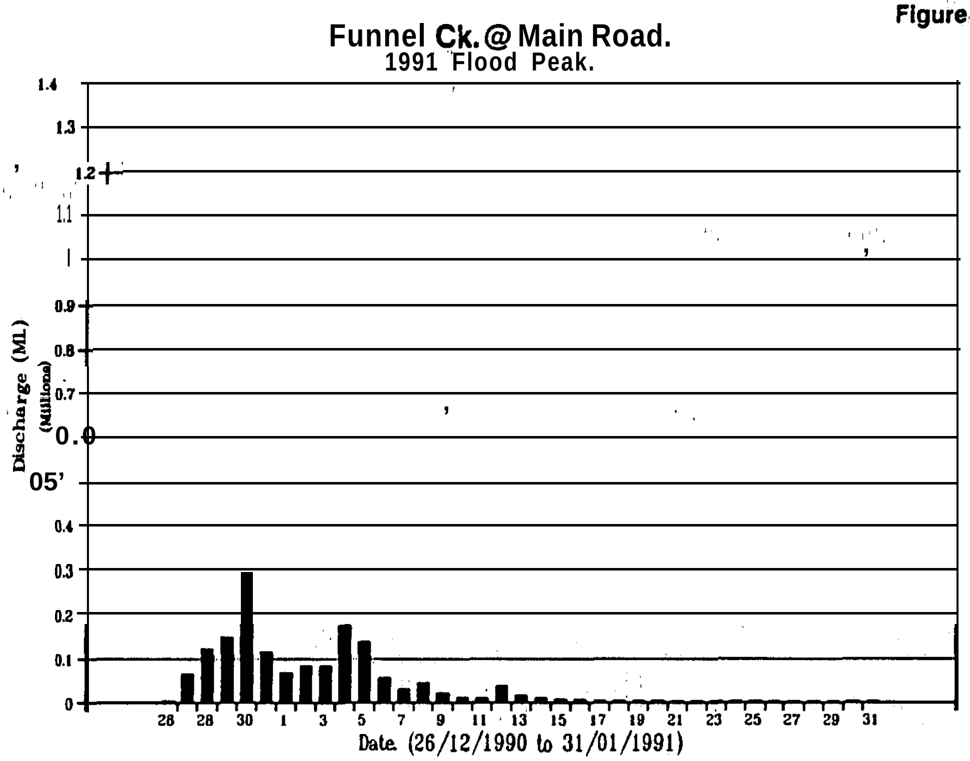


Figure 7.

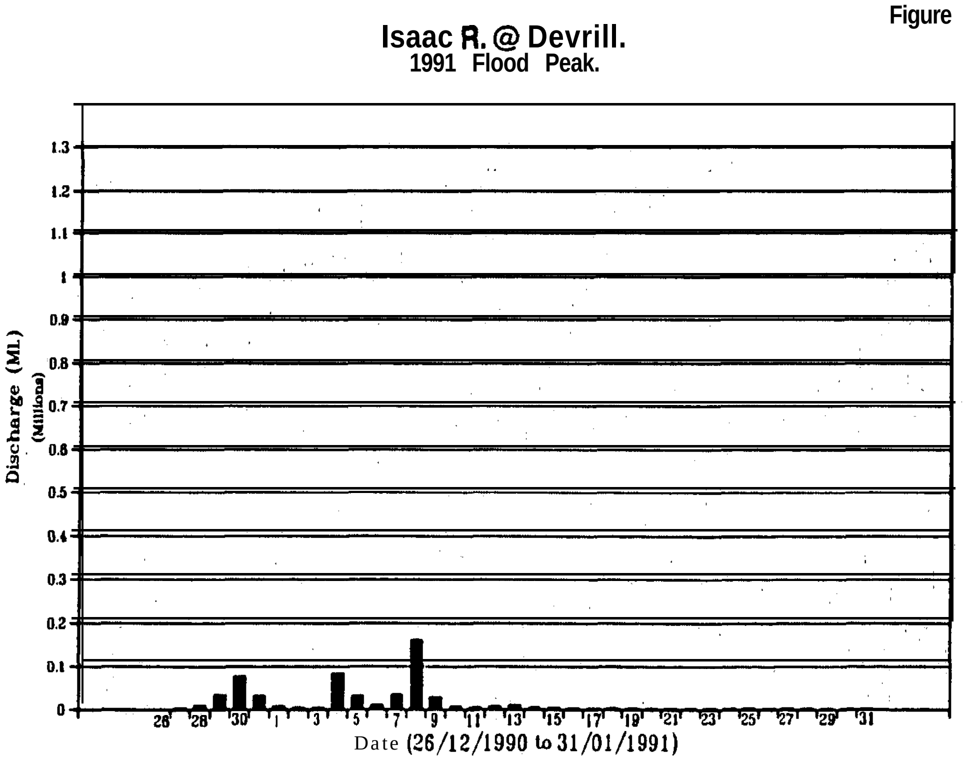


Figure 8.

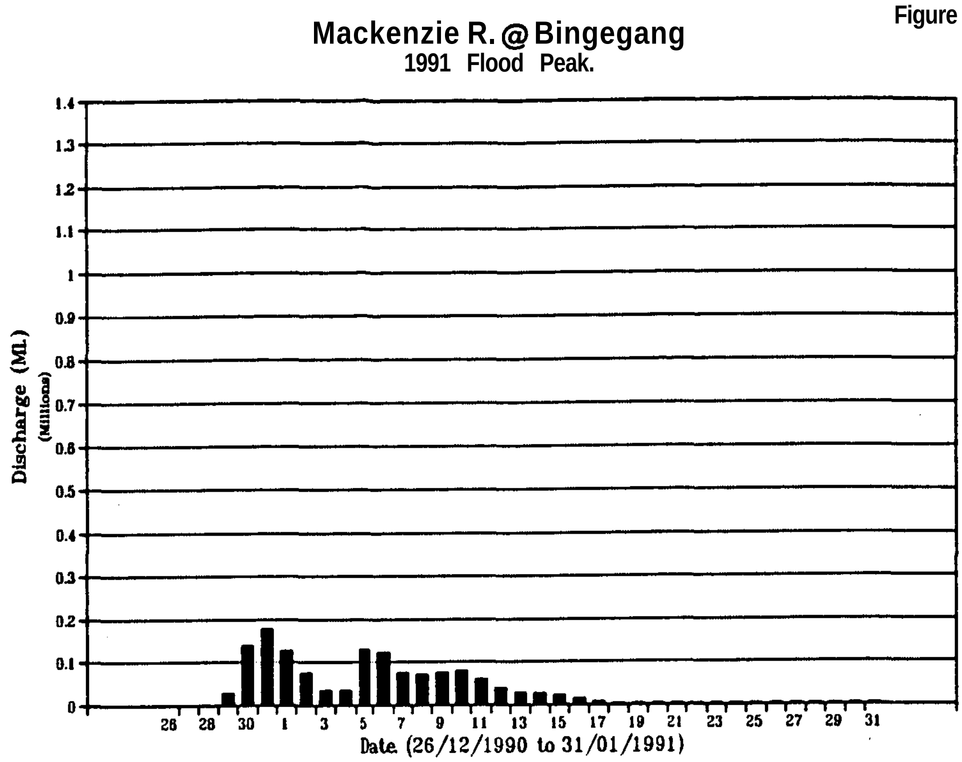


Figure 9.

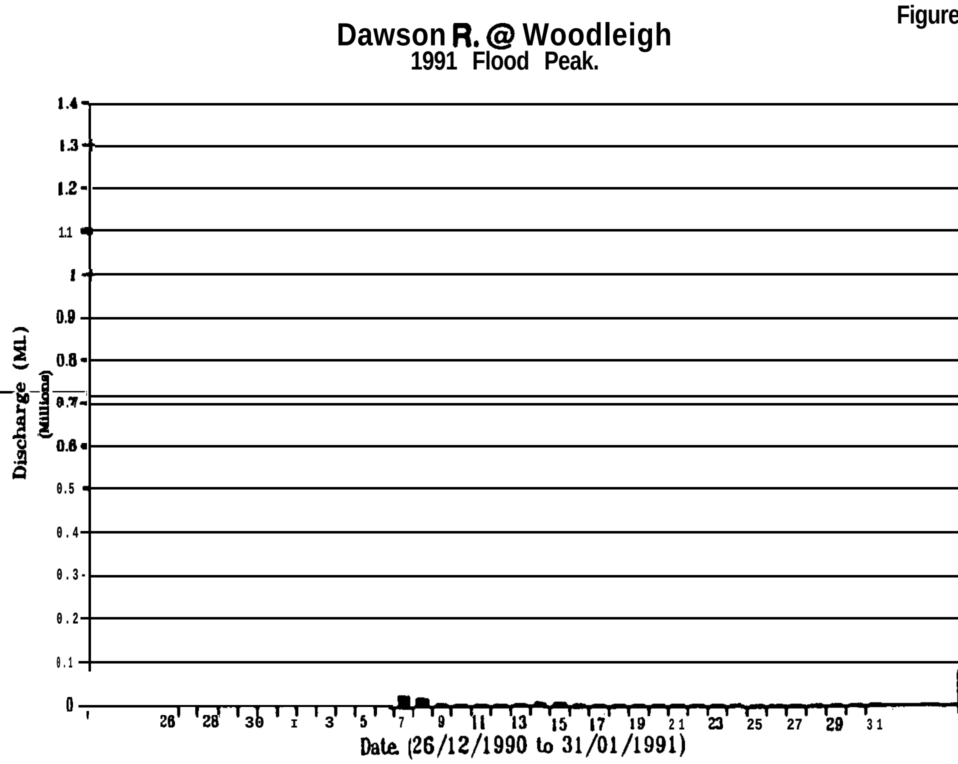


Figure 10.

Don R. @ Kingsborough
1991 Flood Peak.

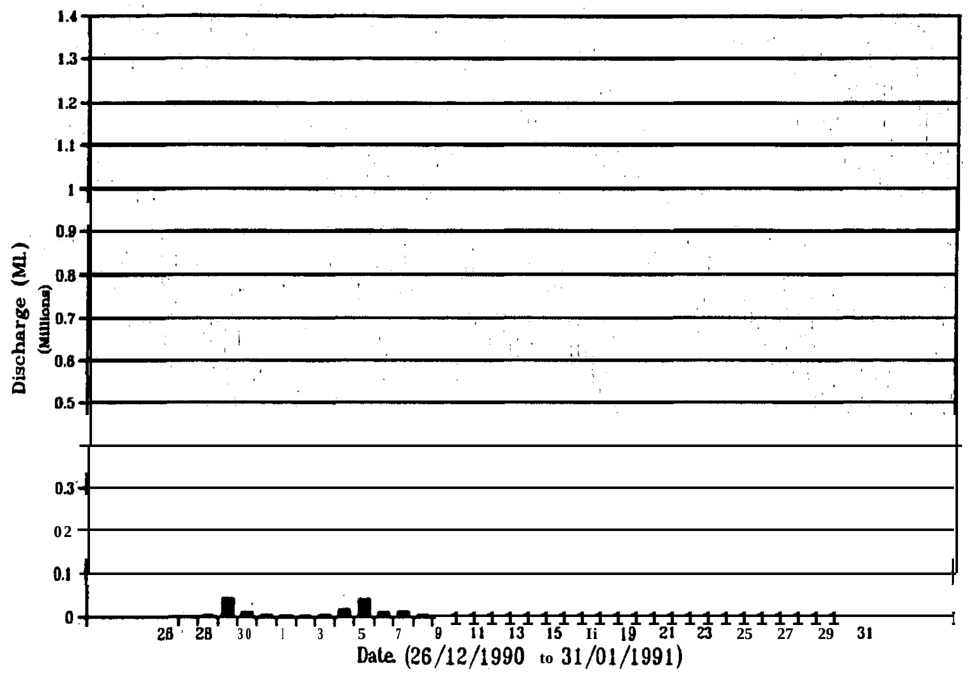


Figure 11.

Neerkol Ck. @ Capricorn Hwy.
1991 Flood Peak.

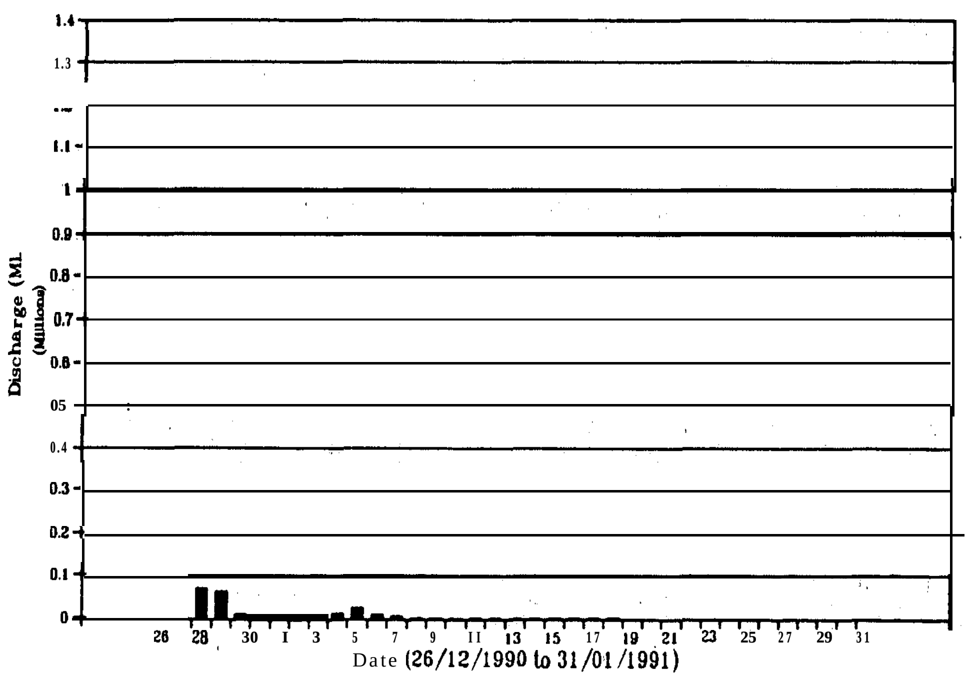


Figure 12

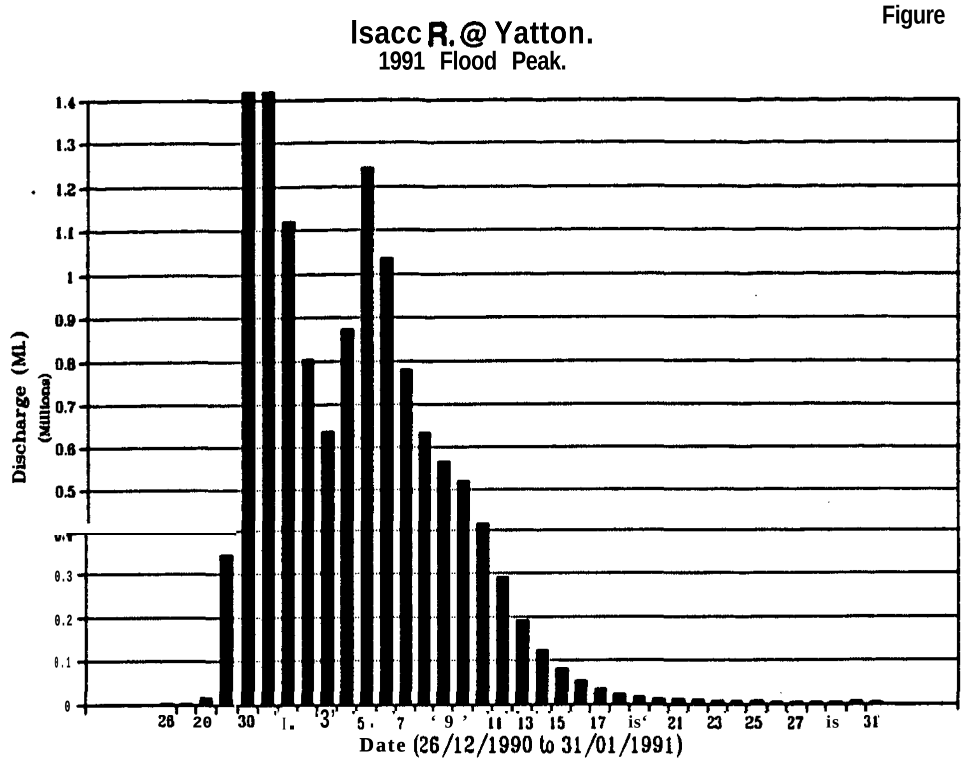


Figure 13.

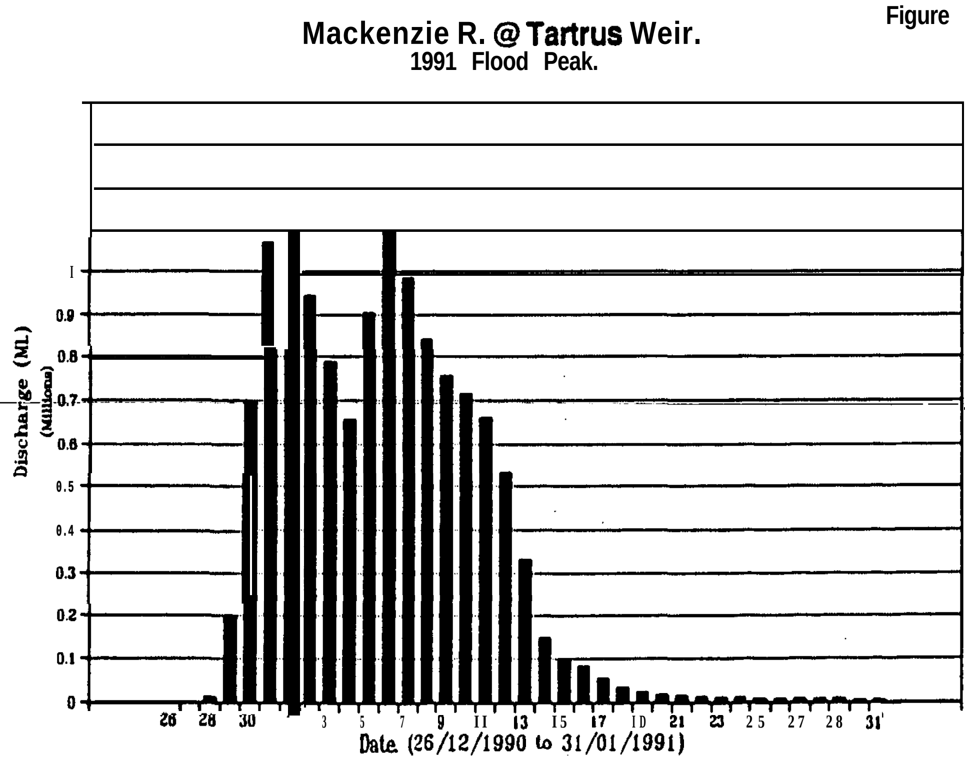


Figure 14.

Fitzroy R. @ Riverslea.
1991 Flood Peak.

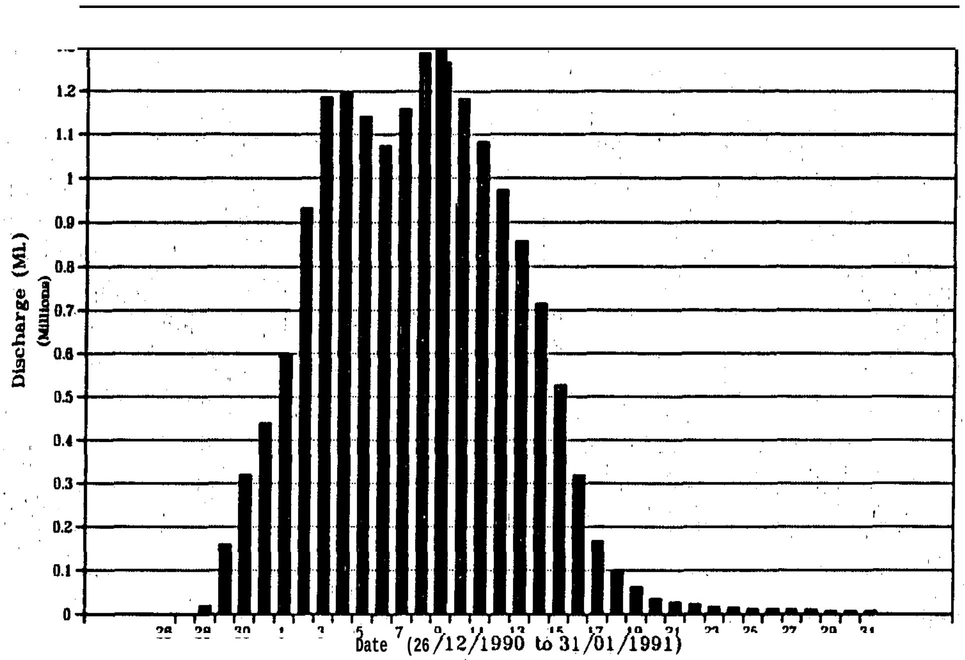
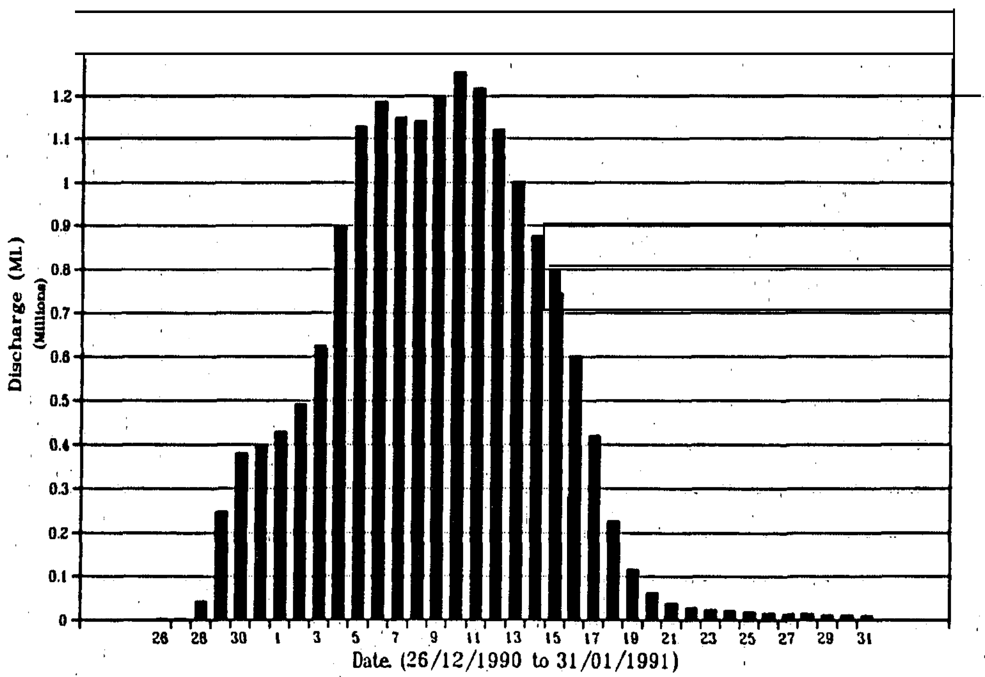


Figure 15.

Fitzroy R. @ The Gap.
1991 Flood Peak.



Some Physical Characteristics and Movement of the 1991 Fitzroy River Flood Plume

O'Neill, J.P., Byron, G.T. and Wright, S.C.
Queensland National Parks and Wildlife Service
Rockhampton

Abstract.

During January 1991, the Keppel Bay area of Central Queensland was inundated with fresh water from the third largest Fitzroy River flood ever recorded. Cyclone Joy had dropped prodigious amounts of fresh water in the Fitzroy River catchment and some 18.5 million megalitres of runoff emptied into Keppel Bay in approximately 25 days. The subsequent path of travel of the fresh water plume was plotted, and the predominant winds and tidal conditions at the time were found to strongly influence its shape and direction of movement.

Salinity levels were found to drop below 10ppt near the water surface over a wide area of Keppel Bay. However most of the area covered by the plume retained a salt water lens underneath. The Keppel Islands were subjected to these low salinity conditions for about 15 days, and evidence suggests that such influxes of fresh water occur on a- semi-regular basis linked to the periodicity of cyclone events.

Introduction

The Fitzroy River in central Queensland drains an area of approximately 140,000 square kilometres (see Figure 1), making it the second largest catchment area in eastern Australia after the Murray-Darling system (Bur. of Met., 1991). A number of rivers including the Isaac, Connors, Dawson and Mackenzie,' all feed into the Fitzroy approximately 100 kilometres west of Rockhampton. From Rockhampton the river takes a meandering 40 kilometre route to the sea.

Historically, heavy rain from tropical cyclones or low depression systems associated with easterly troughs have been the cause of major flooding in the Fitzroy River. Strong winds and large seas are usually associated with these events.

The discharge from the Fitzroy River enters the sea behind the northern end of Curtis Island, in a low energy environment, characterised by low mangrove islands, shallow re-entrants and straits. Wind and wave action in the area is minimised by the protective barrier of Curtis lsland, and the consequent reduced movement of water causes deposition of suspended river sediment. Because of the constrictive nature of The Narrows to the south most of the outflow from the river travels northward, into Keppel Bay. This wide, open bay extends another 50 kilometrcs northwards along the coast and contains more than 15 continental islands, the best known of which are Great Keppel and North Keppel.

The seabed in the Keppel Bay area is composed almost entirely of terrigenous quartzose sands thought to be derived from the Fitzroy and the southern rivers of the Maryborough basin (Maxwell, 1968). These relatively mud-free deposits have been concentrated as a result of hydrodynamic factors related to the predominant south-easterly winds, and the unprotected nature of the coastline. Wave action effectively prevents the deposition of a mud fraction, which is largely removed by the strong tide-induced currents of the area.

The Keppel Islands are continental in origin, and support well developed fringing reefs up to 200 metres wide. These generally occur as isolated reef patches adjacent to headlands or on the protected south and' western sides of the islands. Most of the Keppel Bay area is contained within the Mackay/Capricorn Section of the Great Barrier Reef Marine Park. Under the Great Barrier Reef Marine Park Act, the area is zoned and managed to accommodate a spectrum. of commercial and recreational usage. Effective management, of the area requires investigation of any natural or man-derived changes in the ecological framework, to ensure adjustments to established management practices are made as requited.

Keppcl Bay receives extensive tourist and commercial use. There are tourist resorts on Great Keppel, Pumpkin and North Keppel Islands, and an underwater observatory on Middle Island. A number of

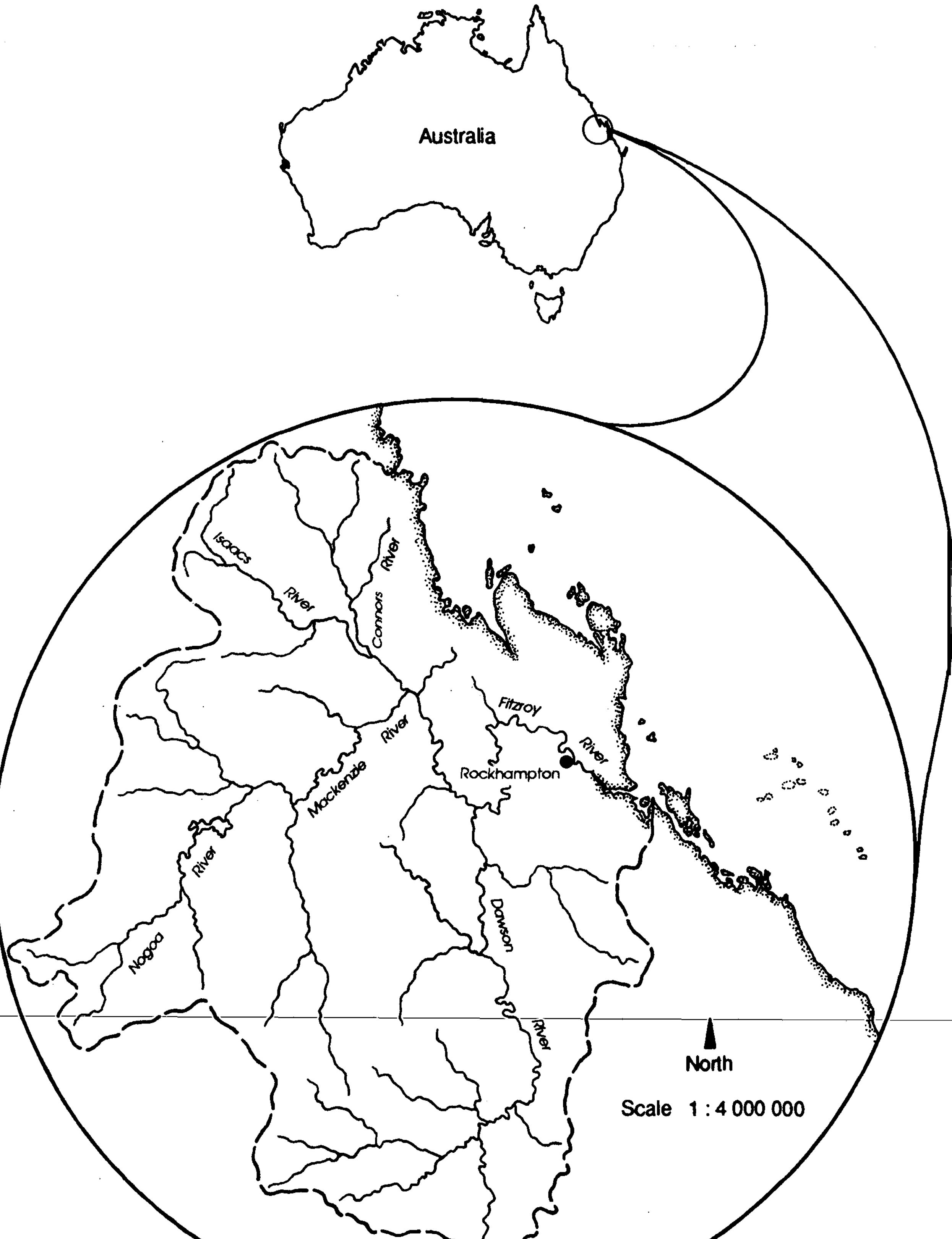


Figure 1

Location Diagram showing the Fitzroy River Catchment

tourist vessels service the islands from Rosslyn Bay harbour on the, adjacent mainland, which also serves as the main point of departure for the local recreational boating fraternity. The area is an important commercial fishery, supporting collecting, trawling, trolling and netting enterprises.

On 26 December 1990, Tropical Cyclone Joy crossed the Queensland coast near Ayr. The resultant heavy rainfall and flood runoff, particularly from the Isaacs-Connors River sub-catchment but supplemented with lesser flows from the Mackenzie, Lower Dawson and Rockhampton areas, resulted in 'the third largest flood ever recorded for the Fitzroy River (Baddiley, in prep.). In excess of 18.5 million megalitres of freshwater was discharged from the Fitzroy River in the 25 days from 28 December 1990 to 21 January 1991 (Keane, in prep.).

This paper describes the physical characteristics and movement of the flood plume during the month of January, 1991. Further projects were undertaken to investigate the nutrient content of the plume (Brodie and O'Neill, in press) and to quantify the subsequent coral death around the Keppel Islands (Byron and O'Neill, in press).

Materials and Methods

Movement

Low level flights over Keppel Bay on January 12, 19 and 23 were used to map and photograph the extent of the flood plume.

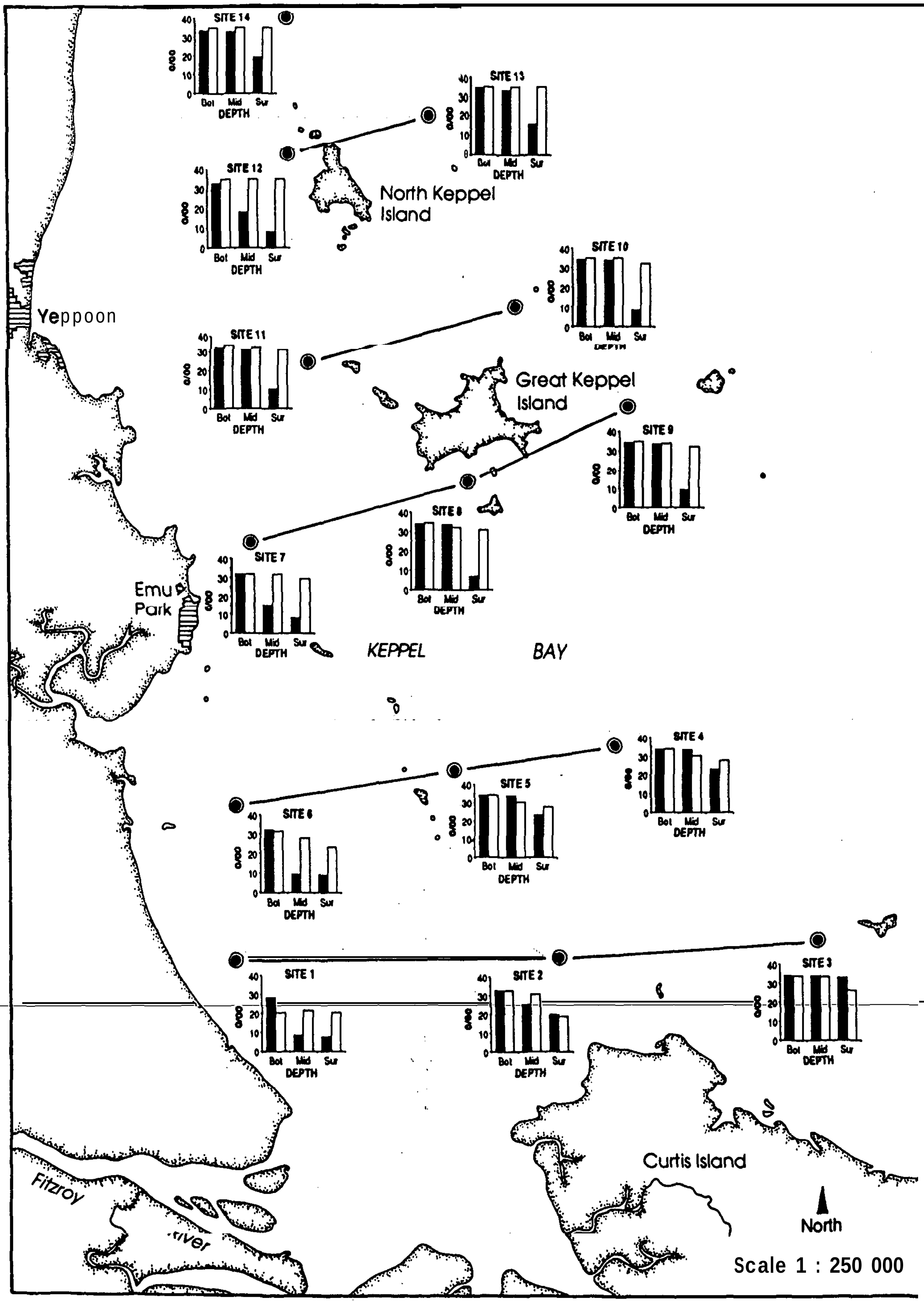
Satellite-derived information showing distance and direction of travel of the plume was not available due to extensive cloud cover during January, 1991.

Physical Properties

14 sites within Keppel Bay were sampled between January 17 and January 23, 1991 as the plume travelled northward along the coast. Measurements of salinity and temperature were made using an Induction Salinometer (Beckman model RS5-3) and readings were taken throughout the depth profile. Secchi depth measurements were also made at each site, and overall depth was recorded using a JRC (model JFV-86) colour echo sounder.

Each site was sampled initially over a two day period (January 17 and 18), and then resampled on January 23, 1991.

Additional measurements were taken at North West Island on January 24, in response to reports of the plume at that location. Salinity, temperature and secchi depth measurements were recorded at various



Notes: Solid fill columns = data collected on 17 &18.1.91, clear fill columns = data collected on 23.1.91.
Depth categories refer to relative depth at which samples were collected: Bot = within 1 metre of the bottom; Mid = mid-stratum; lop = surface.

Salinity Values in Keppel Bay, January 1991 **Figure 2**

locations across the northern reef flat and into deeper water.

River height information recorded at the Gap recording station and daily flow levels for the river were obtained from the Queensland Water Resources Commission.

Wind conditions recorded daily at 3pm on Radar Hill in Gladstone were obtained from the Bureau of Meteorology.

Daily tidal range for the flood period was calculated from the 1991 Department of Harbours and Marine Tide Tables.

Results

The January 1991 flood was the third largest recorded this century for the Fitzroy River, both in terms of peak river height and total discharge volume (Keane, 1991, in prep.). The total volume of water discharged during each of these individual large flood events is much larger than the mean annual river discharge (refer Figure 3).

Baseline flow levels had been recorded for the Fitzroy River for most of December 1990, after a protracted period of drought. On Friday 28 December, the flow increased by over 42,000 megalitres and within nine days it had risen to over one million megalitres per day, remaining above this level for nine days. By January 21 the height of the Fitzroy River had dropped, sufficiently for the river to again be contained within its banks, although the flow rate was still high relative to the pre-flood values (see Figure 4).

During the initial period of flood water discharge and up until about January 13, the predominant winds experienced in Keppel Bay were south-easterlies of moderate strength. From about January 14 until January 27, the wind dropped out to mostly calm conditions. January's tidal range for the area varied from 4.18 metres on January 12 to 1.87 metres on January 8 (refer Table 1).

Extremely low salinities (< 10 ppt) were recorded at the surface over most of the inshore section of Keppel Bay on 17 and 18 January. Salinity levels on these dates increased with northward and eastward travel, and with increasing depth (refer. Figure 2).

Recordings from the inshore sites from Emu Park south (sites 1, 6, & 7) indicated that the freshwater had penetrated to a, greater depth than at the inshore sites further north. In the northern sites the mid-stratum

Mean Monthly Streamflow values for the Fitzroy River (1914 to 1991)

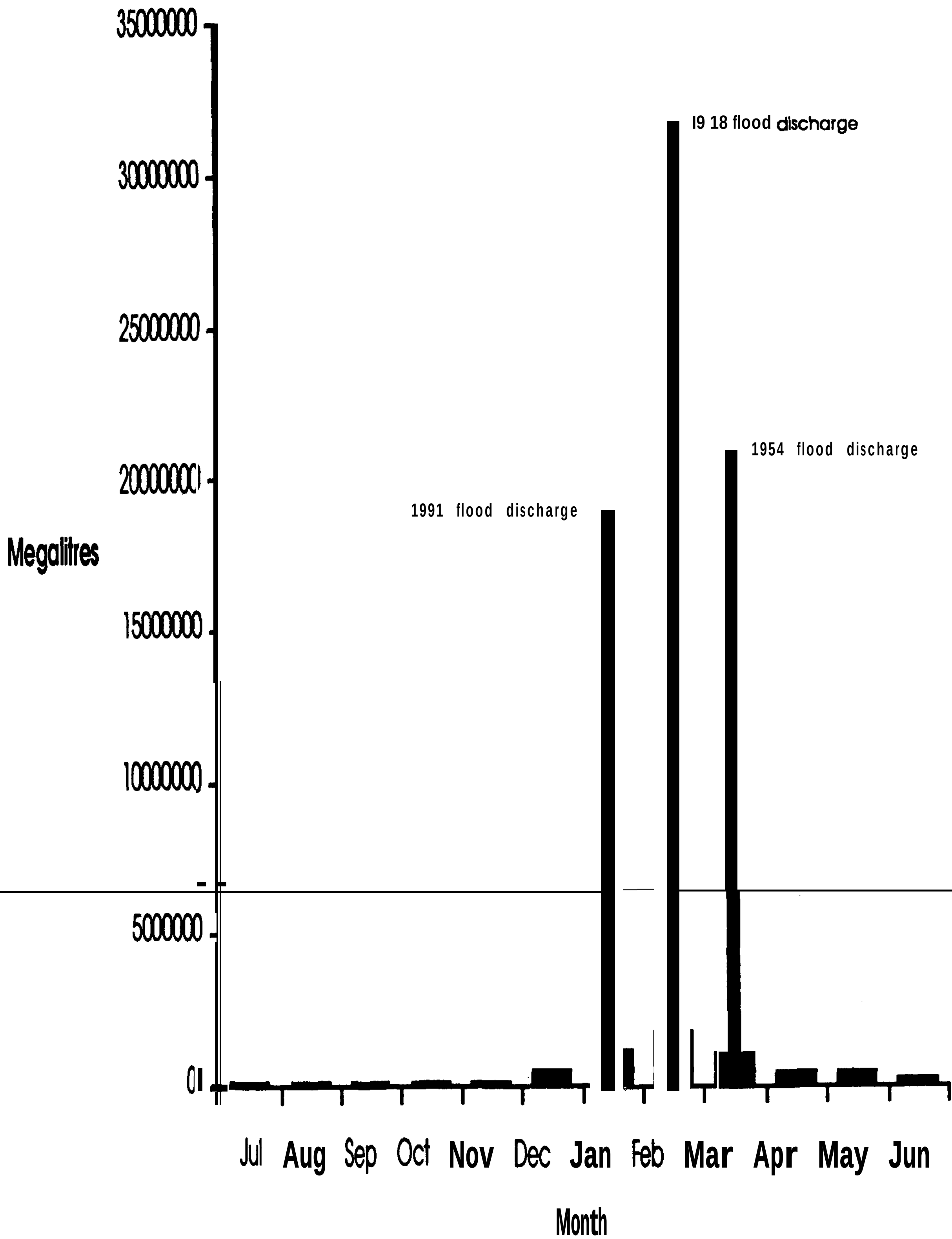


Figure 3

Fitzroy' River flood hydrograph - 1990191

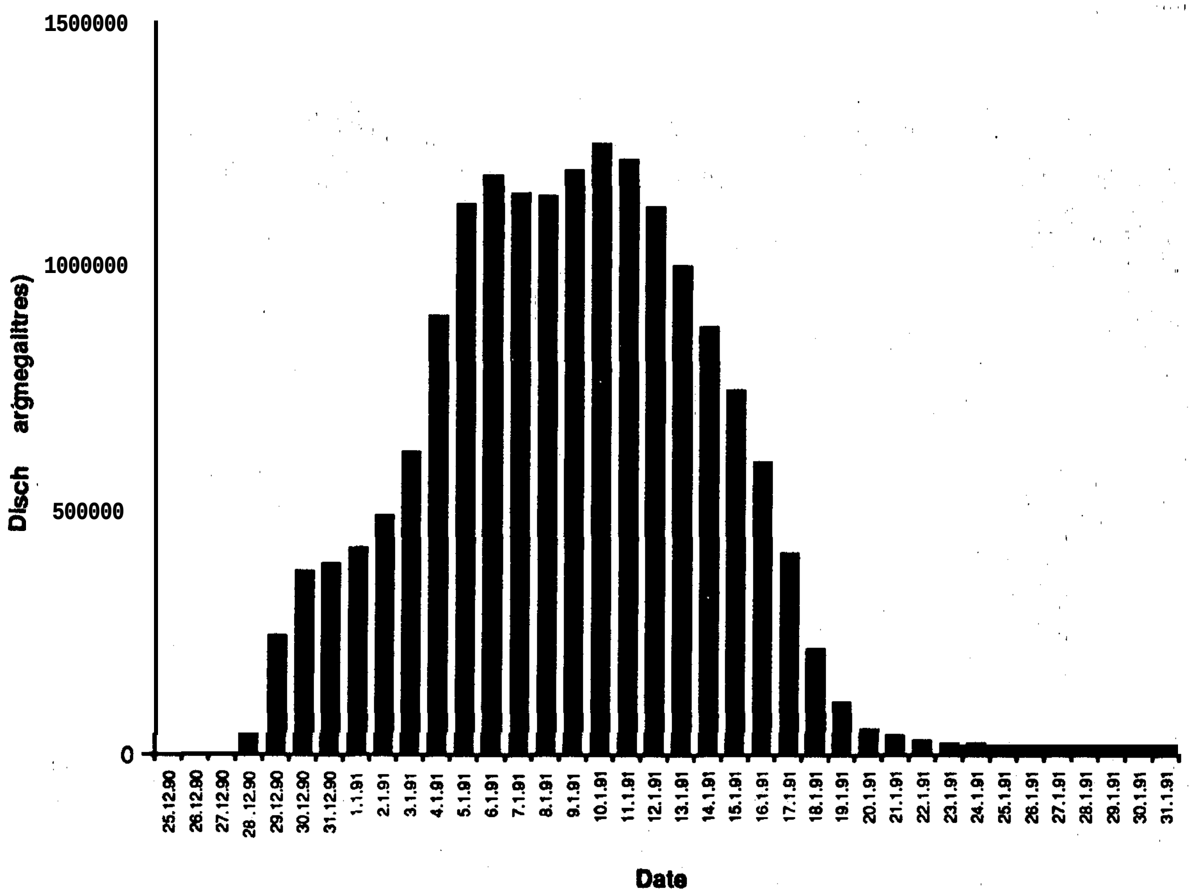


Figure 4

salinity levels were closer to that of seawater (~ 35 ppt).

Sites 9,10 and 13 also recorded relatively low surface salinity values on January 18. These sites were not contained within the main body of the plume moving northwards, but rather within a southward moving back-eddy created by the interference presented by the Keppel Islands (Plate 1). Barren Island and Egg Rock were not subject to the low salinity levels of the plume at this time (Plate 1), nor at any other time of observation. This had clear implications for the health of the coral reefs at these sites (see Byron and O'Neill, in press).

By January 23, when the second set of salinity sampling was completed, the shape, position and concentration of the plume had changed markedly. At this time the discharge from the river had also dropped to its lowest level since December 27, 1990 (refer Figure 4) and the wind had now been blowing lightly from the north-west for a number of days. Tidal range was also at a minimum (see Table 1). Only the sites at the southern end of Keppel Bay now had salinity values of less than 30ppt and the fresh water effect was very much restricted to the near-surface samples (see Figure 2). Salinity values at all points in the stratum had returned to above 30ppt at all sites from Great Keppel Island north. The direction of travel of the plume had actually changed by January 19, as illustrated by its plotted location in Figure 5.

Observed movement of eastern edge of flood plume during January, 1991.

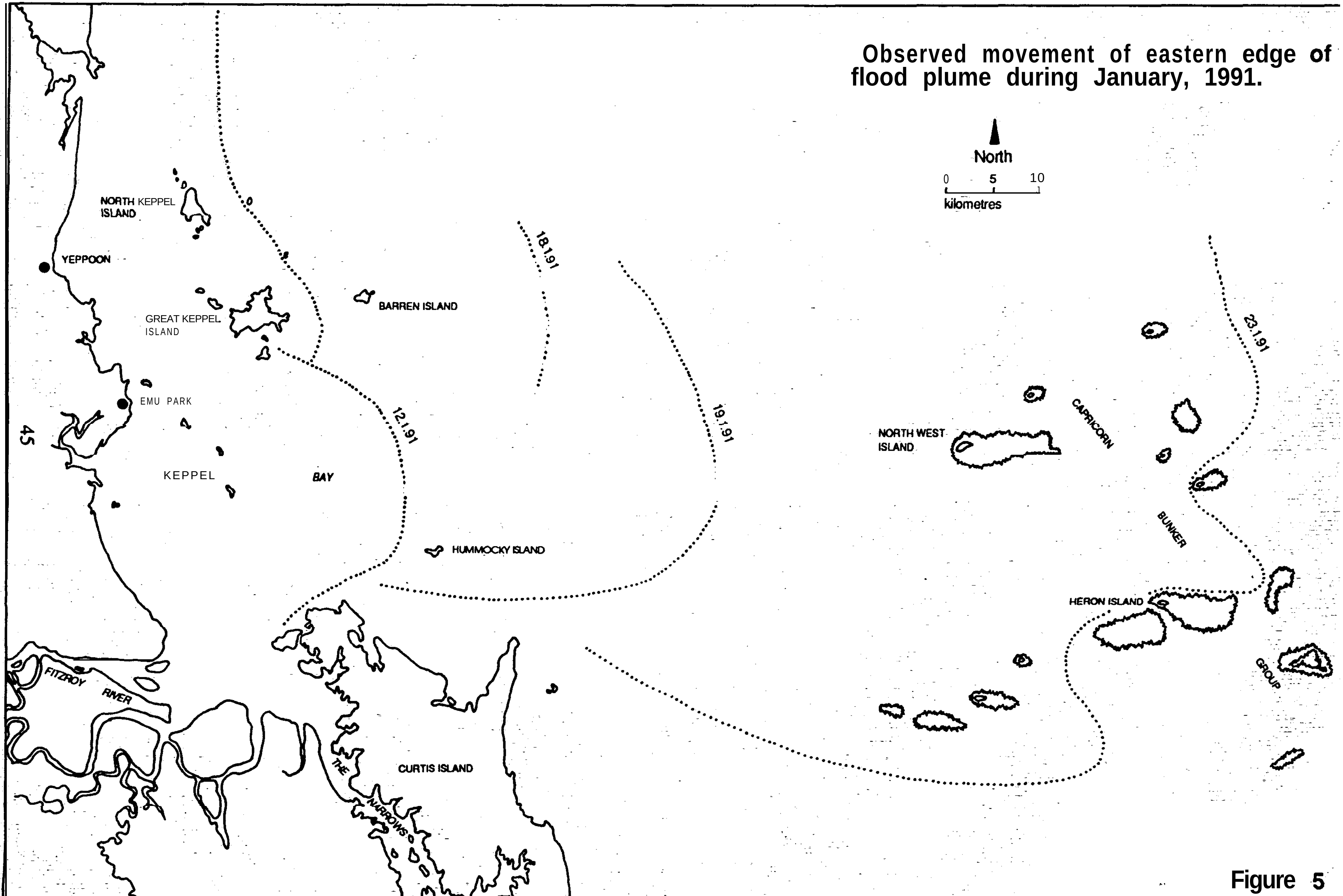


Figure 5

Table 1 Wind and Tidal Information for the period of major outflow of the 1991 Fitzroy River flood.

Note: Wind data is courtesy of the Bureau of Meteorology and were recorded daily at 3pm in Gladstone. Tidal Range is the difference between the largest daily high tide and its consecutive low tide using values taken from the Queensland Department of Harbours and Marine Tide Tables.

Date	Wind Direction	Strength (knots)	Tidal Range (m)
28.12.90	ESE	15	2.75
29.12.90	ENE	15	3.44
30.12.90	SE	10	3.86
31.12.90	E	12	4.17
1.1.91	SE	14	4.18
2.1.91	SE	13	4.16
3.1.91	SE	21	3.96
4.1.91	ENE	14	3.58
5.1.91	NE	14	3.12
6.1.91	NNW	10	2.62
7.1.91	NW	5	2.15
8.1.91	SE	16	1.87
9.1.91	SE	10	1.93
10.1.91	SE	16	2.16
11.1.91	SE	16	2.33
12.1.91	SSE	12	2.65
13.1.91	SE	13	2.87
14.1.91	SE	14	3.03
15.1.91	SE	9	3.12
16.1.91	SE	7	3.22
17.1.91	NE	8	3.30
18.1.91	SE	2	3.31
19.1.91	NW	8	3.23
20.1.91	NNW	0	3.03
21.1.91	NNW	8	2.73
22.1.91	NNW	11	2.38
23.1.91	NE	6	2.10
24.1.91	NE	10	2.06
25.1.91	NNE	11	2.30
26.1.91	NNW	10	2.52
27.1.91	NNW	7	3.11
28.1.91	SE	5	3.62
29.1.91	SSE	7	3.99
30.1.91	SE	14	4.18

Secchi disk readings at the 14 sites increased from a mean of 1.4 metres on the 17 and 18 January to a mean of 4.4 metres on January 23 (see Table 2), and the difference in readings between the two different sampling periods is significant using a Mann-Whitney U-Test (a = 0.01). The magnitude of change in the readings at sites 1, 2 and 3 was much less than at the other 11 sites.

Table 2 Secchi Depth recordings in Keppel Bay on January 17 & 18, and January 23.

Site	Date	Secchi Reading (m)	Date	Secchi reading (m)
1	17.1.91	1.0	23.1.91	2.0
2	17.1.91	0.9	23.1.91	1.0
3	17.1.91	3.3	23.1.91	2.3
4	17.1.91	1.8	23. .9	3.5
5	17.1.91	1.0	23. .9	4.3
6	17.1.91	1.3	23.1.91	3.0
7	17.1.91	0.8	23.1.91	6.0
8	18.1.91	0.7	23.1.91	6.4
9	18.1.91	1.1	23.1.91	7.1
10	18.1.91	1.1	23.1.91	6.2
11	18.1.91	1.0	23.1.91	7.0
12	18.1.91	1.6	23.1.91	4.5
13	18.1.91	2.0	23.1.91	4.0
14	18.1.91	2.2	23.1.91	4.8
Mean		**1.4**		**4.4**

*Secchi depth readings of 23.1.91 are significantly greater than those of 17 and 18.1.91 using, a Mann-*Whitney *U-Test* (a = 0.01).

Water **temperatures were** recorded at all sample depths and sites. No consistent correlation between temperature and movement of the plume was evident., However, the surface temperature at the six sites closest to the river mouth (sites 1 to 6) all increased by mote than 1 degree Celsius in the period of time between January 17 and 23.

By the afternoon of January 23, the flood plume had **reached** the Capricorn Bunker group of islands. On the following day, January 24, salinometer readings were taken at various locations across the **reef** flat it North West Island and into deeper water. It was observed that the salinity level of water on the reef itself dropped to about 30 parts per thousand, although these **areas** appeared to be flushed with **sea** water at high tide. The sediment load of the plume also **appeared** to be substantially less than that around the Keppel Islands,, with secchi disk readings in **the plume** averaging 6 metres.

Freshwater turtles were found alive on North West Island on January 23 and 24, apparently transported seaward with the leading edge of the plume. These **were** later returned to the mainland.

Discussion

It was obvious from the aerial **surveillance** flights undertaken at the time that the shape and location of the plume was not static. At all times the eastern edge of the plume was very clearly defined, the coffee coloured flood waters presenting a stark contrast to the adjacent seawater (see Plates 1 & 2). Changes in location of the eastern edge of the plume were at times observable within a period of hours, however the general direction of travel and shape of the plume remained stable in the period before about January 19. During this period the plume travelled generally northwards and on January 12 was plotted as far north as Island Head, some 70 kilometres north of the Fitzroy River mouth.

The behaviour of the freshwater plume after entering the ocean can be at least partially explained using a model of nearshore tidal currents and nearshore wind drift currents developed by the Beach Protection Authority during a study of the Capricorn Coast Beaches (BPA, 1979). The effects of ocean currents on inshore water movement are thought to be negligible inside the outer sections of the southern Great Barrier Reef (Maxwell, 1968).

The tidal range in the area is relatively large and this results in large quantities of water being moved toward and away from the coast on a daily basis. A consistent pattern of northward flood flow and southward ebb flow has been observed along most of the coast between the Keppel Islands and the mainland (BPA, 1979). However, the interference of coastal islands, reefs and channels is known to cause abrupt changes both in tidal velocities and flow direction. These tidal currents are difficult to separate from the wind induced drift currents often present in this area.

Nearshore wind drift currents are able to develop within 24 hours, and their direction is usually about 30” to the left of the wind direction because of Coriolis forces. Their direction is largely parallel to the shore. In the Capricorn Coast area, a persistent wind from the south east produces a northward moving drift current (BPA, 1979).

The data in Table 1 indicates a consistent pattern of south east winds from late December 1990 until about January 18, 1991. After this period the winds tended to be from the north, and/or of low velocity. While the south easterly winds were blowing, the plume was contained inshore and maintained a northward flow. On January 19, as the south easterly winds abated, the plume began to move easterly, and by January 23 it had travelled far enough in that direction to reach the Capricorn Bunker Group of islands (Figure 5). This behaviour appears consistent with the predictions of the Beach Protection model (BPA, 1979).

The significant overall increase in water clarity recorded in Keppel Bay on January 23 (see Table 2) reflected a change in direction of plume movement rather than a general lessening of plume turbidity levels. Turbidity levels at the three southern sites changed little during this period of time, and actually increased at site 3 on the later date, due to the main body of freshwater then moving through this area.

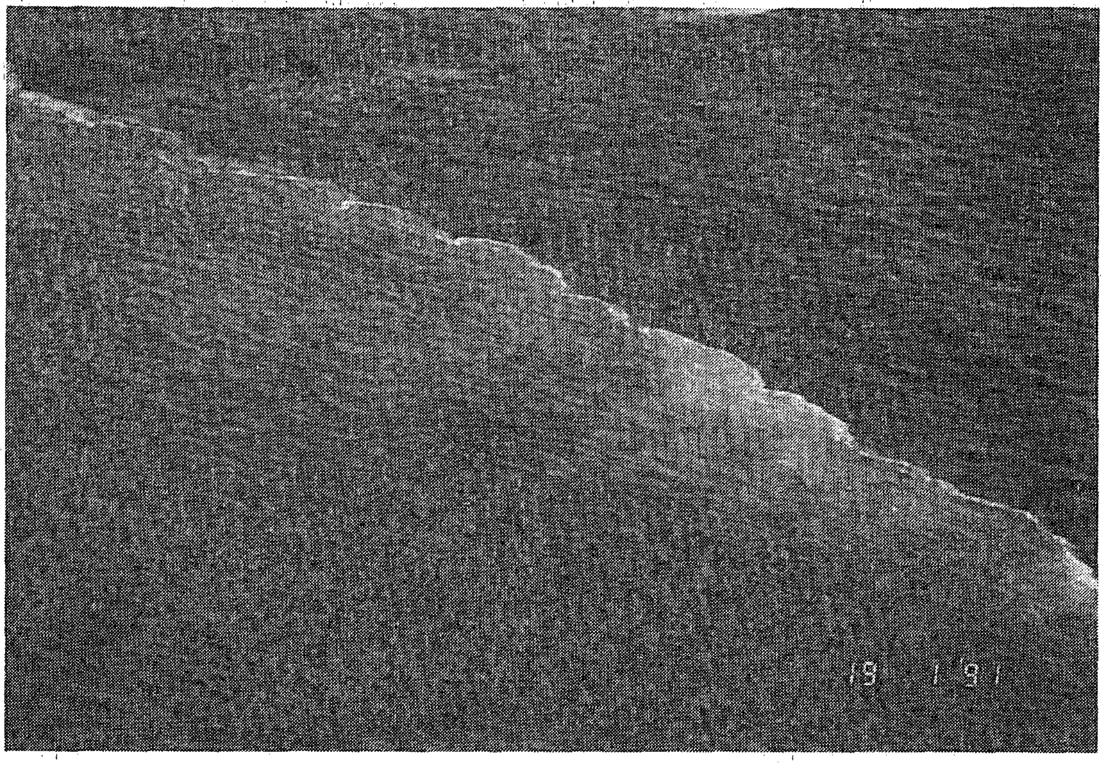


Plate I: Edge of flood plume 19. 1. 91, east of Hummocky Island:

Plate 2: Edge of flood plume 12. 1. 9 1, looking south to Hummocky Island,

The initial northward path of travel of the plume was deflected by the complex topography of the reefs, islands and channels of **the** Keppel group. The very low surface salinity level recorded at site 9 on January 18 was due to back-eddying of the plume around Great Keppel Island, and the surface water at this site was in fact moving **south** at this time. The floodwaters did not mix with the underlying saltwater. It appears from anecdotal evidence that the plume, in consolidated form, moved through the Keppel Islands on January 4, and that surface salinity levels did not begin to recover until after January 19. This meant that the marine life of the area was exposed to very low surface water salinity levels for a period of at least 15 days.

The thickness of the freshwater surface layer **(<20ppt)** around the Keppel Islands during this time was variable, but tended to remain between 3 and 5 metres. This layer moved up and down with tidal movement, affecting marine life in deeper waters on the low tides. Just how long organisms at particular depths were exposed to fresh water would now be impossible to determine accurately. However, with a tidal range at the time of up to 4.18 metres, it is possible that even organisms in the lower intertidal zone did retain exposure on the high tides during this 15 day period to waters with salinities greater than 30ppt.

The flood waters observed moving through the Capricorn Bunker group of islands and reefs on January 23 were comparatively mixed, with salinities mostly greater than 30ppt being recorded. This body of water reached the sea at the time-river -discharge volumes were rapidly falling (refer 18.1.9 1 onwards in Figure **4)**, and headed east as a result of the changed oceanographic conditions previously explained. Without further fresh water reinforcement, this section of the plume quickly dissipated, with resultant very short plume exposure times for this group of islands. No adverse effects on these reefs were predicted at the time, and none have since been observed.

For a Fitzroy River flood to significantly affect the Capricorn Bunker reefs it is likely that light winds would be required during the period of major discharge. The very large rainfall events in this area are mostly associated with cyclonic disturbances, which also have attendant high wind conditions. Because of the clockwise circulation of winds within a cyclone in the southern hemisphere, a situation likely to result in offshore winds together with heavy flooding in the Fitzroy River is a cyclone crossing the coast just south of Rockhampton and inundating the Dawson River. This would produce northerly winds off the northern side of the cyclone near the Fitzroy River entrance at about the same time the Dawson River flood waters would reach the sea. The chances of this occurring must be small, given the very particular path of travel by a cyclone required to produce these conditions.

The above discussion suggests that, as a general rule; fresh water from the large cyclone-induced floods of the Fitzroy River will tend to move north through the Keppel Islands, rather than eastwards toward the Capricorn Bunker group. Certainly, the wind data recorded at the time of the two largest floods, this century (1918 &1954) tends to support this belief (Bureau of Meteorology records, Gladstone). Any ecological or other effects observed in the Keppel Islands as a result of this flood can therefore be expected to occur commonly but irregularly, and in concert with cyclonic events. It is the severity of the effect that'is most likely to change with time, resulting from changes in land use and management practices in the catchment area. This topic is to be investigated in a further paper (Brodie & O'Neill, in prep.).

Acknowledgements

The authors would like to thank the staff of the Queensland National Parks and Wildlife Service and the Great Barrier Reef Marine Park Authority for their assistance, in particular our boat'skipper Brian Morris for his perseverance and extensive local knowledge. We also, thank Jon Brodie from the GBRMPA for his advice and assistance, and Ian Wallis from the Queensland 'Water Resources Commission for help with the streamflow information.

References

Beach Protection Authority, Queensland. 1979. Capricorn Coast Beaches. A detailed Study of Coastline Behaviour along the Capricorn Coast of Queensland, Australia. BPA, Dec., 1979.

Brodie, J and **O'Neill,** J.P. (In prep). Water Quality Changes in the Coastal Environment associated with the Fitzroy River Flood, January, 1991.

Bureau of Meteorology. 1991. Fitzroy River Flood Warning System. Internal Report, Brisbane, April, 1991.

Byron, G. T. and **O'Neill,** J. P. (1992). Flood Induced Coral Mortality on Fringing Reefs in Keppel Bay.Workshop on the Impacts of Flooding, ed G.T.Byron , GBRMPA, Townsville pp 76-89

Keane, M. 1991. (1992). Assessment **of** the 1991 Fitzroy River Flood. How Much Water? Workshop on the Impacts of Flooding, ed G.T.Byron , GBRMPA, Townsville pp 16-35

Maxwell, W. G. H. 1968. Atlas of the Great Barrier Reef. Elsevier Pub. Co., Amsterdam.

PART B

WORKSHOP, PAPERS

NUTRIENT COMPOSITION OF THE JANUARY 1991 FITZROY RIVER PLUME

Jon E Brodie[1] and Alan Mitchell[2]

1 Great Barrier Reef Marine Park Authority, **Box** 1379, Townsville.
2 Australian Institute of Marine Science, PMB 3, Townsville.

Introduction

The impact of agriculturally derived nutrients in river runoff on the Great Barrier Reef (GBR) is presently the subject of considerable controversy (see for example Walker, 1991a, b; Bell, 1991; Bell and Gabric, 1990, 1991; Kinsey, 1991; Hopley, et *al*, 1991; Barnes and Lough, 1991). Opinions on this problem range from claims that the GBR lagoon has become more eutrophic, based primarily on satellite remote sensed chlorophyll measurements (Bell and Gabric, 1990, 1991), to those that claim the problem is exaggerated, the evidence weak and only small parts of the lagoon are likely to be affected (Walker, 1991 a, b).

One factor in the debate about river runoff is clear - the greatest proportion of material transported by the rivers to the shelf occurs during floods and stormflow events. This is well known from work overseas (e.g. Walling and Webb, 1985; GESAMP, 1987) and may be more pronounced in some Queensland rivers which drain catchments having distinct wet/dry season rainfall regimes. Supportive, but limited, evidence of this effect is available from studies in a small number of Queensland rivers (Mitchell, 1988; Cosser, 1989; Mitchell et *al*, 1990). Cosser's work on the North Pine River (S.E. Queensland) has shown that phosphorus is primarily transported attached to particulate matter, that particulate matter is primarily transported during stormflow events and of course, that the volumes transported during these events far exceed normal volumes. Taken in combination, these factors indicate that over 80% of the annual phosphorus load from the river is carried during stormflow periods.

The aforementioned studies clearly indicate that monitoring programs to measure river inputs of nutrients to the GBR lagoon must be targetted to measurements during stormflow events. Studies of the fate of riverborne material offshore must also be made during stormflow periods as these are likely to be the only times when such material directly reaches some offshore areas. While stormflow events may last just a few days, 80% or more of the annual suspended solids flux may occur in this small (-1%) fraction of the year (Walling and Webb, 1982).

Pew studies have been made to gauge nutrient concentrations, nutrient, sediment & freshwater transport, by river plumes in the GBR region, and the areal extent of a plume. Wolanski and van Senden (1983) mapping the Burdekin River plume in 1981 noted the interaction of the plume with the Great Barrier Reef and the possible role of barotropic shelf waves controlling the movement of the plume.

Based on hydrodynamic models, King and Wolanksi (1991) suggest that river plumes are constrained close to the coast in the central GBR. The cross shelf composition'of shelf sediments and the distribution of terrestrial 'marker' chemicals or isotopes in the sediment give support to this hypothesis (Johns et *al*, 1988; Johnson and Carter, 1988; Gagan et *al*, 1987).

During January 1991, the opportunity arose to study the plume of the Fitzroy River during one of the largest floods this century, associated with the aftermath of Cyclone Joy. Sampling 'was conducted by 'staff from the Great Barrier Reef Marine Park Authority, Queensland National Parks and Wildlife Service, the Australian Institute of Marine Science and Heron Island Research Station. This paper describes the results of the plume sampling in the Keppel Bay area.

Methods

Sampling stations were chosen on six transects from the coast (l-3; 4-6; 7-9; 10-l 1; 12-13; 14) from near the Fitzroy River mouth to north of the Keppel Islands (Figure 1). Station 3 was deliberately located outside the visible edge of the plume while all other stations were inside the visible plume to some extent. Oceanographic measurements and sample collection were made using the QNPWS patrol boat 'Avocet'. Stations 1 to 6 were sampled on January 17, 1991 and 7 to 14 on January 18. Oceanographic measurements were also made on 15.16 and 23 January and the results of this work are described elsewhere (O'Neill, this workshop).

Samples were collected by Niskin bottle at three depths - Om, 2m and lm above the bottom. Salinity and temperature profiles were obtained from each station (with a Yeo-Kal salinometer) and a discrete surface sample taken for salinity calibration in the laboratory. Water clarity was measured at each site by Secchi disk. Water samples for nutrient analysis were filtered using individual 0.45μm membrane disposable filters and analysed (accordingly to standard AIMS procedures [Ryle *et al*, 1981]) at AIMS for salinity, ammonia, nitrite, nitrate, total nitrogen, dissolved organic nitrogen, dissolved particulate nitrogen, dissolved inorganic phosphorus, total phosphorus, dissolved organic phosphorus;' particulate phosphorus, silicate, chlorophyll-a, phaeophytin and suspended solids. Nutrient samples were frozen on board for return to the laboratory. Wind speed and direction at each station were noted and the location fixed by compass bearings combined with estimation of distances from nearby islands and the coast.

Results

Results are listed in Tables 1 and 2. The salinities for non-surface samples were taken from the calibrated field salinometer. Figures 2-5 show surface distributions of salinity, chlorophyll, silicate and Secchi disk respectively. All show a similar pattern - the plume moving in a relatively narrow north-easterly direction from the river mouth, mixing to some extent as it encounters the Keppel Island group, diluting and thinning on the surface with increasing distance from the river mouth. The chlorophyll pattern shows the effect of the growth of phytoplankton after a lag, which combined with increased light penetration north of Great Keppel Island, resulted in highest concentrations of chlorophyll in this area.

The proportions of nitrogen (Figure 6) and phosphorus (Figure 7) in various forms are shown plotted against depth at each of the 14 stations. Perhaps the most significant feature of these data is the relatively large proportion of phosphorus present as dissolved inorganic phosphorus, probably derived from particle-bound phosphorus desorbed off particles within a short distance from the river mouth.

Discussion

Approximately 19 million megalitres was discharged from the Fitzroy River during the 1991 flood (Keene, this workshop) with a daily average discharge of approximately 1 million megalitres during the 12 or so days of the peak flow. The volume-of-the plume on January 17, assuming an area of 30 km by 60km by 2m depth, was 3.5 million megalitres or about 3 to 4 days discharge. This calculation suggests that plume water took 3 to 4 days to move between the river mouth and Station 14. Using the total discharge volume and the surface salinity at Station 1 (near the mouth) as a dilution factor, an estimate of the total discharge of nitrogen and phosphorus can be made from the nutrient concentrations at this station. The figure is approximate due to possible changes in river nutrient concentrations with time through the flood, particularly during the initial flush, but is an order of magnitude estimate. The calculated values are 11,500 tonnes of nitrogen and 2,900 tonnes of phosphorus. This flood export can be compared with an estimate of 500 tonnes of nitrogen and 130 tonnes of phosphorus entering the Fitzroy River from Rockhampton sewage in one year.

There are no water quality data available for seawater from the Keppel Islands area under normal conditions. The nearest area for which such data are published is around the Whitsunday Islands (Furnas et al, 1988) to the north. Nutrient, chlorophyll and clarity levels from shallow (<10m) and deeper (10-25m) water areas in *normal* (non-flood) conditions in the Whitsundays are compared with average surface concentrations from similar areas in the present study area (Table 3). Seawater outside the visible plume in the present study (Station 3) has similar composition to that of the Whitsunday area. However, considerably higher levels of **most components** a&observed in the plume **water (ranging from three** times to seventy times).

Cosser (1989) suggests that most phosphorus transported to the sea by Queensland river systems is bound to particulate matter. The **results** for the Fitzroy plume study shows that much of the phosphorus in the plume'is present asdissolved inorganic phosphorus (Table **4),** especially near the river mouth. This spatial pattern has been reported in the plumes or estuaries of other tropical rivers (van **Bennekom** *et* ***al,*** 1978; Fox *et* al, **1985, 1986;** Fox, 1990) and is the result **of** &sorption of phosphorus from the particulate phase as the river water mixes with seawater. This desorption process may **allow** phosphorus to remain in the water column as the plume moves offshore rather than settling out quickly near the coast by various sedimentation processes. However, an increasing proportion of particulate phosphorus is observed away from the mouth (Figure **7),** suggesting some readsorption to particles and uptake by phytoplankton.

The nitrogen levels in the plume **(Figure 6)** are very high for tropical waters (Fumas et al, 1988; Fumas, **1989),** particularly the dissolved inorganic forms of ammonia and nitrate. Nitrate levels are diminished considerably in the northern extent of the plume, presumably due, at least in **part,** to uptake by phytoplankton.

Chlorophyll-a values in the surface plume are very high (Figure **3), generally** 20 times normal inshore values, indicating an extensive phytoplankton bloom within the plume. This bloom **was not visually** obvious as associated seawater **colour** changes were obscured by the turbidity of the plume water. The low phaeophytin values confirm that most of the chlorophyll detected was associated with new algal biomass rather than terrestrial detrital material. The highest chlorophyll concentrations **were** measured north of North Keppel Island, in the same area as the noted decrease in nitrate levels This probably a reflects water travel time from the river mouth, combined with greater light penetration in that area (Figure **5),** allowing phytoplankton to grow.

The chlorophyll levels measured were similar to, but somewhat higher than, levels found by Fumas (1989) in an algal bloom caused by cyclonic resuspension of sediments in **lagoonal** waters in the central GBR. Fumas also noted growth rates consistent with a required period of a few days to achieve maximum phytoplankton **concentrations.**

The further movements of this plume after 19 January and its presence in the further **offshore Capricorn-**Bunker Island group (Prekker, this workshop) some days later may be significant in answering questions **with** respect to the influence of riverine inputs on the GBR. The overall analysis of data from the various marine projects done during and after the flood should assist us in extending our knowledge of riverine influences on the GBR ecosystem.

Acknowledgements

The authors would like to thank Paul **O'Neill,** Steve Wright and Grahame Byron from QNPWS for assistance in sampling and Gilianne Brodie for reviewing the manuscript. Thanks are also extended to Miles Fumas from AIMS for assistance with sampling equipment, chemical analyses and critical review of this manuscript.

References

Barnes, D.J. and Lough, J.M. (1991). Nutrients and the need for scientific debate. *Search* **22,** 178.

Bell, P.R.F. (1991). Status of eutrophication in the Great Barrier Reef lagoon, ***Marine Pollution*** *Bulletin* 23, 89-93.

Bell, P.R.F. and Gabric, A.J. (1990). The use of field survey and satellite remote sensing in determining the extent and causes of eutrophication in the Great Barrier Reef lagoon, Australia. In: Proceedings of the, Fourth Pacific Conference on Marine Science and Technology, Tokyo, **1, 25-32.**

Bell, P.R.F. and Gabric, A.J. (1991). Must GBR pollution become chronic before management reacts. *Search* **22(4),** 117-119.

Cosser, P. R. (1989). Nutrient concentration-flow relationships and loads in the south Pine River, S.E. Queensland. 1: Phosphorus. *Australian Journal* **of** *Marine and Freshwater Research* **40, 613-630.**

Fox, L.E., Sager, S.L. and Wofsy, S.C. (1985). Factors controlling soluble phosphorus in the Mississippi estuary. ***Limnology*** *and Oceanography, 30, 826-832.*

Fox, L.E., Sager, S.L. and Wofsy, SC. (1986). The chemical control of soluble phosphorus in the Amazon estuary. *Geochimica Cosmochimica* ***Acta*****, 50, 783-794.**

Fox, L.E. (1991). Phosphorus chemistry in the tidal Hudson River. *Geochimica* ***Cosmochimica Acta*****,** 55, 1529-1538.

Fumas, M.J. (1989). Cyclonic disturbance **and** a. phytoplankton bloom in a tropical shelf environment. In: Red tides: Biology, Environmental Science and Toxicology, Elsevier, New York, 271-277.

Fumas, M., Mitchell, A.W., Wellington, J. and Brady, B. (1988). Dissolved and particulate nutrients in waters of the Whitsunday Island group, February, 1988. Report to the Great **Barrier Reef** Marine Park Authority, Townsville.

Gagan, M.K., Sandstrom, M.W. and Chivas, A.R. (1987). Restricted terrestrial carbon input to the continental shelf during Cyclone Winifred: Implications for terrestrial runoff to the Great Barrier Reef province. *Coral Reefs 6,* **112-** 119.

GESAMP (1987). Land/Sea Boundary Flux of Contaminants: Contributions from Rivers. GESAMP Reports and Studies No. 32, UNESCO, Paris, 172p.

Hopley, D., Yellowlees, D. and Cuff, C. (1991). Reef pollution in the 1980s. *Search* *22,* 121.

Johns. R.B., Currie, B.R. and Chong, S. (1988). Terrigenous and anthropogenic inputs to a Cairns-Great Barrier Reef sediment transect. Report to the Great Barrier Reef Marine Park Authority, Townsville.

Johnson, D.P. and Carter, R.M. (1988). Sedimentary evidence on the seaward limits of suspended materials from rivers. In: C.L.Baldwin (ed), Workshop on nutrients in the Great Barrier Reef region, 23-26. Workshop Series No. 10, Great Barrier Reef Marine Park Authority, Townsville.

King, B. and Wolanski, E. (1991). Coastal dynamics along a rugged coastline. In: D. Prandle (ed), Dynamics and exchanges in estuaries and the coastal zone. Ch 27, 577-598. Springer-Verlag, New York.

Kinsey, D.W. (1991). Can we resolve the nutrient issue for the reef. *Search* 22(4), 119-121.

Mitchell, A. (1988). River inputs of nutrients. In: C.L.Baldwin (ed), Workshop on nutrients in the Great Barrier Reef region, 16-22. Workshop Series No. 10, Great Barrier Reef Marine Park Authority, Townsville.

Mitchell, A., Rasmussen, C., Blake, S., Congdon, R., Reghenzani, J. Saffigna, P. and Sturmey, H. (1990). Nutrient concentration and fluxes in North Queensland coastal rivers and streams. In: Proceedings of the Workshop on Land Use Patterns and Nutrient Loadings of the Great Barrier Reef Region, 17- 18 November, 1990, Townsville, 108- 161.

Ryle, V.D., Mueller, H.R. and Gentian, P. (1981). Automated analysis of nutrients in tropical seawater. *Australian Institute of Marine Science Oceanographic Series* OS-8 1-2, 24pp.

Van Bennekom, A.J., Berger, G.W., Helder, W. and De Vries, R.T.P. (1978). Nutrient distribution in the Zaire estuary and river plume. *Netherlands Journal of Sea Research* 12, 296-323.

Walker, T.A. (1991). Is the reef really suffering from chronic pollution. *Search* 22(4), 115-l 17.

Walker, T.A. (1991). In defence of scientific caution. *Search* *22,* 178.

Walling, D.E. and Webb, B.W. (1981). Water quality. In: J. Lewin (ed), British Rivers. George, Allen and Unwin, London, pp126-169.

Walling, D.E. and Webb; B.W. (1985). Estimating the discharge of contaminants to coastal waters by rivers: Some cautionary comments. *Marine Pollution Bulletin* **16, 488-492.**

Wolanski, E. and van **Senden,** D. (1983). Mixing of Burdekin River **flood** waters in the Great Barrier Reef. *Australian Journal of Marine and Fresh Water Research* **34, 49-63.**

Table 1: Oceanographic data from Fitzroy River flood plume sampling.

Stn	Depth (m)	Date	Temp.	Sal (ppt)	Chloro. (µg/l)	Phaeo. (µg/l)	Suspend Solids (mg/l)	Secchi Disc (m)
1	0	**17-Jan-91**	26.6	7.9	9.86	0.00	35.65	1.0
	2			**8.0**	6.34	0.00	15.50	
	7		26.4 25.9	**28.5**	0.66	0.00	12.35	
2	0		26.5	**11.1**	2.06	0.26	8.90	0.9
	2			23.0	0.84	0.21	16.75	
	9		26.3 25.9	**33.0**	1.08	0.29	13.60	
3	0		26.4	**34.6**	1.22	0.32	9.20	3.3
	2		26.2	34:o	1.33	0.39	9.80	
	18		26.1	34.0	0.99	0.44	8.95	
4	**0**		26.7	23.9	0.88	0.14	31.40	1.8
	2		25.9	33.5	0.86	0.20	9.65	
	16		26.1	34.0	0.78	0.84	7.10	
5	0		27.2	**8.6**	9.23	0.00	19.30	1.0
	2		26.7	**11.3**	10.42	0.00	11.70	
	13		25.9	32:0	0.50	0.19	13.20	
6	0		26.8	**9.5**	9.74	0.00	7.20	1.3
	2		26.8	**9.5**	13.93	0.25	12.55	
	5		25.8	32:0	0.46	0.13	9.60	
7	0	18-Jan-91	26.3	8.3	7.48	0.00	17.20	0.8
	2		26.3	**8.4**	8.50	0.00	11.85	
	8		25.9	**32.0**	0.55	0.28	10.15	
8	**0**		26.5	**7.0**	7.53	0.00	16.70	0.7
	2	--	--26.3	**16.0**	4.98	0.00	6.55	
	6		26.0	**33.6**	1.38	0.34	9.85	
	11		26.1	34.0	0.84	0.75	15.05	
9	0		28.1	**9.6**	5.56	0.79	7.65	1.1
	2		26.1	**22.0**	4.41	0.41	11.10	
	22		26.2	**34.4**	0.73	0.32	9.40	
10	0		28.7	**8.4**	8.50	0.00	7.00	1.1
	2		26.4	**24.0**	9.74	0.00	11.55	
	24		26.4	34:o	0.70	0.41	8.95	
11	0		28.4	**9.4**	7.67	1.15	15.10	1.0
	2		26.1	**28.0**	9.23	0.00	13.50	
	10		26.3	33:o	0.7 1	0.28	13.60	
12	0		28.5	10.5	14.90	1.33	10.15	1.6
	2		**26.6**	13:3	20:05	**1.07**	**5.70**	
	7		26.3	33.0	3.30	0.62	8.60	
13	**0**		27.7	15.8	15.86	0.77	32.00	2.0
	2		26.6	19.0	16.20	0.71	10.25	
	19		26.3	34.0	0.69	0.39	8.85	
14	0		28.0	18.8	11.56	1.07	11.75	2.2
	2		26.5	21.0	12.74	0.35	8.75	
	22		26.1	33.4	0.70	0.50	8.00	

Key: Temp. = Temperature; Chloro. = Chlorophyll-a; Phaeo. = Phaeophytin.

Table 2: Nutrient data from Fitzroy River flood plume sampling.

Stn	Depth (m)	NH_4	NO_2	NO_3	DON	PN (µM)	PO_4	DOP	PP	Si
1	0	1.71	0.69	2.41	20.63	8.06	1.37	1.98	0.45	152.0
	2	1.40	0.46	1.26	9.81	6.46	1.12	0.52	0.50	108.0
	7	4.06	0.84	1.56	5.92	11.17	1.33	0.00	0.72	38.8
2	0	2.69	0.57	1.26	17.79	6.81	1.20	0.95	0.50	149.0
	2	2.69	0.62	1.74	9.11	3.95	1.09	0.50	0.42	108.0
	9	1.58	0.15	0.53	10.67	3.95	0.42	0.12	0.42	27.2
3	0	0.54	0.02	0.15	6.34	3.58	0.07	0.05	0.22	2.8
	2	0.60	0.03	0.15	6.32	5.88	0.07	0.15	0.20	3.9
	18	0.68	0.02	0.17	2.15	2.00	0.06	0.07	0.16	2.5
4	0	2.13	0.45	1.33	8.62	3.70	1.03	0.19	0.17	71.3
	2	2.02	0.33	1.02	6.60	2.41	0.77	0.00	0.20	57.2
	16	1.11	0.06	0.28	4.26	3.43	0.15	0.10	0.35	4.8
5	0	1.05	0.84	2.19	11.77	5.55	1.21	1.26	0.56	168.0
	2	1.18	0.85	2.22	5.36	3.59	1.34	0.12	0.55	160.0
	13	2.07	0.33	0.63	6.36	6.43	0.41	0.41	0.35	11.9
6	0	0.94	0.70	2.13	1.34	7.72	1.21	0.00	0.42	157.0
	2	0.42	0.62	1.50	14.00	2.23	1.23	0.00	0.61	162.0
	5	2.30	0.58	1.03	5.01	5.91	0.84	0.08	0.20	30.7
7	0	0.76	0.93	2.16	14.62	6.22	1.58	0.69	0.49	174.0
	2	1.30	0.91	2.10	11.64	2.89	1.35	0.43	0.56	158.0
	8	1.77	1.20	1.71	6.92	5.78	0.55	0.21	0.32	24.3
8	0	1.90	0.82	1.61	14.24	3.71	1.44	0.00	0.66	134.0
	2	1.43	0.84	2.19	14.16	3.03	1.15	0.25	0.46	144.0
	6	1.75	0.36	0.88	6.40	3.53	0.40	0.00	0117	26.5
	11	1.41	0.17	0.51	4.95	5.85	0.16	0.13	0.20	6.0
9	0	1.02	1.02	2.18	10.13	4.27	1.29	1.03	0.50	163.0
	2	1.57	0.97	2.18	5.61	1.57	1.20	0.00	0.47	153.0
	22	1.77	0.03	0.25	5.32	5.48	0.10	0.16	0.11	3.5
10	0	0.60	0.82	1.12	10.01	8.12	1.14	0.53	0.68	169.0
	2	0.86	0.72	1.25	13.77	2.02	1.30	1.08	0.57	126.0
	24	3.53	0.06	0.33	1.82	6.33	0.15	0.13	0.15	4.5
11	0	1.55	0.53	0.78	4.56	5.12	0.77	1.12	0.63	81.5
	2	1.97	0.46	0.70	3.17	1.91	0.84	0.94	0.54	66.8
	10	2.27	0.96	1.23	25.19	8.18	0.33	0.21	0.17	18.7
12	0	0.63	0.20	0.02	18.12	8.02	1.02	0.28	0.70	145.0
	2	1.01	0.17	0.02	13.67	2.02	1.13	0.35	0.58	115.0
	7	2.47	0.74	1.07	10.06	10.57	0.47	0.49	0.27	40.2
13	0	0.91	0.16	0.02	11.32	7.38	1.11	0.69	0.85	117.0
	2	3.31	0.21	0.05	10.78	1.21	0.68	1.10	0.73	66.4
	19	1.27	0.04	0.27	6.33	9.85	0.09	0.27	0.12	3.2
14	0	4.02	0.20	0.20	15.13	6.51	0.68	0.32	0.64	65.0
	2		0.09	0.02	12.33	1.65	0.85	0.59	0.64	87.3
	22	1.08 1.35	0.05	0.22	18.64	7.18	0.12	0.40	0.12	3.8

Key: NH_4 = ammonia; NO_2 = nitrite; **NO3** = nitrate; DON = dissolved organic nitrogen: PN = particulate nitrogen; PO_4 = phosphate; DOP = dissolved organic phosphorus; PP = particulate phosphorus; Si = silicate.

Table 3: Surface-averaged data from Whitsunday Islands and Fitzroy River flood plume.

Area	No. **stns.**	**NH_4**	**NO_2**	NO3	DIN	DON (**µM**)	PN	PO4	DOP	PP	Si	Chl **(∝g/l)**
Shallow (O-10 **m)**												
Whitsund. Is.	**1**	0.31	0.02	0.09	0.40		2.30	0.20		0.16	2.2	0.57
Fitzroy, in plume	**6**	1.38	0.60	1.46	3.44	12.84	6.99	1.19	0.84	0.53	143.1	8.62
Deeper (11-25 m)												
Whitsund. IS.	**8**	0.18	0.02	0.20	0.38	4.00	2.09	0.24	0.40	0.10	1.7	1.25
Fitzroy, **Stn** 3, out of plume	**1**	0.54	0.02	0.15	0.71	6.34	3.58	0.07	0.05	0.22	2.8	1.22
Fitzroy, in plume	**7**	1.66	0.62	1.24	3.51	11.60	5.61	1.13	0.57	0.58	126.8	8.45

Key: No. **stns.** = number of stations sampled, NH4 = ammonia, NO2 = nitrite; NO3 = nitrate; DIN = dissolved inorganic nitrogen; DON = dissolved organic nitrogen; PN = particulate nitrogen; PO4 = phosphate; DOP = dissolved organic phosphorus; PP = particulate phosphorus; Si = silicate; Chl = Chlorophyll-a.

Table Fdur

Particulate and Dissolved Inorganic Phosphorus

Station	DIP	PP
1	1.37	0.45
2	1.20	'0.50
4'	1.03	0.17'
5	1.21	0.56
6	1.21	0.42
7	1.58	0.49
8	1.44	0.66
9	1.29	0.50
10	1.14	0.68
11	0.77	0.63
12	1.02	0.70
13	1.11	0.85
14	0.68	0.64

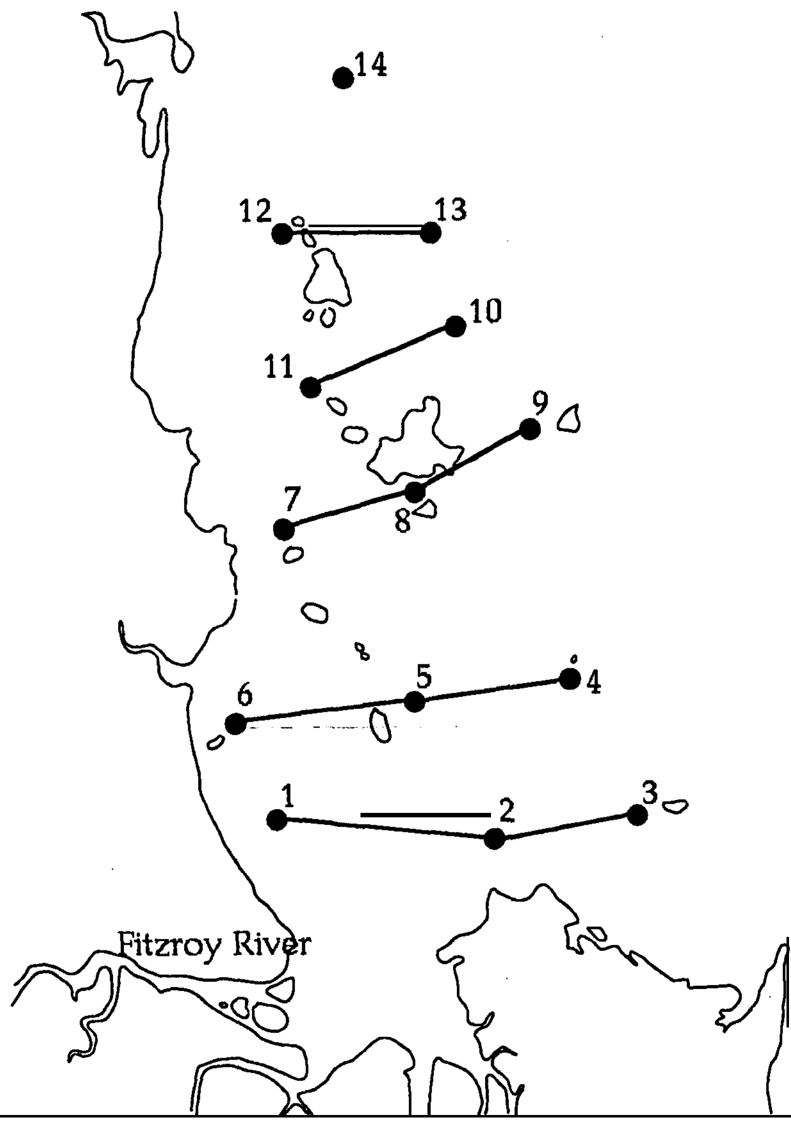


Figure 1: Sampling stations in Fitzroy River plume study.

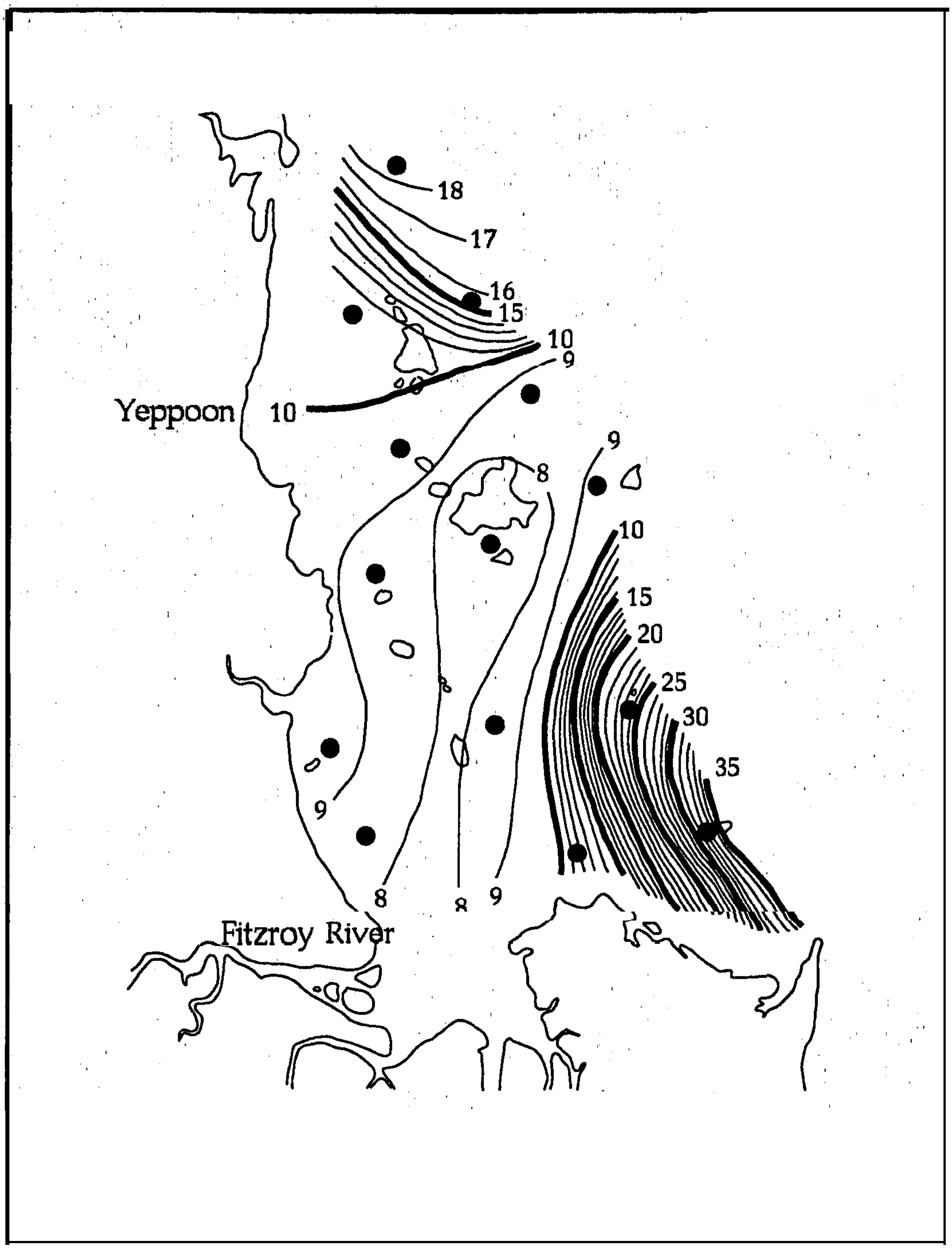


Figure 2: Surface salinity (ppt) in Fitzroy River flood plume.

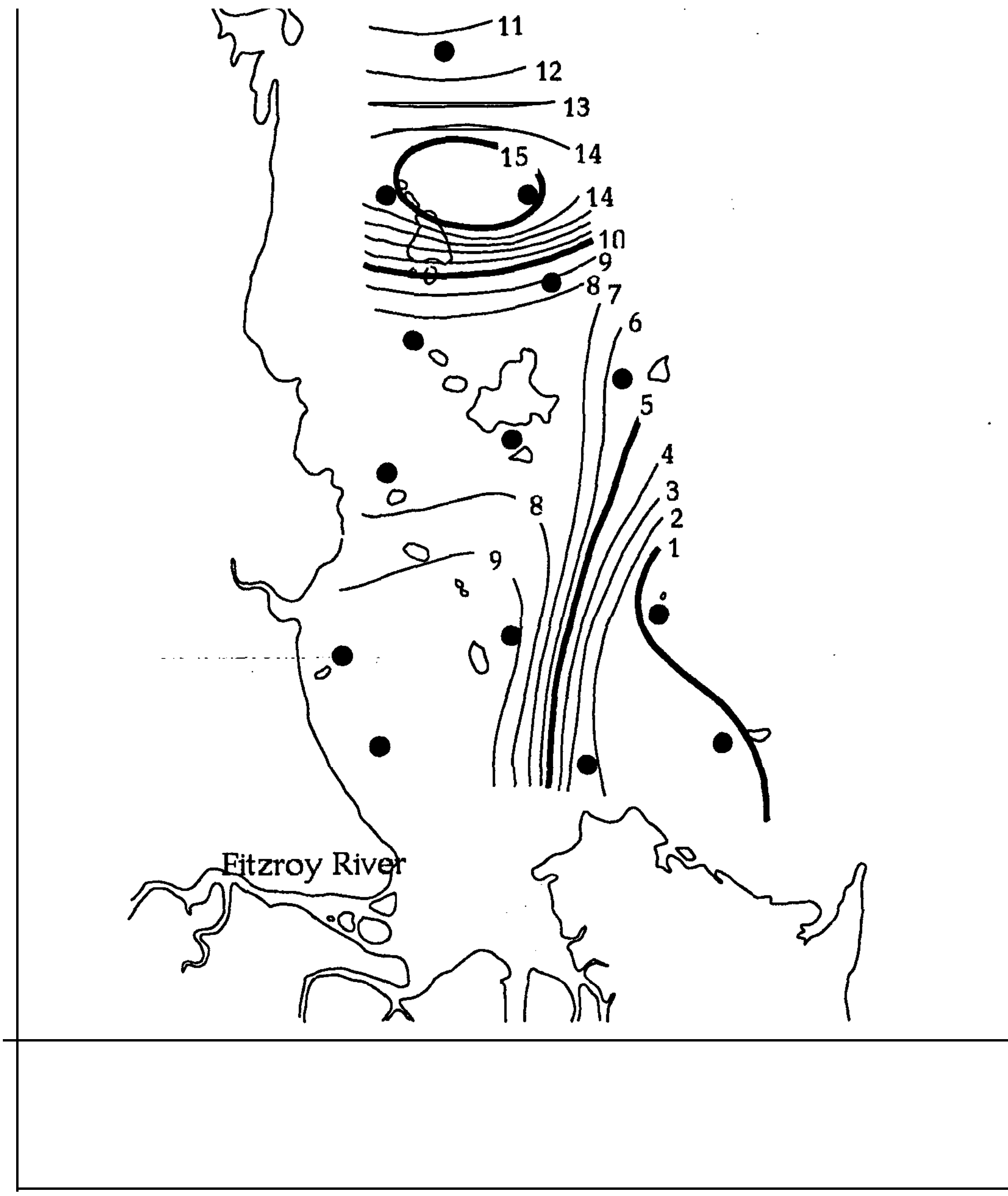
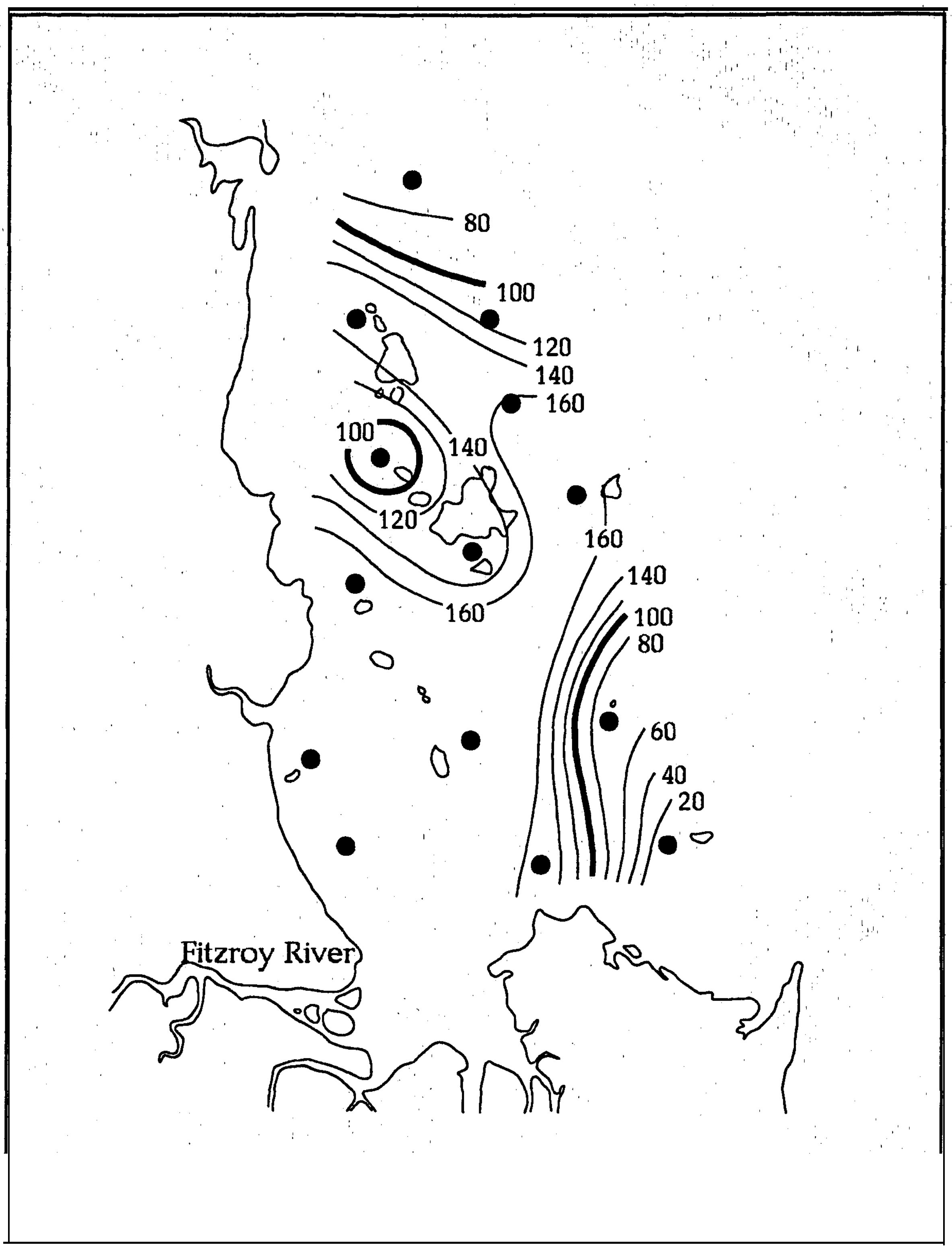


Figure 3: Surface chlorophyll-a (ug/l) in Fitzroy River flood plume.



Fi'gure 4: Surface silicate concentration (uM) in Fitzroy River flood plume.

I' ,

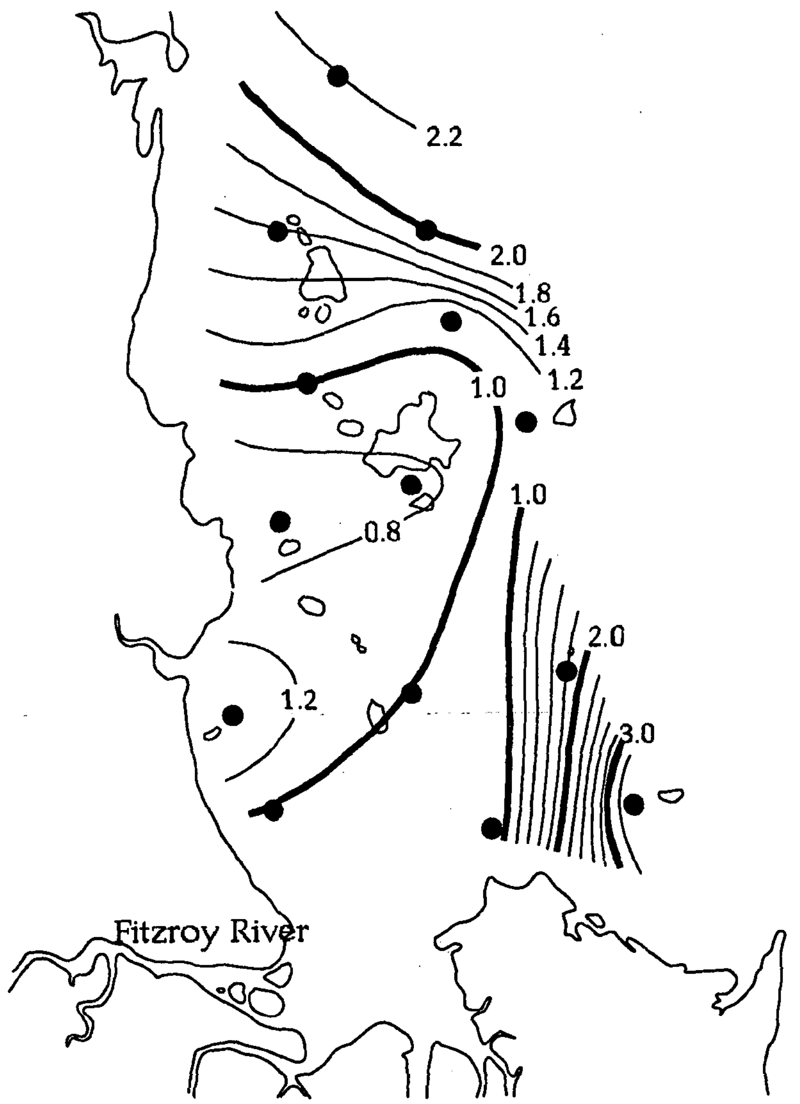


Figure 5: Water clarity, as measured by Secchi disc readings (m) in Fitzroy River flood plume.

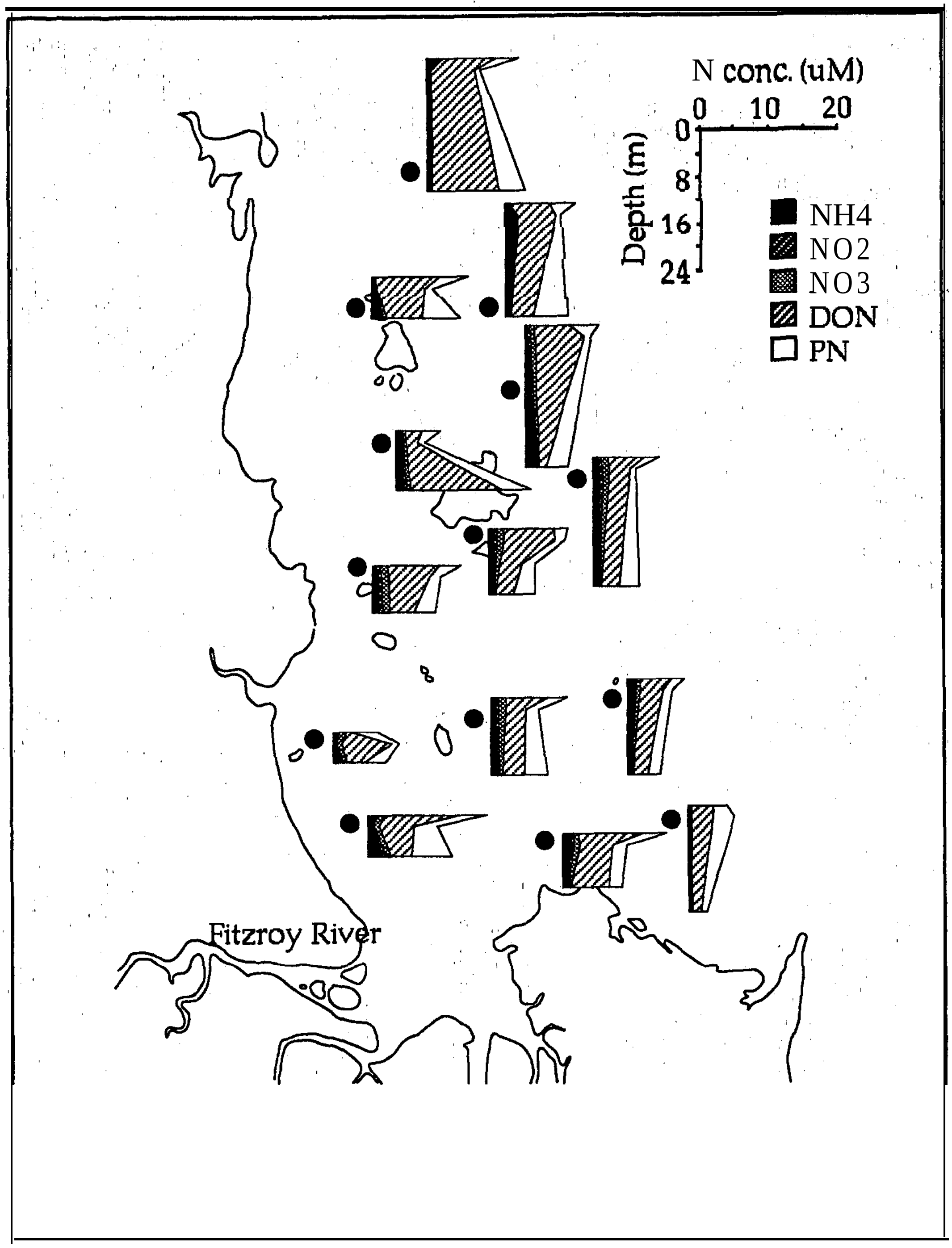


Figure 6: Nitrogen concentrations (uM) as ammonia (NH4), nitrite (NO2), nitrate (NO3), dissolved organic nitrogen (DON) and particulate nitrogen (PN) with depth of sampling (m).

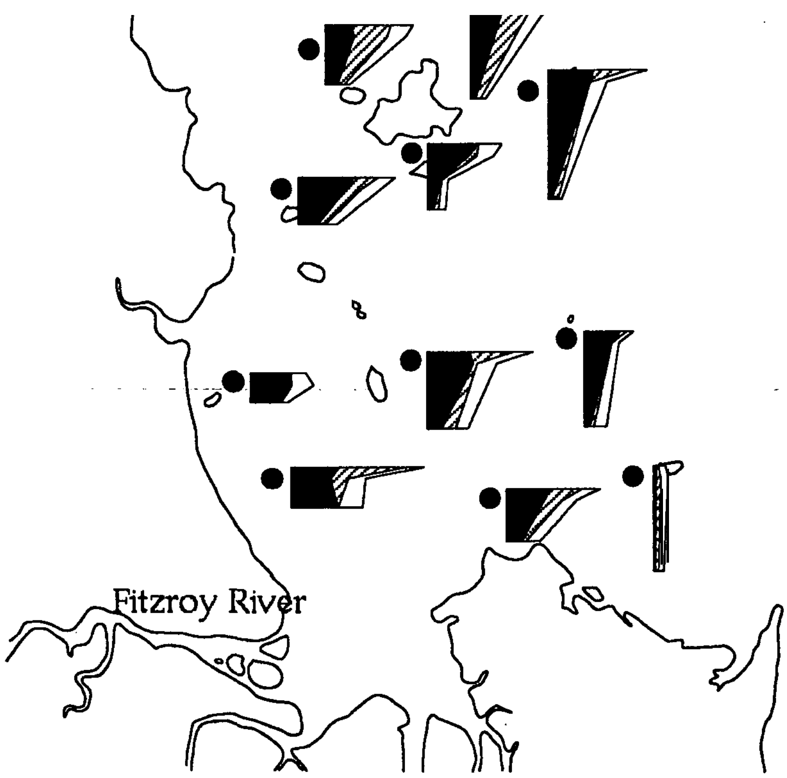


Figure 7: Phosphorus concentrations (uM) as phosphate (PO4), dissolved organic phosphorus (PON) and particulate phosphorus (PP) with depth of sampling (m).

THE EFFECTS OF THE 1991 CENTRAL QUEENSLAND FLOODWATERS AROUND HERON ISLAND, GREAT BARRIER REEF

Myriam Preker
Heron Island Research Station, University of Queensland, Great Barrier Reef, via Gladstone, Queensland, 4680

Twelve oceanographic stations were sampled around Heron, Wistari, Sykes and One Tree Reefs (Capricomia Group - Great Barrier Reef) from January 23-28,199 1, to monitor the effects of the 199 1 Central Queensland floodwaters on the Great Barrier Reef. All water samples were analysed for salinity and for the following, nutrients: NO_2, PO_4, NH_4, NO_2+NO_3, Si and NO_3. The Heron Island Research, Station's long-term water sample data showed that salinities in the Capricorn area remained significantly low until 18 February 1991. Two stations affected by the lowered salinities were surveyed for signs of biota stress.

FLOOD INDUCED CORAL MORTALITY ON FRINGING REEFS IN KEPPEL BAY

Byron, G.T., and O'Neill, J.P.
Queensland National Parks and Wildlife Service
Rockhampton

Abstract

In January of 1991 Tropical Cyclone Joy crossed the coast near Ayr, northern Queensland. The ensuing rainfall caused extensive flooding throughout the Fitzroy catchment in central Queensland. In excess of 18.5 million megalitres of flood runoff escaped down the Fitzroy River into Keppel Bay. This runoff and the associated sediment had a major impact on the fringing reefs surrounding the continental islands within Keppel Bay.

The shallow fringing reefs on the southern and western shores of the major islands were devastated with mortality of 90% common.

The analysis of this coral mortality clearly showed that taxonomic and bathymetric differences created disparate patterns of overall effect. Ecological consequences. following this major environmental perturbation are considered and anthropomorphic exacerbation of the consequences are discussed. Whilst it is expected that the surviving reefal areas will reseed the damaged reefs, thereby providing the basis for recovery of ecosystem integrity, the future management of upstream activities may significantly alter the potential of the system to recover.

Introduction

The Fitzroy basin covers an area of 140,000 square kilometres on the North East coast of Australia. The Nogoa, Comet, Isaac, Connors, Mackenzie and Dawson Rivers are major tributaries draining into the Fitzroy River before it enters the sea 40 km southeast of Rockhampton,.

The climate throughout the basin is distinctly seasonal, with heavy summer rainfall and protracted dry winter spells.

Most of the large volume flood flows in this basin are due to extremely high, short-term rainfall, resulting from monsoonal or cyclonic synoptic activity. Widespread flooding is common throughout the gently undulating terrain and broad floodplains, with the subsequent runoff taking a considerable time to discharge into the Pacific Ocean through the Fitzroy River.

On 26 December 1990, Tropical Cyclone Joy crossed the Queensland coast near Ayr, and produced heavy rainfall and flood runoff in the Isaacs-Connors River sub-catchment (Baddiley, in press). This was supplemented with lesser flows from the Mackenzie, Lower Dawson and Rockhampton areas and caused the third largest flood in the Fitzroy since records began in 1860. In excess of 18.5 million megalitres were discharged from the Fitzroy River in the 25 days from 28 December 1990 to 21 January 1991 (Keane, in press).

The discharge from the Fitzroy River enters Keppel Bay at its southernmost point (refer Figure 1). The flood plume from this event was mapped throughout the Bay during the course of this event arid its movement and physical characteristics have been reported separately by O'Neill, Byron and Wright (in prep).

Keppel Bay contains some 15 continental islands, a number of which have extensive fringing reefs., Three of these islands support tourist resorts, and a fourth, an underwater observatory. Clearly, these developments have been located to take advantage of the adjacent coral reef communities, with water sports providing a major focus for activities offered. It was these coral areas that were most affected by the flooding from the Fitzroy River.

Historic evidence suggests that this recent flood was simply another event in a long series of natural environmental perturbations. However, due to recent changes in the adjacent land use processes, the, severity of impact of such natural events is very likely increasing. The cumulative effects of increasing silt deposition combined with irregular massive freshwater immersion, may be reducing the viability and potential for reestablishment of the coral communities in certain locations throughout Keppel Bay.

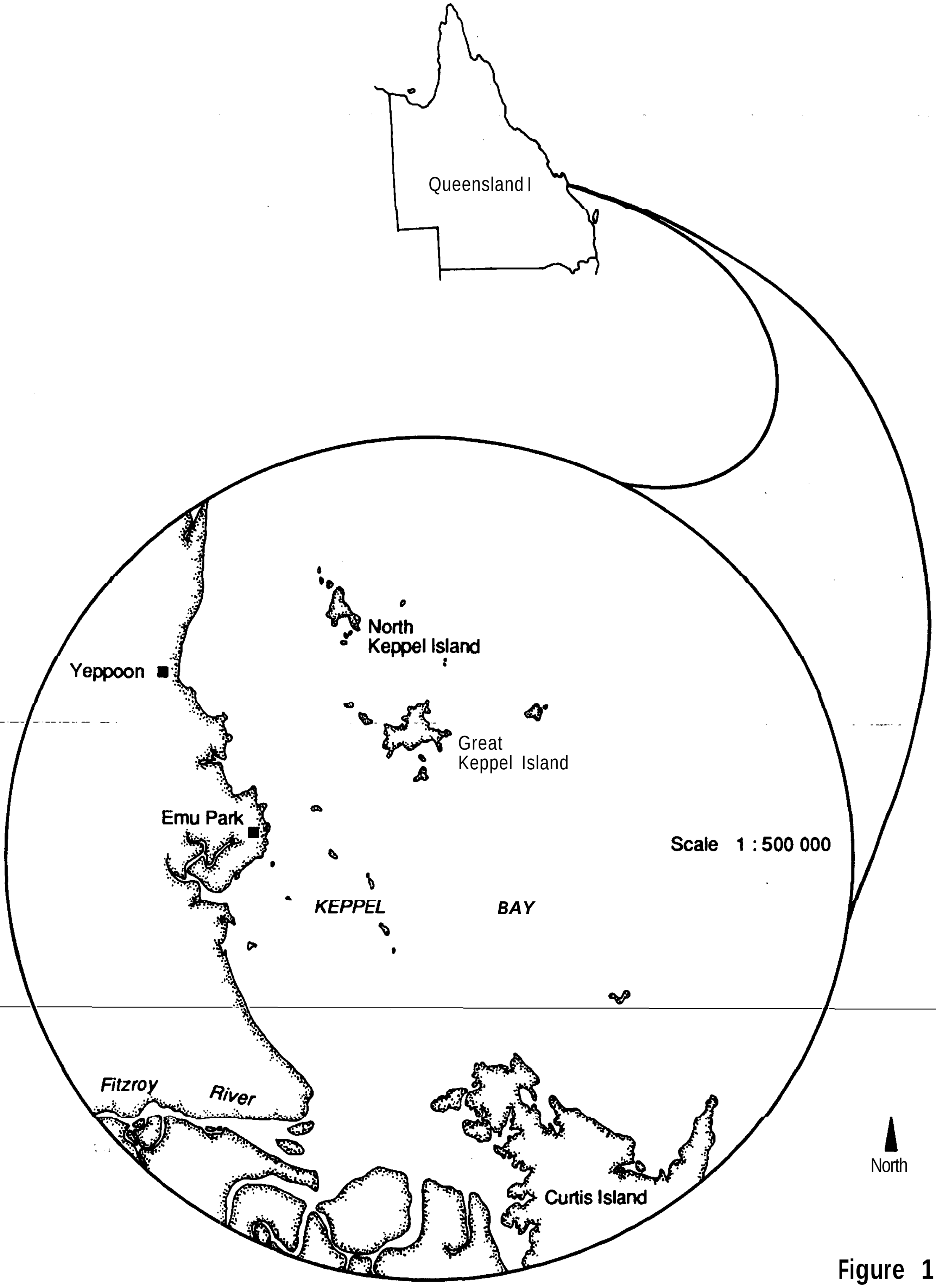


Figure 1

Locality Map of Keppel Bay

Methods'

Areal extent and location of fringing reefs were mapped from AUSLIG 1:15,000 colour aerial stereo photography flown on 7/8/90.

The more extensive coral communities were chosen for analysis of impacts, however smaller communities were also observed for an overall understanding of impacts throughout the bay.

The selected sites (Figures 2,3,4), were observed using standard manta tow techniques described by, Moran, et. al. (1989), with slight modification, as described below, to suit the particular circumstances of 'the syrvey.

Two observers were towed at 2 knots approximately 20 m behind a vessel and were separated by less than 3 m. Pre-determined tow transects were run parallel to the reef edge, with each tow lasting'two minutes.

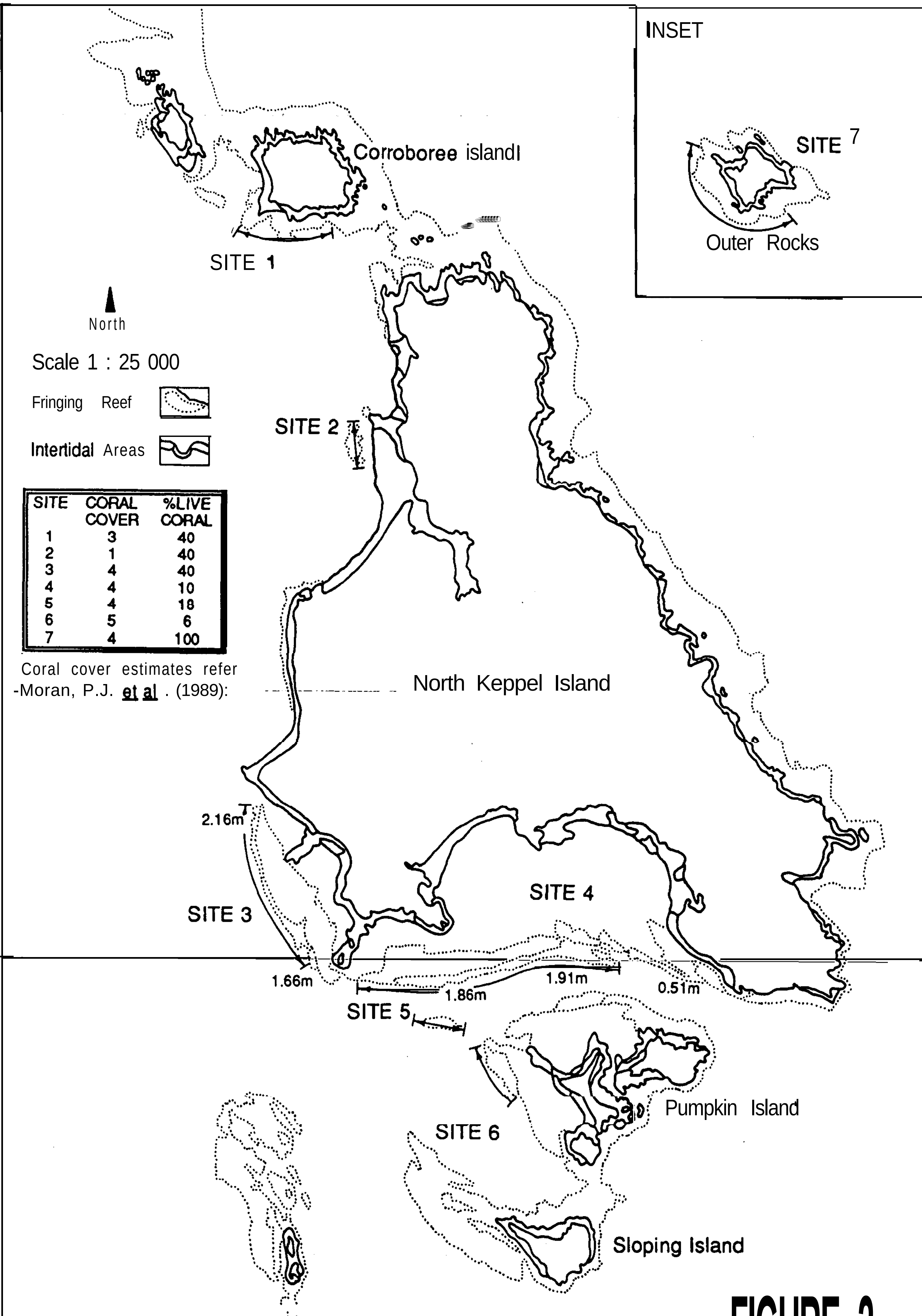
At the commencement of each tow a position fix; using a JRC, JLU-121 Global Positioning System, and, depth,, using a JRC, JFV-86 colour echo sounder, were recorded. At the conclusion of the tow another position fix and depth measurement were recorded. The observers independently'estimate the amount of coral cover and the percentage of that coral that was live and the dominant genera or growth form of coral. After a series of two minute tows, (maximum 12), the observers returned to the. vessel and a third person transposed the data from the manta board recorders to data sheets.

In a number of locations where there were clear bathymetric limits to the mortality, depth measurements were taken from the surface to the interface of live and dead coral.

All depth recordings were later corrected to a standard tidal Low Water Datum (LWD) using standard tidal curves as described in the Queensland Official Tide Tables (1991).

Results

There was significant mortality of corals on fringing reefs in Keppel Bay which was directly attributable to the flooding event generated by Cyclone Joy. Up to 90% mortality was common on the momaffected reefs within the Bay.



SITE	CORAL COVER	%LIVE CORAL
1	3	40
2	1	40
3	4	40
4	4	10
5	4	18
6	5	6
7	4	100

FIGURE 2

Note: Depth shown in **metres** is lowest extent of mass coral mortality below Low Water Datum (LWD).

The most devastated areas were the'shallower fringing reefs on the **southern and western** sides of ***North*** Keppel, Miall, Middle and Great Keppel Islands (Sites **3,4,9,10,13- 19),(refer** Figures **3,4,5).** These areas suffered extensive mortality across the reef flat and down the crest with only the deeper fringes surviving. Sites on the exposed or eastern sides of the same islands (Sites **11,23)** however, exhibited comparatively **little mortality, (<30%).**

The sites in deeper water such as Passage Rocks (Site 7) and the edges of Miall and Middle Islands were largely unaffected, (~30%).

The **coral** communities further **offshore at Outer** Rock (Site 7) and **Barren** Island (Site 8) **showed little,** if any, damage that could be attributed to the flooding event.

Mortality at various sites was limited by depth with an obvious boundary between **live** and **dead** coral *(Acroporu sps.* only).

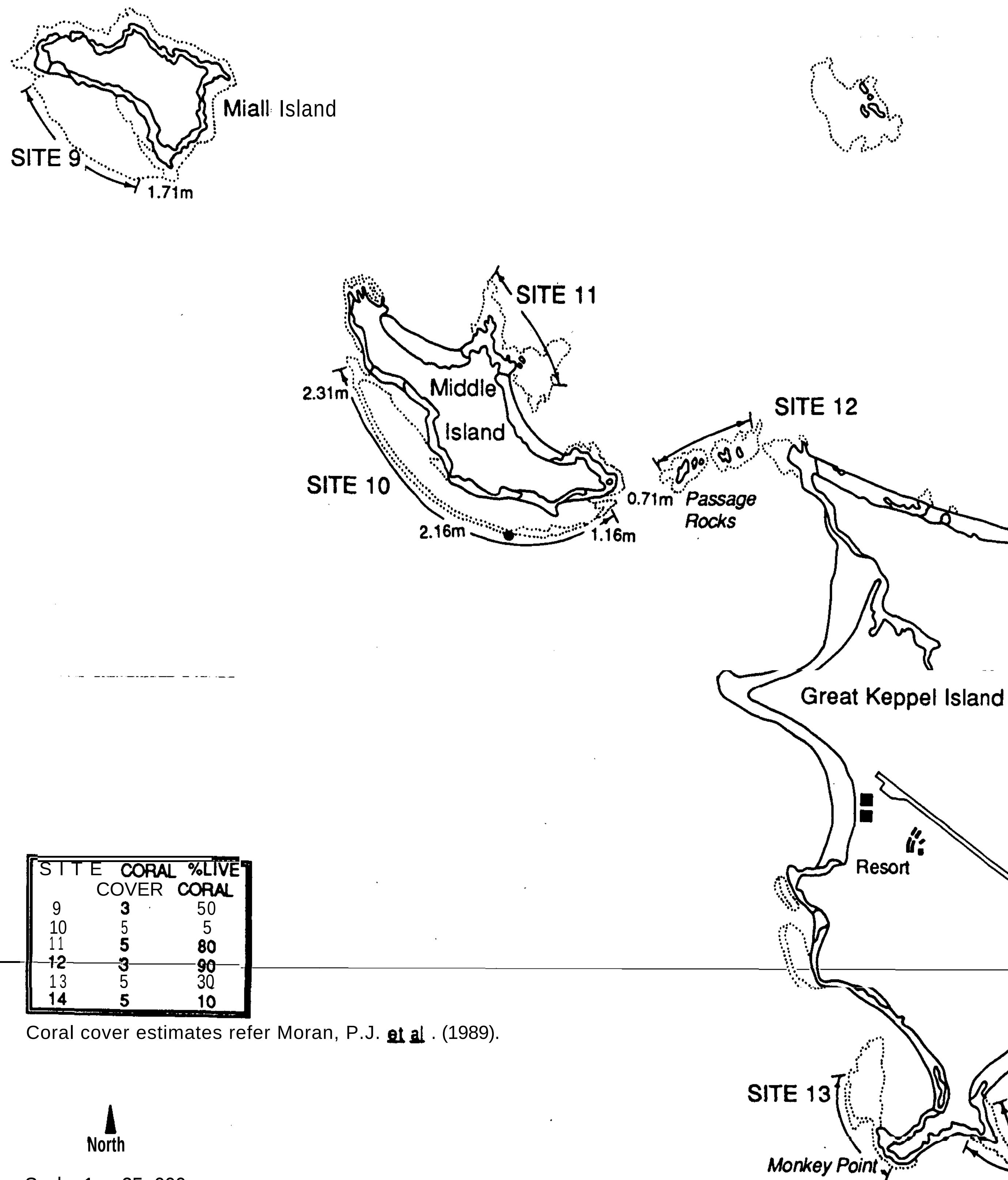
The Middle Island underwater observatory was closed to the public on the 29th of December '1990 due **to** the presence of floodwater and regular aerial reconnaissance through until the 19th of January reported the plume persistence at this site.

All ***Acroporu sps.*** throughout the **leeshore areas** on the major fringing reefs experienced. greater than 80% mortality. 'However, the ***Favia* ,** ***Fungia,*** and ***Porites sps.*** particularly, remained healthy in many areas where ***Acroporu sps.*** succumbed (Sites **13- 18).**

At Miall Island (Site 9) soft corals had also died while at the southern end **of Great** Keppel Island (Sites 14-19) virtually all coral life was affected.

Bleaching ,(ie. loss of **colour),** was evidenced at Monkey Point, Great Keppel Island, Halfway Island and Humpy Island (Sites **14,20,22**) and occurred approximately at the time of flooding. Whilst there was no **specific** monitoring of the affected colonies, it was noted that this bleaching did not last greater, than 5 months. By this time all bleached corals had either died or recovered.

At Monkey Point which is a boulder **reef dominated** by small massive corals, (Site **14),** many colonies were bleached. These colonies were conspicuous by their numbers and represent an uncommon community within Keppel Bay. This community **was** observed over a period of **5** months and it was noted that most of the colonies recovered.



SITE	CORAL COVER	%LIVE CORAL
9	3	50
10	5	5
11	5	80
12	3	90
13	5	30
14	5	10

Coral cover estimates refer Moran, P.J. et al. (1989).

Scale 1 : 25 000

Fringing Reef

Intertidal Areas

Note: Depth shown in metres is lowest extent of mass coral mortality below Low Water Datum (LWD).

FIGURE 3

Discussion

The freshwater flood effects from the Fitzroy River were evident in the majority of reefs throughout Keppel Bay. Of those reefs affected the inshore expansive fringing reef communities on the southern and western sides'of islands were most devastated. These reefs are dominated by large banks of fast growing *Acropora formosa, A.millepora* and *A.micropthalma,* (Van Woesik, 1989).

It was evident that various species of corals were affected in different ways to exposure to the flood plume. At all sites where mortality occurred, *the Acropora sps..* were most severely affected. As expected the coralcommunities further offshore showed little if any damage that could be attributed to the flood, due to the shorter time of exposure to the plume, which was additionally more saline and thinner in profile than at the sites closer inshore (O'Neill, Byron and Wright, in prep).

Anecdotal evidence from previous major flooding events (1954,-83,-88) record a similar pattern of effect on the corals in Keppel Bay (B.Morris, pers.comm.). It was obvious that certain colonies particularly at Great Keppel Island (Sites 17,19) 'have been dead for a considerable time prior to this flood event as they were overgrown with the brown algae *Padina australis.*

It has been established that reef corals in general have a low tolerance to freshwater immersion (Banner, 1968). Indeed the effects of floodwaters from a cyclone on Stone Reef offshore Bowen in 1918 showed total elimination of benthic organisms to a depth of 10 (-3 metres.) feet below mean tide level, (Hedley, 1925).

Flooding is undoubtedly a primary regulator of the pattern of development and succession of fringing reefs within Keppel Bay. These common but irregular pulses of mass mortality determine the spatial and temporal extent of these reefs. Differential recruitment to the affected areas may also result if the sediment loads exceed a level which will support developing recruits. In areas such as Clam Bay, (Site 19), where there are large deposits of fine sediment, resuspension of silt is likely to severely restrict potential reestablishment. Whereas previously this Bay supported large areas of healthy coral, little regrowth has occurred since the previous floods of 1983'and 1988.

Natural perturbations such as this have always affected coral reef development. It is suspected however that anthropomorphic actions such as land clearing would indirectly exacerbate the impacts.

The development of **the** lands of the brigalow belt, ***(Acacia harpophylla),*** for agriculture in the mid 1960's to the early '1970's resulted in the clearing of several million hectares of central Queensland, primarily in the Fitzroy catchment (Webb, 1984). The two major problems of soil erosion and soil salinity that were associated with this extensive clearing remain with us (Johnson, 1985). Large volumes of sediment from **the** brigalow lands are likely to have settled and **will** remain within Keppel Bay. Whilst no overall measurement of the silt load was available for this event, initial estimates made by the Water Resource Commission suggest that **10-20** million tonnes of silt passed down the Fitzroy River during the flood period, (Keane, pers. **comm.).**

Even though the floods have abated, there will be long term ongoing stress of fringing reefs as the waters of the bay are continually muddied by the resuspension of bottom sediment stirred up by winds, tides and currents. Many fringing reefs do grow in highly turbid situations, however increased sediment will affect and inhibit coral growth, (Johnson, 1989). While some coral species **are** better adapted to cope with high sediment conditions than others, all species do have critical limits.

Clearly the ***Acroporu*** sps. don't cope well with such stress but have a shorter regeneration time. The ***Fuvites*** and ***Porites*** sps. on the other hand appear to rely on a strategy of survival of the individual. The critical limits of these later species, if reached, could lead to local extinction with long term recovery times.

The relatively high mortality and dominance of ***Acroporu*** sps. on most affected **reefal** areas suggests high turnover and growth rates of these species, particularly on the reef flats. It has been suggested that generally shallow reefs show less short-term stability and lower predictability than deeper reefs, (Brown and Howard, **1985),** an hypothesis which appears to hold true in this instance.

Bleaching was evident at Monkey Point on Great Keppel Island, Halfway Island and Humpy Island. At Monkey Point where the bleached corals were primarily ***Favites*** and ***Porites*** species, a significant recovery was noted 4-5 months after the event

Bleaching of coral, which is a loss of **colour** caused by either the expulsion of zooxanthellae or by a loss of photosynthetic pigment or a combination of both is the result of an environmental stress on the coral (Brown, 1990). Whilst this bleaching may be initiated by a wide variety of environmental stimuli bleaching events have generally been attributed to elevated seawater temperatures (Gates, 1990) and susceptibility has been correlated with respiration rate (Jokiel and Coles, 1990).

SITE	CORAL COVER	%LIVE CORAL
8	5	90
15	2	20
16	4	30
17	4	10
18	4	10
19	5	30
20	5	50
21	4	40
22	5	50

Coral cover estimates refer Moran, P.J. et al (1989).

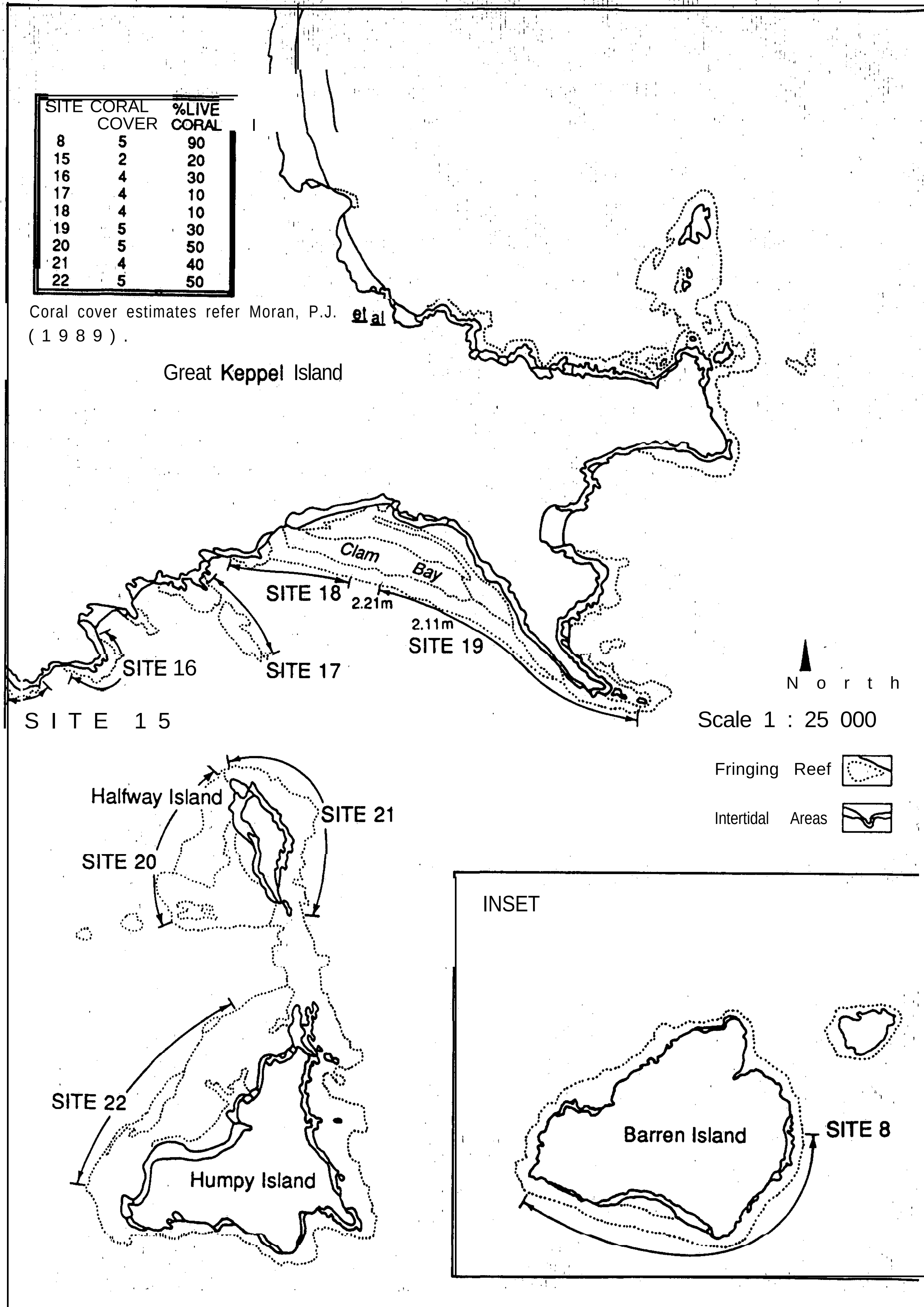


FIGURE 4

Note: Depth shown in **metres** is lowest extent of mass coral mortality below **Low** Water Datum (LWD).

During the El Nino event of **1982/83** widespread bleaching was reported from the Gulf of Panama (Glynn and Croz, **1990),** Indonesia (Brown and **Suharsono,1990),** Hawaii and other Indo-Pacific reefs (Jokiel and Coles, 1990) and the Great Barrier Reef, Australia (Harriott, 1985).

The recovery of colonies from bleaching has been previously reported (Hayes and Bush, 1990). Typically, however, the bleaching events were quick small scale events caused by simple exposure, freshwater immersion, temperature extremes, storm shock, turbidity, sedimentation, parasites or pollutants (Harriott, 1985).

Isolated bleached corals ate commonly observed in the Great Barrier Reef, (Fisk **& Done, 1985),** and we therefore cannot **totally** eliminate the possibility of coincident bleaching caused by some other factor and this flood event. **However,** it seems likely that the bleaching in Keppel Bay following the flood event was due to the cumulative effects of warm summer seawater, low **salinity** levels and excessive and continued sediment deposition. These factors would all have been more intense in the shallow water inshore corals.

The bleaching of ***Favites*** sps. at Monkey Point (Site 14) was still evident up to 4 months after initial recordings. The recovery of these corals following this period was noticeable during the 5th month, with seemingly all colonies recovering fully.

The relationship between depth and mortality was highly variable. As would be expected, there was no consistent correlation between these variables as the floodwater was unevenly and irregularly distributed throughout the bay with varying degrees of persistence. Van Woesik (1991) has reported a critical depth of **-1.3m** Low Water datum **(LWD)** for his eight sample sites at Great Keppel, Miall, Middle, Halfway and Humpy Islands. Whilst generally we agree with **the trends** argued by Van Woesik our data suggests that this critical depth is not consistent throughout the Keppel Bay reefs (refer figures **2,3,4).** Depth of effect varies with site from **-0.51m** LWD at North Keppel Island to -2.3 lm LWD on the southern end of Middle Island reef. This difference would appear to be consistent with plume persistence and thickness as the areas which suffered to the greater depths experienced prolonged periods of floodwater inundation. Previous reports of freshwater impacts, (Hedley, **1925),** and bleaching, (Fisk **&** Done, 1985) on corals in the Great Barrier Reef have **referred** to a critical depth.

The boundary of effect exhibited in thisinstance would suggest that the freshwater overlaying the seawater throughout the bay remained essentially as a separate body of water, with minimal mixing with the saltwater lens underneath. This is consistent with observations of the physical nature and movement of the freshwater plume during January 1991, (O'Neill, Byron & Wright, in prep), where it is reported that the freshwater travelled intact, out through the Capricorn Bunker group of Islands, prior to dispersing.

The analysis of coral mortality clearly showed that taxonomic and bathymetric differences created disparate patterns of overall effect. The ecological, and hence management consequences of this major environmental perturbation are therefore difficult to generalise. Site effects are highly variable but largely result from a combination of depth, location and community type.

Clearly managers and developers alike need to consider these dramatic environmental changes when planning for the future use of areas. Whilst considerable effort is expended on a regular basis monitoring and managing anthropomorphic impacts and change throughout the Great Barrier Reef Marine Park, little. effort is expended on the natural changes occuring in our resources. Quite often; as 'managers we have limited understanding of the extent of natural changes in our resources and we are unable to manage or plan for major environmental events such as floods or cyclones. When such events do occur we take a reactive role of measuring the impacts and managing the consequences.

Acknowledgementi

The authors would like to acknowledge the assistance and support of the Queensland National Parks and Wildlife Service staff and management and the Great Barrier Reef Marine Park Authority, in particular our skipper Brian Morris for his cooperation, skill and extensive local knowledge, Steve Wright for his data analysis skills and willingness to help and Sharon Chambers, Dave Marshall, John Messersmith and, Peter Kirkby for their assistance in the field.

References

Baddiley, P. (1992) Fitzroy River basin rainfalls and the 1991 flood event. Bureau of Meteorology, Brisbane.in: Workshop on the Impacts of Flooding, ed:G.T.Byron,GBRMPA Townsville. pp 3-15

Brown, B.E. (1990), Preface: Special issue - Coral bleaching Coral Reefs 8: 153.

Brown B.E. and Howard L.S. (1985), Assessing the effects of 'stress' on Reef Corals,

Blaxter, J.H.S., Russell, F.S. and Yonge, M. (1985) Advances in Marine Biology Volume 22, Academic Press, London.

Done, T. (pers. comm) Australian Institute of Marine Science.

Fisk D.A. and Done T.J. (1985), Taxonomic and Bathymetric Patterns of Bleaching in Corals, Myrmidon Reef (Queensland). Proc 5th Int. Coral Reef Cong. Tahiti Volume 6 149-154.

Gates R.D. (1990), Seawater temperature and sub-lethal coral bleaching in Jamaica. Coral Reefs 8: 193-197.

Harriott V.J. (1985), Mortality rates of scleractinian corals before and during a mass bleaching event. Mar. Ecol. Prog. Ser. Vol 21 8 l-88.

Hayes R.L. and Bush P.G. (1990), Microscopic observations of recovery in the reef building scleractinian coral, Montastrea annularis after bleaching on a Cayman reef. Coral Reefs 8:203 - 209.

Hedley C. (1925), The natural destruction of a coral reef, transactions of the Royal Geographical Society in Report of Great Barrier Reef Committee 1:35-40. Canberra.

Johnson D. (1989), Inner Shelf Fringing Reefs, Reeflections, April 1989. GBRMPA, Townsville.

Johnson, R.W. (1985) The impact of agricultural development on the vegetation of the Brigalow lands of Queensland, in. Gasteen,J., Henry,D. and Page, S. (eds.) Agriculture and conservation in Inland Queensland. Wild. Pres. Soc.Qld., Brisbane pp 10-12.

Jokiel P.L. and Coles S.L. (1990) Response of Hawaiian and other Indo-Pacific reef corals to elevated temperature. Coral Reefs 8:155 - 162.

Keane, M.' (1992) Assesment of the 1991 Fitzroy River Flood. How Much Water? Water Resources Commission, Rockhampton.in: Workshop on the Impacts of Flooding, ed:G.T.Byron,GBRMPA Townsville. pp 16-35

Moran P.J. et al (1989), A Guide to the, Aims Manta Tow Technique, Australian Institute of Marine Science, Townsville.

O'Neill J.P., Byron G.T. and Wright S., (1992) Physical characteristics and movement of the 1991 Fitzroy River flood plume.in: Workshop on-the Impacts of Flooding, ed:G.T.Byron,GBRMPA Townsville. pp 36-52

Oliver J. (1985), Recurrent seasonal bleaching and mortality of corals on the Great Barrier Reef. Proc 5th Int Coral Reef Cong Vol. 4.

Van Woesik, R. (1990) An assessment of the coral reef communities of the Keppel Isles, report to the Great Barrier Reef Marine Park Authority, Towrisville.

Van Woesik, R. (1991) Impact of the 1991 floods on coral communities of the Keppel Islands, report to Great Barrier Reef Marine Park Authority, Townsville.

Webb, A.A. (1984) Consequences of agricultural land use in the Brigalow belt. in.The Brigalow Belt of' Australia, ed. Bailey, A. The Royal Soc of Qld Symp. Oct 82 (Bris) pp. 131-147

EFFECTS OF LOW SALINITY ON THE TISSUES OF HARD CORALS ACROPORA SPP. POCILLOPORA SP AND SERIATOPRA SP FROM THE GREAT KEPPEL REGION

J.S. Glazebrook and R. Van Woesik
Faculty of Aquatic Science, Deakin University, Warnambool
Sir George Fisher **Centre** for Tropical Marine Studies, James Cook University, Townsville

The shallow coral reefs on the leeward edge of the Keppel islands were substantially damaged by the flood waters. Approximately 85% of the coral was dead and overgrown by turf algae two weeks after the flood event. Absolute mortality continued to **-1.3m** (Low Water Datum), below this demarcation a narrow band of bleached coral was evident.. In contrast to the leeward sides, the reefs to windward have only narrow reef flats and were only marginally affected (5%). Mortality was most extensive for acroporids and pocillliporids. Survival in shallow habitats was apparent for faviids ***(Leptastrea, Cyphastrea, Goniastrea, Favites and Favia*** species). Ironically, the species most vulnerable to low salinities ***(Acropora)*** dominate the reef assemblages - a consequence of regional circumstances.

Ten coral fragments were collected from sites considered to be marginally affected by the fresh water plume from the Fitzroy River viz. Clam Bay and **Barron** Island.

The microscopic appearance of **the** soft tissues examined suggested an acute toxic syndrome. Histopathological changes included hypertrophy, hyperplasia and lysis of the epidermis as well as degenerative changes in the gastrodermis which sometimes extended to necrosis. Bacterial emboli were present in the sub-epidermis.

Surface salinities as low as 8 ppt were recorded in the region.

EFFECTS OF THE JANUARY 1991 FITZROY FLOOD ON, INTERTIDAL INVERTEBRATE COMMUNITIES OF 'KEPPEL BAY

M. Coates
Department of Biology, University of Central Queensland

Seasonal flooding of coastal streams and/or the Fitzroy River, may cause significant, but short.lived dilutions of the surface water of Keppel Bay. For example, during April 1989 the salinity of coastal water remained at 18 to 20 ppk for three days (normal seawater salinity in these areas is between 35 and 36 ppk). During March/April, 1990 salinities between 14.4 and 24.5 ppk were recorded for seven days. Monitoring of intertidal communities revealed no significant mortality during these episodes. However, very heavy flooding of the Fitzroy during January, 1991 reduced salinities to between 5 to 14 ppk for 13 days, and again during February to 18 to 22 ppk for a further 11 days.

These last dilution events caused heavy mortality of barnacles, oysters and gastropods along the Capricorn Coast. Previous surveys had provided good baseline data for these coastal sites.

Mortality on offshore islands of Keppel Bay appeared less severe. Unfortunately, good baseline data exist only for Pleasant Island, which is relatively distant from the mouth of the Fitzroy, where some changes in species abundances and distributions were recorded.

Long term ecological studies are underway to study the recovery of these areas after this natural catastrophe. A major question here is will the communities in these areas return to their original makeup and if so how long will the process take.

FISHERIES AND FLOODS

G. Byron
Queensland National Parks and Wildlife Service
Rockhampton

Floods have both a positive and negative effect on commercial and recreational fisheries.

The Fitzroy River floods of recent years have shown a marked difference in relative impact on the fisheries of Keppel Bay. For the three month period following both the 1988 and 1991 floods catches by commercial fishermen of the Rockhampton region were approximately 30% lower for estuarine species of fish (ie. barramundi, bream, mullet, tailor, whiting, etc.) than for the similar period in non-flood years. The period of effect appears to lapse after three months, with catches returning to 'normal'. A large percentage of this reduced catch is likely to be caused by the inaccessibility of the resource during the actual flooding.

The commercial prawn and scallop landings, however did not exhibit a consistent pattern between these flood events. Following the 1988 flood event catches of prawns, crabs and scallops were reduced by up to 35% on other years. In the three months following the 1991 Fitzroy River flood the landings of prawns and scallops showed little change from other years, whilst returns of crabs rose slightly. During the 2-3 weeks of peak flows the waters were largely inaccessible, and it therefore appears that there was a catch increase of approximately 30% during the period when fishing activity took place.

Anecdotal evidence from local fishermen suggests that the variation between post flood catch levels was related to the amount of debris associated with the flood.

During and immediately after the 1988 flood large amounts of both floating and submerged debris was reported in Keppel Bay, including extensive masses of water hyacinth *(Eichhomiu crassipes)*. Whilst it was generally reported that there were large populations of prawns and scallops within Keppel Bay, they were largely unavailable to fishermen due to the excessive net fouling caused by this debris.

Conversely, the relatively small amounts of flood debris encountered after the 1991 flood allowed an increased harvest.

The species composition of the prawn catch, also reportedly changes following flood events. Whilst available data does not break down commercial prawn landings into species, discussions with fishermen revealed that coral prawns comprised a large component of the post flood catch. Thisspecies is rarely taken in any quantity at other times within the Bay.

The increasein prawn and scallop populations following floods may be due to the boost of available fodder these detrital food chains receive.,

Recreational. fishermen throughout Keppel Bay reported that following the flood a number of reef fish. which are normally uncommon in the Bay (eg: *Scarus sps., Choerodon venustus*) were turning up regularly in catches.

One of the more positive aspects of the flood for fisheries was that several recordings of fish movements, either around or over manmade streamflow barriers were recorded.

A number: of barramundi: tagged' by Capricorn Tag and Release Club members below the Fitzroy River barrage were recaptured up to 200km (by river) above the barrage at the junction of the Dawson and Mackenzie' Rivers.

It is considered that in thisinstance the fish had travelledaroundkhe barrage across the Yeppen Lagoon as the-velocity of the mainstream of the river was greater than the burst swimming speed recorded for this species.

Similarly Irecorded a rise in species-compositionand abundance above the weir in Water Park Creek, Corio Bay immediately following flooding events of 'this year.

1

EROSION OBSERVATIONS AND LAND MANAGEMENT RECOMMENDATIONS FOR THE FLOODPLAINS FOLLOWING CYCLONE JOY FLOODS IN JANUARY 1991.

D.G.Chapman
Land Conservation Branch
Queensland Department of Primary Industries, Rockhampton.

Introduction

Flood rains occurred in the Fitzroy River catchment between 26 December and 7 January 1991. They resulted from Cyclone Joy that appeared off Cairns in early December and was blocked by a high pressure system off the Queensland coast.

Rainfall varied from 250mm inland, 870mm at Rockhampton and up to 25OOmm in the upper Connors River catchment area. Local rainfall in the vicinity of Rockhampton between 26 and 3 1 December totalled 600mm causing local flooding and saturated conditions. Further flood peaks moving down the river system caused an extended peak over 11 days at heights of 9.1 • 9.3 metres.

The extent of the flooding caused severe erosion and sedimentation in the river system. Cropping lands on the floodplain were stripped to the depth of ploughing. Improved pastures perished on the floodplain due to inundation over 10 days. Upland grazing country eroded due to the lack of ground cover.

Queensland Department of Primary Industries officers instigated a survey to determine the nature, extent and effects of the floods on the agricultural and pastoral lands subjected to flooding.

An aerial survey of the river system was undertaken by officers from the Land Conservation Branch on 24 January. Further ground inspections were conducted over the next 4 months.

EXTENT OF FLOODING

The area inundated was extrapolated from satellite imagery of the 1988 flood.

Satellite imagery revealed that 4000 km2 was inundated from the river mouth to the Connors • Isaac River junction.

The flood peak at Rockhampton **reached 9.3** metres making it the third biggest flood this century., Landholders adjacent to Rockhampton reported record' flood levels and our observations confirmed **that** peak levels would have exceeded the second highest flood that occurred in 1954.

The factors leading to that high peak on agricultural land were:

- high intensity rainfall in the catchment between 26 and 31 December, and;
- 'changes to floodplain hydraulics involving clearing, provision of roads, railways and other structures.

Floodplains **were** inundatedup to 10 days and erosive flow **velocities** in the order of 2.4 metres a **second,** resulted in severe erosion.

EFFECTS OF FLOODING

Floodplain cultivation. Areas cultivated were stripped of topsoil to the depth of ploughing. Paddocks stripped to a depth of **100mm** representing a soil loss of 1300 tonnes per hectare. However, **in** most situations stripping was accompanied by deposition. Paddock workability was severely affected due to wet deposition areas, new flood channels and wire from damaged fences. Worst **areas** affected **were** those under wheat stubble. Stubble was completely removed by erosive flows and piled up **against** fences causing diversion of flow and **severe** damage. Farming plants and irrigation layouts suffered damage.

Floodplain grazing lands. The loss of sown pastures was extensive, due to long inundation. Most notable species to suffer were rhodes grass, buffel and silk sorghum. There was a germination of urochlda that replaced a lot of the grasses, and the spread of parthenium infestations in flooded areas was evident. **Ponded** pasture species, **para** grass and hymenachne survived well.

Pondage banks incurred damage due to overtopping. These banks also caused the diversion of flows onto neighbouring properties with increased **velocities.** 'Flow in parallel flow flood channels caused scouring. A newly blade ploughcd area in the river junction area suffered severe scouring.

River. bank. The nature of the flood contributed to riverbank slumping. Saturated soils were undermined and soil loss occurred. The highvelocity flood removed protective vegetation' on the bank with resultant erosion. Where vegetation such as **para** grass survived a degree of protection was achieved. The most spectacular erosion **occurred at** Pirates Point toward the river mouth. A new channel

150 metres wide and 7 metres deep was created when 430 000 tonnes of alluvial soil was removed. It also represents the loss of 200 hectares from one property as an island was created.

CONCLUSION

Due to the complexity of the problems involved, a coordinated approach by landholders and advisers is required. Landholders in the junction area of the Mackenzie River and Isaac River have initiated co-ordinated action to alleviate flood damage. Advisers from the Water Resources Commission, Queensland Forest Services, Agricultural and **Land** Conservation Branches of the Queensland Department of Primary Industries, have presented recommendations to the landholders. Basically, a land management plan of the floodplain is required that co-ordinates land use activities across the floodplain. Integrated measures such as tree strips across property boundaries need to be planned to minimise the affects on neighbouring landholders.

Regular cash cropping on the floodplain is risky and not advisable. Soil loss is too great to warrant continual cropping and a permanent vegetative cover needs to he established. Forage cropping using permanent flood tolerant species is recommended. With the availability of irrigation water, shallow ponding systems may be a viable option. The use of forage tree and grass pasture systems can be considered on the higher alluvial country not subjected to the larger flood peaks. These can be either dryland-systems or irrigated systems.

Where clearing has occurred too close to major watercourses, regrowth of trees and grasses should be encouraged. The use of buffer strips of trees and scrubs across the floodplain to reduce erosive velocities should be considered in any plan.

Forage systems that cannot be utilised by cattle due to flood risk may augment feeding in a complementary lot feeding situation on higher ground or in the production of hay and silage to sell in drought times.

The aim of any land use on the floodplain should be to retain a permanent protective vegetative ground cover to minimise erosion.

LAND INFORMATION - A VITAL RESOURCE BEFORE, DURING AND AFTER FLOODS

G.S.Knight
Queensland Department of Lands
Rockhampton

The Queensland Department of Lands holds, or has access to, a wealth of information that could, be used to combat the effects of floods. A brief description of the mote generally available products appears below.

*AERIAL PHOTOGRAPHY

Aerial photography has been captured for a number of previous flood events:-

1978,
1983
1988
1991

The photography is of various flying heights and coverages, concentrating generally on the city area. Key diagrams are held at the Land Service Centre, Rockhampton. The quality of the Aerial Photography is subject to the meteorological conditions at the time. The optimum time for capture is obviously at the peak height of the flood, but, if at that time, there is a high percentage of cloud cover or a high degree of air turbulence, that may not be possible.

In January 1991, a contract for flying was let at short notice. The photography capture was co-ordinated by the Department of Lands and costs were shared by a number of organisations. Due to weather, conditions, flying was done approximately 1 day after the peak of the flood at Rockhampton.

The photographs were used to put together a mosaic of the floods. During the January 1991 floods, the Department also made the 1988 flood photography held in Rockhampton available for loan to various organisations such as the State Emergency Service and the Department of Transport.

*MAPPING

The Department of Lands does not have any flood mapping for the Fitzroy River/Rockhampton area.

The best scale Topographic mapping presently available is at 1: 100 000 with a 20 **metre** contour interval. The Department is looking to improve that situation with mapping at a scale of **1:25** 000 on program for the Rockhampton area. This will exclude flood-prone **areas** where it is felt that a larger scale and better contour interval will be necessary.

As the State Mapping Authority, the Department of Lands wishes to have at least some input into the future mapping which is undertaken. While not necessarily doing the actual work (the major part most likely to be issued **to** consultants) the Department has certain requirements and specifications regarding formats, accuracies and datum, and has a long experience in the co-ordination of large mapping projects. It also offers cost sham mapping schemes with Local Authorities and other State Government Departments.

There are a number of map types which could be produced. The Orthophoto map, produced from scale rectified aerial photographs is a quick and less expensive method of producing coverage for a selected area. Orthophotos can be overlaid with contours and/or cadastral (legal boundary) information and nomenclature. Topographic line maps depicting contour or spot heights and physical features can also be produced. This information would be captured in digital form allowing its use on computers and Geographic Information Systems. Digital Elevation Models giving a 3-Dimensional view of a particular area can be produced from this information.

Basically, any mapping work performed should aim to satisfy the requirements of all organisations with an interest in the flooding of the Fitzroy River. Mapping is an expensive exercise and therefore a co-ordinated approach is recommended.

*DIGITAL CADASTRAL DATA BASE

The Department of Lands is the supplier of the Digital Cadastral Data Base (DCDB) which is a **computerised** record of legal boundaries and property descriptions. (See attached example of a plot of the **DCDB** - Appendix 1). Many government and local authorities presently use the **DCDB** for their mapping purposes.

The DCDB can be used as a base layer in a Geographic Information System with other information overlaid to it. For example, if flood coverage information in the fon of **computerised** lines could be overlaid to the DCDB, a Geographic Information **System** could quite simply produce a list of all the properties affected.

This could be in the form of 'Lot on Plan description. Presently the **DCDB** 'is available. Flood information would have to be captured.

*VALUATIONS DATA BASE

The Department of **Lands administers** the Valuations Database. (See appendix 2) The main purpose of this database is to keep track of Queensland's land valuations but it also contains a lot of other useful information. It can supply the name and address of the owner of each parcel of land and searches can be **performed** for all properties in a particular **street.**

'An indication' of Whether a parcel is flood **affected** or not is included for valuation purposes only and does not purport to give the **degree** in which it was affected. A yes in this field can mean that a few centimetres of water covered a corner of the land or it could mean total inundation.

The **Valuations** database was used during the 1991 flood to develop a list of owners of properties adjoining the Fitzroy River to enable Department of Primary Industries to estimated stock losses.

The Valuations Database is available to the general public through the Centre for Information Technology **(CITEC)** Public Access System.

The Department of Lands is continuing to develop the State's land information systems with proactive; and contributory roles in the acquisition of geographic data such as aerial photography and topographic mapping. Requests for further information or proposals in this area should be directed to

The Regional Director or the Regional **Operations** Manager
Titling and Information, Department of Lands,
Rockhampton Q 4700.
Tel 319 580.

ROCKHAMPTON FLOOD MANAGEMENT

John McCabe
President
Capricorn Conservation Council Inc

Introduction

This submission raises a number of issues relating to floods in Rockhampton and the management of the Fitzroy River floodplain areas which might not be forthcoming from contributors who have a concern for specific local problems.

The submission covers a number of points including:

- The desirability of some form of self management of flood problems by affected landholders/residents.
- The need to manage floodplain areas for a number of land uses both during floods and in non-flood periods.
- The natural environment values of floodplain areas and the manner in which these values could be affected if certain management ideas were implemented.
- The problems of transport corridors in floodplains.

PUBLIC PERCEPTIONS OF FLOOD PROBLEMS

It is reasonably apparent that the Rockhampton and district community has a relatively high ability to cope with problems of flooding in the Fitzroy River and associated streams. This is due to a number of factors including the time delay before major flooding occurs, and the length of occupancy and experience of residents in localities which have been periodically affected by flooding.

During large floods, while many services am affected; the major centres of administration and flood servicing (local authority services, police, communications etc) remain unaffected. This situation contrasts with Charleville for example, where total flood inundation occurred. It would be a useful exercise to detail loss of flood service centres around Rockhampton as flood height rose to the 1918

evel, and higher. The adoption of council restrictions on buildings in flood areas after the 1954 floods has also been significant in, minimising problems which may have occurred with population growth. A probable maximum flood for Rockhampton should also be calculated. This might involve heavy local rain in the twenty-four hour period before a major flood peak reached the city.

While them is an often expressed sentiment in the community that flooding is a natural hazard to be dealt with as it occurs there are also widely held views that floods can be contained and that water should not be allowed to flow to the sea to be 'wasted'. Local non-expert views on flood problems are important sources of information but there is a need also to educate the public on the dynamic processes and natural history of floodplains. If this education process does not take place the flood management actions funded by government are often not appreciated by the affected community particularly where the recommended action is no-action in terms of major expenditure.

'Consultations, displays of maps and photos, and educational trips can all assist in developing public understanding (Attachment 1).

PROFILE OF THE LOWER FITZROY FLOODPLAIN

The Mackenzie and Dawson Rivers which join to form the Fitzroy River are for much of their length low gradient streams which meander across relatively wide floodplains with occasional constrictions by local geological features. The upper Fitzroy is a stream with similar characteristics with floodplains varying from a few hundred metres to 2 kilometres or more in width. Below The Gap the Fitzroy occupies a generally wider floodplain with meanders being a strong feature downstream from Yaamba and in the tidal section downstream from Rockhampton. In flood the river from The Gap to the mouth at Cattle Point is 120 kilometres although the distance is much further at normal levels.,

The width of flood flow downstream from Yaamba is relatively wide and becomes generally wider towards the mouth of the river. Below Rockhampton the floodplain widens rapidly to a maximum width of over 20 kilometres at the mouth as defined by a line between Cattle Point and the tidal edges to the Rundle Range.

THE WESTERN FLOODWAY

The most constricted part of the floodplain is across the transect formed by the hills at Fairy Bower through the high ground of South Rockhampton to North Rockhampton. Here the river proper is about 500 metres wide in flood while the floodplain west of the city is about four and a half kilometres. wide. It is clear that some importance should be attached to management of the total 'width of the floodplain.

Man-made constriction of the floodplain has occurred with the barrage, the abutments to road bridges in the city and the raised road/rail crossings south of the city. In addition there has been minor filling of floodplain areas at many locations around the city beginning many years ago with the filling in of Jardine Lagoon and other shallow water wetlands.

The 500m wide main river channel passing through Rockhampton is both deep and fast-flowing. Assuming an average depth of 12m in the most constricted part of the the main channel, and a water speed of $30kmh^{-1}$, $180000m^3$ will pass any given point in an hour. Assuming an average depth of 2.5m across the western floodway and a minimum width of 4500m together with an estimated flow rate of $10kmh^{-1}$, at least $120000m^3$ will pass a set point in an hour. Clearly the value of the western floodway as a flood by-pass facility must not be underestimated, particularly as this will have greater significance as the height of floods increases.

It is strongly recommended that the flood relief effect contributed by the western floodway be assessed and management strategies devised which allow this system to be maintained or improved. Further study of the impact of road/rail embankments, and proposed airport levee banks and runway extensions are essential.

Consideration should be given to acquisition of strategic lands in the western floodway or permanent non-development covenants or zonings to ensure long term opportunity for minimising restrictions to flood flow. Continued removal of nonessential features restricting flood flow (such as the old North Coast Railway line south from Port Curtis should also be considered.

With respect to the new road/rail embankments the cost/benefit of establishing greater length of piered bridging should be evaluated. Construction and alignment of bridging to facilitate most efficient current flows at high flood should be a consideration. While it may be that a greater length of clear bridging will do little to affect maximum flood heights the possibility of reducing the period of closure of rail and highway access should also be considered.

LOCALISED INTERFERENCE TO FLOODPLAIN

While the community and local authorities have since 1954 generally had a reasonable appreciation of the need to manage floodplains for the possibility of future flooding there are also indications that floodplain areas are regarded as sites for the disposal of waste material, and for reclamation to flood free sites with higher land values. Over the past 35 years at least 4 major municipal garbage tips have been located on the floodplain (Lion Creek, Moore's Creek, Yeppen Lagoon, and Lakes Creek Road). In addition there is constant legal and illegal disposal of mainly waste material from building sites in flood areas sometimes with a specific future objective such as establishment of a tourist information centre, but often as a random decision by council staff or private businesses or landholders.

There has also been the approved filling of floodplain areas for commercial developments such as QRX, Hastings Deering and other sites at Port Curtis. The filled sites are generally designed to a flood free height or for shallow inundation by floodwaters in a managed situation.

All of the above situations, in conjunction with road embankments, airport levees etc cause some alteration to flood patterns. While the loss of floodplain to filling is probably not significant in constricting overall flow there is evidence that it may be having unwanted effects at some locations through changes to current flow direction and speed. This is particularly evident at sites such as the, Lakes Creek Municipal tip which at the height of the 1991 flood was in a relatively fast flow area while sections of the river channel in that vicinity had minimal or even reverse flow.

In the nine months since the flood the raised flood free section of the Lakes Creek tip has been expanded to many times the size it was in January and as this level is above the height of adjacent road, rail and residential areas, the redirection of current flows should be evaluated. It is not difficult to visualise that, this tip may have a significant influence on flow if it continues to expand at current rates.

I am not advocating a total cessation of developments within the floodplain, but it is suggested that where filling works of significant sites such as the commercial developments at Port Curtis takes place the developing agency be required to plan for sufficient flood by-pass facility which will not increase heights or current speeds in adjoining properties.

It is to be expected that problems with constriction of flood flow will manifest initially as localised runoff in urban creek systems such as Moore's Creek, and Frenchman's Creek. The Kershaw Botanic 'Gardens, constructed on the old Moore's Creek tip, are designed to flood and must provide a relief valve for local runoff. Upstream of the bridge over Musgrave Street however, there is a progressive filling in, with building site waste, of floodplain areas which had previously been gravel mined.

This continuing constriction of an urbanising catchment may cause unexpected flash flooding of residential properties on the opposite bank of Moore's Creek Further constriction of the flood channel should cease.

Similar situations,occur to a lesser extent with other urban creek systems, in North Rockhampton. It is noted, for example that a frequent site for dumping of unused ready-mix concrete is on creek embankments. Old car bodies are also used in some creek sites and along the Fitzroy River downstream from Gavial Creek The perception that waterways and floodplain areas are sites for disposal of unwanted material does not assist the process of developing sound management procedures.

NATURE CONSERVATION VALUES OF FITZROY FLOODPLAIN

The lower Fitzroy River floodplain contains one of the largest aggregation of natural wetland systems in Queensland. These wetland systems have been created mainly by the meandering of the river forming cut off oxbow lake systems and by the deposition of sediments creating large shallow lagoons. While these natural wetlands are in a generally degraded state (Attachment 2), they remain one of the most significant sites for waterbird aggregation in Queensland.

The river floodplain also has features of biogeographical significance. The presence of coolibah (*Eucalyptus coolibah*) at the eastern most extremity of its wide distribution across Australia is one indication of this significance. The river and associated creeks surrounding Rockhampton also support populations of the restricted Black Iron-box (*Eucalyptus ruveretiunu).*

Flood mitigation works undertaken as a result of this study could result in either further degradation of the natural systems or they could be designed to restore and/or complement them. Flood mitigation works such as those undertaken on urban streams in Brisbane have generally reduced the diversity of the associated natural environment of fringing vegetation, stream bed profiles, and aquatic life. 1

On the other hand, construction of a road embankment or excavation of a flood channel can create a usually temporary water feature which harbours a diversity of wildlife. There is considerable scope around the wide Fitzroy River floodplain to ensure that the latter effect is achieved.

There are constraints however particularly with respect to the Rockhampton airport. Aviation authorities would not generally favour works which increase the presence of large waterbirds in airport surrounds. A further constraint is the possibility that flood mitigation works designed to enhance aquatic life forms may add to the mosquito breeding problem.

There is evidence however that the density of successful mosquito breeding is greatest in temporary pools and drains away from permanent water systems in which there is a reservoir of aquatic life forms (fish, frogs and predatory insects) which can rapidly expand into sites of high mosquito larval density.

The abundance of prickly mimosa (*Acacia niloticu)* and rubber *vine (Cryptostegiu grandiflora) in* Fitzroy floodplain areas has a significant effect on the natural vegetation dynamics. Prickly mimosa has a large water distributed seed and a habit of forming thickets of such density that there could be a measurable impeding, of floodwater **flow when** compared **with the** relatively, open, formation in grassy **coolibah woodland.** Rubber vine also forms dense thickets which can impede waterflow **although the greatest** threat posed **by this** weed species is the possibility, through uncontrolled growth, of suppressing and killing natural tree growth. Improper control measures **such as** the **use of** hot **fires, and** application of herbicides such as **Velpar** and Graslan, **is causing loss** of **stream bank fringing trees along the** Fitzroy River and tributaries.

Similar arguments can also be developed! also: for the management **of** 'other weed: species such. as water hyacinth **and with** respect to the aquatic **pasture** species,, **para** grass. Both thesespecies were reduced as a result of **recent flooding, para grass being most** affected insituations where' **drought and overgrazing preceded inundation for** two **to three** weeks under floodwaters.

The Port Curtis: Junction Lagoonchanged following, flooding, from. **a complete carpet of water** hyacinth to, a water lily covered system- supporting, a. great diversity of **bird** species. During the lower level' flood of '1988 the water hyacinth in this lagoon was pushed back up drainage systems in-the **railway yards from** where it rapidly **recolonised** the lagoon as water receded. In general **the** 199 1. floods have been highly beneficial for wildlife species triggering a massive breeding of fiih and **other organisms as** well as the bird species, which **thrive on aquatic** plants and, animals.

'**Edge** effect' is probably the most important feature of natural waterbodies which, **where** a spacepermits, can be replicated in a constructed flood channel: system. **Slope** profiles from 3% to: about 20% are ideal for creating wide and **moveable** shallow water zones which, **are** the key to productivity in freshwater lagoon systems.. The adjacent deeper water adds diversity and a drought refuge for aquatic organisms, **and** waterbirds..

Given the concern that the fish ladder on the Fitzroy River Barrage **is** ineffective-and may never, **be made** to function correctly there is also an interest in the role of the **western** floodway as a route for. upstream migrating **barramundi (*Lates calcarifer*) and** other **fish** species **which** move: from tidal to. **fresh waters.**

It is obvious from the above that **there are** potentialmultiple use values to **be gained from sound** environmental floodplains; **Where flood** channel. and.by-pass constructions are under consideration:; for Fitzroy floodplain areas, values other than flood mitigation should' be ignored:.

BARRAGE. IMPOUNDMENT' MANAGEMENT

Concernhas **been** expressed at **the rate of erosion** of **the outside** curve **of** 'the meander **bend of** the Fitzroy

River at the Six Mile which is close to the point at which the river **first** breaks its bank to form the western floodway.

Examination of 1956 aerial photography suggests that the rate of erosion is not as severe as expected although there is no doubt that future problems with the Ridgelands Road and various services could occur. There **are** techniques available to reduce the rate of erosion particularly by reducing the speed of current flow at the toe of the high bank and the Capricorn Conservation Council has advised the Fitzroy Shire Council of these techniques when the matter was raised in previous floods.

There is a case for tighter management of the Barrage impoundment area, particularly with **respect** to adjacent land uses, management of **bankside** vegetation, stock grazing, and recreational usage.

There is also a concern that current sand removal operations at the Six Mile (Pink Lily Sands) are posing a future threat to bank stability in a process similar to that which caused bank slumping along the **urban** reaches of the Brisbane River.

On the other hand a steady **removal** of sand from the Six Mile area may assist in flood **flow** and in minimising siltation caused by the damming effect of the Barrage. An environmental assessment of the effect of dredging at the Six Mile is needed so that better standards and conditions can be set with respect to this operahon.

THE SCRUBBY CREEK DEVIATION

The impact of the high level road/rail crossing on flood levels at Fairy Bower and the washout of the sill and channel on the Scrubby Creek deviation are issues on which many points of view will have to be considered.

Examination of early air photography suggests that the Scrubby Creek system has tended to change direction at various times once it enters the floodplain zone because of minimal slopes and insufficient force of water to maintain a channel through scouring processes. The current course of the creek via the deviation through the Yeppen lagoon system may be a restoration to a natural flow which was previously in place within the last two hundred years.

Them is no doubt however that the early construction of the rail line to Gracemere as well as the road has had some impact in forcing the creek channel to divert The current flow through Yeppen Lagoon has had a beneficial environmental effect by maintaining water quality and increasing waterbird habitat and the growth of sedges up the channel from the lagoon proper.

Nevertheless, a number of potential disadvantages have arisen:

- The possibility of flash flooding to the Port Curtis residential and industrial area.
- Interference with the grazing rights of at least one property owner both by excessive 'widening of channel' and by creation 'of wet sedgelands of greater size and increased period of inundation.

A further consideration with respect to this deviation is the possible impact of discharged cooling tower waters from Stanwell Power Station. On current evidence these waters, originally drawn from the Fitzroy River may, even after concentration of salts in the cooling tower operation, may actually improve the quality of low level water flow in the Neerkol Creek/Scrubby Creek system. However there remains the possibility that a combination of water usage and discharge coupled with poor land care management may increase the problems of salt scalding which is currently evidenced by the death of tree species in a shallow basin area south of the Capricorn Highway.

With respect to local flooding threats to the Port Curtis area the refilling of material beneath the Yeppen road and rail bridges should be evaluated and consideration given to widening the channel system, down to and past Hastings Deering. It may be desirable to acquire land and/or gazette easements to facilitate such works..

DEPOT HILL AND PORT CURTIS FLOOD MANAGEMENT

These suburbs are the most severely affected in terms of isolation of the greatest number of urban residents. There have been suggestions that, while the long term residents have always had the capability of managing flood problems without a great deal of public assistance, the recent flood resulted in outside aid coming in to such an extent that the value of self-help actions was reduced. To this is added the further confusion of recreational sightseers, and unsupervised helpers causing problems.

While outside help should not be withheld there is an argument that, self help programs would be facilitated if certain services were managed from within the affected communities. For example, one or two Council or Emergency Services owned flood boats could be located within the flooded communities before arrival of a flood and these craft would be operated by trained resident volunteers. This form of self management would allow police and emergency service volunteers to be assigned more to the area of crowd control and external servicing. It would also mean that rescue equipment is located in the flooded community at night and is ready to operate at daybreak.

I understand there is some consideration of planning protection for areas such as Port Curtis and Depot

Hill through the construction of levee banks. It is important that design for such banks take into account the environmental arguments raised above and that such constructions do not cause problems by impeding runoff from intense local rainfall events. It is suggested that if a levee system is constructed around Depot Hill the excavation of material be carried out so as to extend the existing Port Curtis Lagoon as a main watefflow channel towards Gavial Creek. The design of this system should be such as to ensure that a functional natural water-body is present during non flood periods. Removal of the embankment of the old North Coast Rail Line (currently used for wagon storage) and bridging under the new line to ease flood build up in Lower Dawson Road should be considered as part of this design.

It is suggested that the continued filling of the Lakes Creek Road tip and any proposal to construct levees for the protection of the racecourse and other sporting facilities on the opposite side of the river to Depot Hill would be sufficient to cause current flow problems elsewhere.

TOXIC WASTE MANAGEMENT ON FLOODPLAINS

A number of incidents occurred during and after the 1991 flood which suggests that better control of material stored or dumped on floodplains should occur.

A quantity of 200 litre drums of a mineral processing liquid Sodium xanthate were lost in the floodwaters and it is understood that about 16 drums were recovered. Capricorn Conservation Council has evidence that about 60 drums were purchased at a disposal sale at the Mt Morgan Mine. It is not known whether all drums were full or empty or whether the entire quantity was stored at Port Curtis at the time of the flood. The property from which these drums were lost is now believed to have storage facilities for waste oil and the problems associated with further flooding are obvious.

Due to the rapidity of flood rises there was also problems with loss of municipal garbage which had not been sealed under compacted earth in sufficient time.

The old municipal tips also contain known and unknown quantities of toxic waste material which would have been inundated during the flood. For example there is a known quantity of cyanide stored in the old Moores Creek dump.

Inspection after flooding of the compacted wall of the Yeppen Lagoon dump (which closed about 10 years ago) revealed a fissure from which was emanating clear water and a deposit of sludgy, presumably organic material. Unfortunately, an attempt to collect a sample from this discharge the next day was precluded by overnight rain which again inundated the fissure. No water flow was in evidence following the subsequent drop in water levels and it is presumed the wall has resealed. This incident however, 'suggests that it is inappropriate to construct dumps on floodplain even when utilising compacted retaining walls.

Other potentially major sources of contamination during flooding include the railway yards, dumps and workshops which are saturated with diesel and other materials and the petroleum storage facilities.

TRANSPORT CORRIDORS

The closure of the Bruce Highway, Capricorn Highway and North Coast Railway line for a considerable period 'during flooding is an imposition on both the Rockhampton community and on other parts of the state particularly north Queensland. The conflict between high level solid floodplain crossings and restriction of flood waters has been mentioned above in several places and will no doubt result in detailed submissions from affected areas.

Proposals to be considered in assessing transport options in a flood situation include:

- The expected remaining life'span of the Alexander Railway Bridge and a large number of timber bridges between Rockhampton and Glen Geddes.

  (This raises a number of options for rail routes through or around Rockhampton.)

- The possibility that the preferred rail option may be to by-pass Rockhampton and construct a flood free line from Gracemete passing west of the floodplain to Ridgelands and crossing the Fitzroy River upstream of Yaamba to rejoin the existing rail line at Canoona This construction could also involve a secondary high level road access.

- The possibility of construction of a flood free road from Gracemere to Glenroy Crossing and, on to Marlborough. This would involve a high-level bridge over Glenroy Crossing.

- The Transport Department's consideration of a new high level highway crossing of Alligator Creek (near railway line) and the impact this may have on floodwater entry to the Hedlow Creek basin and escape of local runoff from this system.

- The proposal for a tourist road which can also serve as a flood free road from Yeppoon to north of Yaamba presumably passing over or skirting around the wetlands associated with Hedlow Creek and upper Alligator Creek.

- The probability that none of the above options will be satisfactory given funding constraints.

It is stressed that when options for transport corridors are considered there be an analysis of environmental considerations and public participation be sought in the initial planning.

---

[1] Neller, R.J. and Amy, A.H. 'Bedform Recovery Following Channelisation of Kedron Brook,' (1983) 18th Conference Inst. Aust. Geographers Melbourne.

Attachment 1

Social Activity

Bus trip to the Fitzroy floodplains - 1 July

About forty members and friends of U3A were hosted by Peter Warren (retired City Council Flood Mitigation Planner) and John McCabe (President of the Conservation Council) on a field outing of the wet lands around Rockhampton. We met at the Town Hall where John and Peter explained to us (with the use of visual aids) the reasons behind the flooding of the Fitzroy River and the resultant changes in the flora and fauna and effects on future flood planning. This was to set the mood for our outing.

We enthusiastically boarded our bus and drove a short distance to Quay Street which John explained was built on the natural levee or depositional zone of 'me river and therefore higher in places than the floodplain country which lies beyond the town. A small amount of riverine vegetation still surviving included the Forest Red Gum, Coolibah (with hardened bark) and weeping paper-barked tea trees and the Leichhardt trees. Prickly mimosa, one of the major weed species of floodplains was evident as we moved along Wharf Street, where, at the height of the recent flood, the main rush of water left the river channel and flowed overland across the southern bank to rejoin the river channel at Nerimbera. Silt deposits at low tide are evident.

Our bus drove us along Derby Street and over to Allenstown Shopping Centre where the gentle rise and falls in topography are indicative of old levee crests and drainage lines away from the river where the growth of the coolibah is restricted. It was difficult for us to imagine this was once a drainage area now that it is all 'built up by suburbia'.

Reaching the Yeppen Lagoon we all alighted from our bus to watch the waterbirds nesting in trees, the black cormorant (in the area since 1988), magpie geese, brolga and many other species. John said this deep narrow lagoon is indicative of old river channels of the river or one of it's side, streams. He explained that wide shallow lagoons like Gracemere and Murray are on the edge of flood plains and usually formed by a build-up of flood material over a time.

We all piled back on to our bus and drove over on the Gracemere Road to visit Bessie Sue Lagoon; (Incidentally, it's locally known that 'Bessie Sue' was a partchinese lady who once lived over in that area in a small hut where she raised many children). It is now a deep lagoon similar in appearance to the Yeppen filled with reeds, sedges and introduced species of pasture grass. The tuberous reeds found there are prime foods for magpie geese and brolga and waterfowl use these shallow swampy areas after flooding before retreating to the drought refuges of the main lagoons. We all watched the spoonbills, egrets etc feeding.

At the Six Mile John showed us the breakthrough point for the western floodwaters which effectively isolates South Rockhampton as an island. Driving towards **Alton** Downs the growth of coolibahs is in evidence again (floodplain) and these are replaced by other varieties of **eucalypt** as we gradually rise above the floodplain.

We stopped for lunch at a place known as Long Island on the bank of a billabong which contained blue waterlilies as well as a **pinky-white** lotus lily variety called ***Nelumbo nucifera*** which John said was the same species as the sacred lotus of SE Asia. After lunch we ambled over to another billabong and noted the red gums and paper-barked tea **trees** which line the waterway to the coolibahs growing in the heavy black cracking clay soil. Some of the massive trunks on the larger coolibahs represented ages of some **250-300** years. Parts of Long Island has ram riverine rainforest species particularly dominated by the cluster fig **(*Ficus racemosa*).**

Finally, our bus tour field trip ended by a quick trip to the Laurel Bank which is a well known part of the river noted for its wide deep channel. Once again, she oaks, melaleucas and eucalyptus trees line the bank leaving the coolibahs **set** well back

Attachment 2

Extract from:
THE CENTRAL QUEENSLAND STUDY

A COMPENDIUM OF KEY NATURAL AREAS IN CENTRAL QUEENSLAND AND THEIR CURRENT CONSERVATION STATUS

FIRST EDITION JUNE 1987
EDITED BY BRUCE CUMMINGS
QUEENSLAND CONSERVATION COUNCIL
CAPRICORN CONSERVATION COUNCIL

6.401 Rockhampton Wetlands

The Rockhampton wetlands are a widespread group of permanent and intermittent waterbodies spread across the wide alluvial valleys of the Fitzroy River system.

The Fitzroy, Queensland's second largest river in its final 130km takes a wide loop to the south before terminating in the 440 square kilometre tidal estuarine system of Keppel Bay and The Narrows. To the north the wide, shallow Broadsound remains as evidence of the former river mouth, now separated by the uplift of a low mountain range south of Marlborough.

The meanders of the river, in its mature phase has left a system of lagoons and small water courses across the floodplain which comprises one of the most significant wetland aggregations in Queensland.

The floodplain area, dotted with permanent and intermittent water bodies, arcs around the City of Rockhampton. Some lagoons (eg. Woolwash, Frogmore, Yeppen and Crescent) are long, deep, and narrow remnants of old stream channels. Others are wide and shallow, and some such as the Murray 'Lagoon fringing the Rockhampton Botanic Gardens, have had low levees constructed to improve waterholding capacity. It is the shallow lagoons and temporary waterbodies, which appear after storms and during wet seasons, which produce a massive growth of organisms on which most bird species feed.

Another aggregation of wetlands occurs about 30km north of Rockhampton in the South Yaamba area. There is a considerable movement of birdlife between these waterbodies, and the stretches of the Fitzroy River backed up by the barrage at Rockhampton.

The Alligator Creek catchment which extends to within 10km of the coast north of Rockhampton, is another part of the Fitzroy wetlands. Green Lake and Lake Mary are among the significant waterbodies

set here in an unusual landscape of stark volcanic plugs.

Downstream from Rockhampton, particularly at Broadmeadows and along the southern fringes of the river, extensive freshwater bodies lie behind the mangroves of tidally inundated **areas.**

Landuse

The Rockhampton wetlands are not a pristine natural land system, undisturbed by man's activities. By many criteria they can be considered to be badly degraded.

The Archer Brothers, the regions **first** European settlers set the pattern in 1855 when they moved their stock into the grassy woodlands surrounding the shallow lagoon they named Gracemere. Others quickly followed and today the rich alluvial soils of the lower Fitzroy support the largest concentration of beef cattle in Australia.

Clearing of the natural forest, regular burning and the impact of stock on the native grasslands and water edges began a process of land degradation that is still continuing today. The introduction of exotic plants, as pasture grasses and woody weeds such as ***Acacia nilotica*** (prickly mimosa) provided a further impact.

Despite these impacts, the wetlands still carry impressive flocks of waterbirds. The magpie geese which at one stage had **virtually** disappeared are again building up numbers. The beautiful white pygmy goose is found here in large numbers, favouring the deeper more permanent lily covered lagoons. Other species of waterbirds, including egrets, herons, jabiru, ducks, and shore birds such as snipe and plovers also occur in large populations.

The remnant forest of ***Eucalyptus microtheca*** (Coolibah) and ***E. tereticomis*** (forest red gum) surrounding **the lagoons provide brooding hollows for both water dwelling and forest birds. In some areas** monsoonal type rainforest fringe the river and associated wetlands with ***Ficus racemosa*** (cluster fig) being particularly evident, however Rubber Vine **(*Cryptostegia grandiflora*)** is overtaking some areas.

Tenure and Management

Most of the Rockhampton wetlands cover land under freehold tenure. One area at Long Island on a bend in the river is an Environmental Park. Some sections of wetlands are within Camping and Water Reserves, usually with grazing rights to an adjacent landholder. The Rockhampton City Council has title to some wetland areas adjacent 'to urban areas, but are not involved in the conservation **management of** these areas, which are usually under grazing pressure.

Many artificial habitats have been created by the construction of bund walls to retain shallow water for the growth of **Para** grass. Because of the dense matting grass, effective management may in some cases require continual grazing to keep the shallow waters open. Some areas **free** of **grazing** are necessary **for** reed dwelling bird species such as bitterns, **crakes,** rails etc.

The renewed interest in restoring stocks of barramundi (Lutes ***calcarifer)*** to the Fitzroy River system may **lead to** better management for other wildlife species.

Other management recommendations include:

- Acquisition of some key wetland refuges as environmental parks, or their management as Fauna Refuges.

- The establishment of bird observatories and information areas so that the wetlands can be **promoted** as a resource of visitor interest.

- Information campaigns to inform landholders on aspects of management which will preserve wetland features and species, particularly those affected by grazing.

Attachment 3

Bird species associated with The Scrubby Creek/Yeppen floodplain area

Based on observations by John McCabe and others, 197441991

The species listed here include birds associated with waterbodies and edge systems, water associated with flood inundation, raptors associated with wetlands and other species breeding or feeding in close association with wetland areas.

Australian Pelican	seasonally common	
Darter	common	breeding
Little Black Cormorant	very common	breeding Yeppen Lagoon after water rises 200+
Little Pied Cormorant	common	
Pied Cormorant	occasional	
Black Cormorant	occasional	
Australasian Grehe	common resident	
Great Crested Grebe	common at tunes - may be absent for years	
White-necked Heron	common	resident
White-faced Heron	common	resident
Great Egret	common	
Intermediate Egret	very common	active in grassy wetlands after-rain
Little Egret	common	water edges
Cattle Egret	occasionally common	grassland
Rufous Night Heron	common	roosts heavy vegetation Scrubby Creek/other areas
Black-necked Stork	occasional	

Magpie Goose	common	roosting feeding numbers! appear to be increasing after low in 1970, dependent on spike rush (*Eloeocharis dulcis*)
Black Swan	occasional to very comnion	700+ resident Murray Lagoon 1990
Wandering Whistle Duck	occasional	on water
Plumed Whistle Duck	common	edge grazer
Radjah Shelduck	vagrant	
Grey Teal	common	very common after floods
Pacific Black Duck	very common	
Pink-eared Duck	vagrant	floods
Hardhead	common	
Maned Duck	common grazer	
Cotton Pygmy Goose	'common	floating water plants
Green Pygmy Goose	uncommon	
White Pygmy Goose	common	
Australasian Shelduck	vagrant	
Glossy Ibis	occasional	water edge
Sacred Ibis	common	grassland
Straw-necked Ibis	common	grassland
Royal Spoonbill	common	
Yellow-billed spoonbill	common	
Osprey	occasional	
Black Rite	common	
Brahminy Rite	occasional	
Whistling Rite	common	breeding
White-bellied Sea Eagle	occasional	
Little Eagle	occasional	breeding

Swamp **Harrier**	occasional	
Branded Land Rail	common	
Painted Snipe	vagrant	
Ducky Moorhen	very common	water
Swamphen	common	**edges**
coot	common	
Brolga	occasional	
Comb-crested Jacana	common	water lillies etc
Masked Lapwing	common	
Red-kneed **Dotterel**	occasional	
Black-fronted **Dotterel**	common	creek gravels and shores
Lesser Golden Plover	occasional	muddy edges
Black-winged Stilt	common	
Marsh Sandpiper	occasional	muddy edges
Sharp-tailed sandpiper	occasional	muddy edges
Lathum's Snipe	occasional	grassy wetland
Red-necked Stint	occasional	muddy edges
Silver Gull	occasional	
Caspian Tern	common	
Gull-billed Tern	common	
Whiskered Tern	seasonally common	

Notes: The January 1991 floods coming on the end of a dry period where the wetland perimeters were overgrazed have resulted in a temporary reduction of pasture grasses such as **para** grass which have spread or been planted in most swampy areas. Sedges have taken advantage of the reduced competition and if this advantage continues certain waterbird species may be **favoured.**

Common names as per Simpson and Day, 'Field Guide to the Birds of Australia,' (1984)

THE 1918 FLOOD - NATURE, EFFECTS AND COMMUNITY RESPONSE.

Barbara Webster
History student
University of Central Queensland.

Flooding is not an uncommon occurrence in Rockhampton. In the 135 years since white settlement, there have been 51 inundations in excess of 6 metres on the gauge. In analysing the effects of the 1991 flood and the subsequent community response, valuable insight can be gained from a study of how the town coped with a similar crisis in the past. In January and February 1918, Rockhampton experienced what has become known as "The Great Flood" when the Fitzroy River exceeded all previous records by rising to a height of 10.1 lm and remaining above 9.5m for 10 days. Only two other inundations have exceeded 9m - the 1954 flood (9.4m) and that of 1991 (9.3m) - however Aboriginal stories tell of even higher floods in the past.

The Great Flood of 1918

The Fitzroy River was already at bank level from upcountry rain when Rockhampton was deluged by torrential falls associated with a cyclone which devastated Mackay on Sunday 20 January. Apart from seriously damaging many buildings, the disturbance dumped almost 24 inches of rain'on the town and throughout the river basin over the next four days. Overflowing both banks in the town reach and at Pink Lily, and backing up through the Main Drain, the floodwaters assumed a similar pattern of distribution as in 1991. The flood also displayed the typical profile of two peaks (Table 1) - one of 9.35m from local run-off and a second of 10.1 lm nine days later when more rain coincided with the arrival of the Mackenzie River waters. Fortunately the Dawson River was not in flood as well, or even higher levels would have resulted.

Effects of the Flood,

With the town in a state of major flood for over a month, the physical effects were substantial.' Water covered approximately 80% of the Rockhampton municipality including over 17 miles of streets and extended almost to the Post Office. It inundated the gasworks and the railway station, workshops and goods yards, together with all the wharfs and many warehouses and shops in the town centre. Of the 1400 homes in the flooded area, it was estimated that several hundred were partially or fully submerged1 In the separate municipality of North Rockhampton, about one third (200) of the residences were affected, as well as the Borough Chambers and the facilities at the cricket grounds and racecourse. At Lakes Creek, the river extended well into the meatworks. Floodwaters swept away seven houses and destroyed furniture and personal possessions in many others. Five, lives were lost by drowning. Stock losses were high, with over 2000 cattle being swept downstream from three South Yaamba properties alone, while many small crops at Gracemere were destroyed.

Essential services and communications were badly affected (Table 1): gas supply suspended for three weeks, electricity for eight days and water supply for ten days. Nightsoil collection and disposal was also seriously disrupted, contributing to 26 cases of typhoid fever. The initial storm downed telegraph lines to the south for three days. All main rail links were severed, with the southern line inoperable for three weeks. At the peak of the flood, authorities closed the Fitzroy Bridge and removed the telephone cable to North Rockhampton, leaving only the Alexandra Rail Bridge to connect the two communities. With transport at a virtual standstill, food supplies were also under threat.

Sociological Response

Faced with such massive disruption and physical isolation, how did the 1918 community react? Analysis of the sociological and psychological response is possible from the detailed newspaper reports at the time. Generally, co-ordination and cooperation typified the emergency stage, followed by growing discord during the reclamation stage.

The Inspector of Police directed initial operations. Policemen, 40 special flood constables, ambulance officers, railway and council workers and many volunteers used dinghies, motorboats, horse carts and trains to assist in evacuations; while others worked around the clock sand-bagging vulnerable sections along Quay Street. Most evacuees found accommodation with friends or relatives, but those without shelter were made comfortable in the numerous halls and schools set up as refugee centres. Relief vouchers were issues to those in need. Pleas for clothing, bedding and food brought forth generous donations from business and the public while the Rockhampton and District Flood Relief Committee collected over five thousand pounds for distribution to victims.

A committee comprised of a cabinet minister, police inspector, police magistrate and the mayor oversaw the continuing counter-disaster operations. Small boats transported those not evacuated from flood areas to a landing stage in East Street. A ferry service across Yeppen Lagoon maintained fresh food supplies, thereby averting further crisis. As well, Rockhampton merchants used this service to send goods to western centres which were also experiencing severe flooding. Slaughter of cattle rescued from the river replenished dwindling meat supplies. The only route out of town was by train to Broadmount, then steamer across to Port Alma to connect with the Brisbane train. At the flood peak, this stopped also. Law and order prevailed throughout and, in fact, convictions for almost all crimes decreased that year.

When the waters receded and clean-up operations began, signs of community discord became apparent. Depot Hill residents complained of lack of official attention to their plight and of the intrusion of sightseers. Landlords and tenants argued over rent and cleaning expenses. The Flood Relief Committee disagreed on **exactly** 'who should receive assistance. Longstanding animosities within and between both municipal councils erupted over flood management and funds. Moreover, with a state election only a few weeks away, the flood became a political issue. The **Labour** government and **graziers** bickered about, compensation for slaughtered cattle, while the government's tardiness in honouring a pledge, of financial support was capitalized upon by the Nationalists.

Psychological Response

Significant attention is now paid to the psychological consequences of disasters on both individuals and the wider community. In 1918, the effect on individual victims is difficult to **discern** from newspapers. A few reports of "distress" appear but with anxiety, depression and psychosomatic illness still viewed as weakness or abnormality, journalists may not have been alert to these reactions or may have 'refrained from commenting upon them. Conversely, a greater acceptance of loss and hardship as part of life seemed to prevail then, with one reporter describing "Pathetic little groups of women and children, endeavouring to **preserve** the true Australian stoicism." Moreover, the flood must be placed in historical context. With World War 1 claiming the lives of many local men'at that tune, flood losses were comparatively minimal.

However, within the wider, unaffected community, a marked psychological response was evident. In short, the town was absolutely fascinated by the spectacle. Sightseers abounded, scenic photographs were eagerly sought after, cinemas showed modem "moving films" for months after the event and an illustrated souvenir number of **The Capricornian** was a best-seller. There was also a great flowering of ideas to minimize future flood problems: adoption of overhead electricity, more effective flood warning, **nightsoil** incineration, a sewerage system, compulsory flood insurance, raising and rerouting railway lines and reactivating the abandoned port of Broadmount. More grandiose were suggestions to construct a dam and cut away points on the river and even to **resite** low-lying portions of the town. Few of these came to fruition.

Conclusion

A study of the 1918 flood reveals far more than mere historical detail. Knowledge of the flood **itself,** its effects **and the** community response allows a better perspective of the **recent** 1991 flood by providing a basis for comparisons and contrasts. Three important points emerge from historical flood studies. First, such events **are** a recurrent aspect of life in **Rockhampton. Second,** in 1918 the town coped with a greater, longer and more disruptive flood withoutthe help of today's modem technology and support services, and did so remarkably well indeed. Third, while the **intervening** 73 years have brought significant change in physical ability to cope with flooding, the community response elicited by such a crisis remains much the same as in 1918.

Notes

1. Commonwealth Bureau of Meteorology heights given in Schedule **of Peak Flood Heights at Rockhampton,** Rockhampton City Council Engineering Department 1991.

2. **The Morning Bulletin, The Daily Record,** and **The Capricornian** 18 January - 6 April 1918. Unless otherwise indicated, all information has been drawn from these sources.

3. As found by Dynes and Quarantelli (1975) cited in Department of Social Security. The **Experience of Cyclone Tracy,** A.G.P.S., Canberra, 1981.

4. **Rockhampton and District Flood Relief Fund Cash Book - 1918,** CQ Collection, Rockhampton Municipal Library.

5. 'Report of the Commissioner of Police', **Parliamentary Papers,** Vol. 2, 1918, p. 991.

6. As found by Raphael (1976) cited in D.S.S., op. cit., p. 16.

7. **The Daily Record,** 30 January 1918.

Date	Rainfall to 9a.m.	River Height RCC[1]	River Height CBM[2]		Above flood peak of 1954	Above flood peak of 1991	Services Inoperable: Gas	Elect	Water	T'graph	Rail
1918 JAN.	inches	ft in	m								
Sun 20		19 6									
21	4.56	21 10		Flood							
22	9.69	29 2									
23	7.53	29 5	9.35	Peak							
24	2.04	29 5									
25		27 10									
26		27 5									
Sun 27/28		27 5 / 27 7									
29	4.10	29 4									
30	.19	30 6									
31		31 6									
FEB.1	.63	31 11	10.11	Peak							
2 / Sun 3	1.03	31 10 / 31 5									
4		31 4									
5		31 3'									
6	.85	30 7									
7/8	1.84	29/20 10/14									
9		29 4									
Sun 10/11	1.25	28 5/3									
12		27 10									
13		27 3									
14/15		26 0									
16		26 '0									
Sun 17	7	n.a.									
18	.35	22 5									
19		16 6		Within banks							

[1] As recorded in 1918. Maximum level as per Rockhampton City Council records. Adjusted 1' in 1928 to make peak 32'11". Recordings not at same time each day.

[2] Commonwealth Bureau of Meteorology readings as per present gauge.

TABLE 1 PROFILE OF 1918 FLOOD

INVOLVEMENT OF DEPARTMENT OF FAMILY SERVICES IN FLOOD RESPONSE, JANUARY 1991

Lex Burgess
Regional Manager
Department of Family Services and **Aboriginal** and Islander Affairs

Under the State Disaster Coordination Strategy the Department of **Family** Services has responsibility for the payment of subsistence grants for people who are in hardship as a result of the disaster and for emergency repairs to dwellings. These funds are made available from the Department of Treasury and claims are debited directly to that Department. The Department of Family Services involvement is to process applications and to liaise with Treasury concerning their payment.

Under the Natural Disaster Relief arrangements non repayable grant funding is provided to needy persons towards the purchase of basic subsistence needs in the immediate wake of a natural disaster and to provide initial repairs to restore owner occupied dwellings to a habitable and secure condition. The purposes of the assistance schemes are:

a) Subsistence Needs

To assist persons in poor financial circumstances who are so severely affected by a natural disaster event such that they find themselves living in substandard conditions without the means to obtain basic subsistence needs. This money then is directed towards the purchase of food, bedding, clothing and basic furniture. Assistance is not provided as compensation for items damaged or destroyed.

b) Emergency repairs to private dwellings

To assist persons in poor financial circumstances who am similarly affected by a natural disaster event that they are unable to secure their dwelling and so the funds are made available for initial repairs to make their dwellings habitable and secure. Assistance is not provided:

1. towards repairs of a long term nature, not essential in making the home habitable;

2. as compensation for damage incurred or;

3. as an alternative to adequate insurance.

Under the guidelines which operated in January, the maximum amount payable'for subsistence grants was $3,070 for a family or $1,030 per single person.

This amount was subject to an assets and means test.

Assets	Available immediately eg. Cash at banks.
Non Pensioner	'$3,200
Pensioner	$13,200

Income

Family	$490 pw - $32 for each dependant child
Single person	$370 pw

For the immediate relief of hardship, of the monies that a person would be eligible for under subsistence grants, cash grants of up to $100 per person, with a limit of $500 per household, were made available immediately on application. In practice there were a large number of such applications which were not followed up with substantive applications later.

At the request of the Police Superintendent, who was District Controller, Rockhampton district, the Department of Family Services and Aboriginal and Islander Affairs organised such payments from 6 January and continued until Wednesday 16 January. Payment of subsistence claims were made by cheque following that.

A total of $12 1,000 has been expended on' Subsistence claims.

Emergency repairs to dwellings

Claims for emergency repairs to dwellings were processed and forwarded to the Department of Administrative Services for assessment and to Treasury for approval for amounts in excess of $1,000. Approximate estimates of damage varied between $15,000 and a few hundred dollars. Typical estimate was around $4,000. The total amount paid out in emergency repairs todwellings has been $82,523.

The claims for emergency repairs are in fact still being fmalised.

The amount of work required by departmental staff in processing these claims for payment was excessive. Some 75 hours of paid overtime was incurred and staff were brought from Mackay and Brisbane to assist with the processing.

The process was closely co-ordinated with the local authorities response and in particular with the Rockhampton City Council's Flood Relief Appeal. In order to ensure that there was little duplicity and to replace multiple claiming, applications were processed at City Hall, where staff of the department were located to work in conjunction with officers of the Rockhampton City Council so that the two schemes were coordinated.

Support services

Under the State Counter Disaster-Plan, the Department of Family Services and Aboriginal and Islander Affairs was responsible for coordinating support to victims. During the period just prior to the flood, a series of meetings had been held involving community organisations so that the plan to provide counselling and emotional support to victims of disasters had in some way been pre-arranged. The organisations who had been involved with Careforce, Centacare, Lifeline, Community Health and the Department of Social Security.

As initial meeting of the group was held on 3 January and an outline of the current position was given. Guidelines concerning the natural disaster relief arrangements and personal hardship and distress payments were distributed. The non-government organisations indicated their ability to provide personnel to assist in completing claim forms and also to provide counselling.

The Commonwealth government had not declared the area a disaster, however special benefit payment was payable for primary producers who had lost their livelihood as a result of the flood and people where employment was discontinued because the business in which they were employed had been closed because of the disaster.

Subsequently the group met and divided the disaster affected area around Rockhampton into the street zones and took responsibility for ensuring that each household was visited. A representative of the Railways Department joined the group responsible for counselling of Railway employees. Addresses of clients of the various agencies was distributed so that there would be no duplication of calling on people. A card index was developed for each street and the houses not to be visited were noted on that index.

Volunteers attached to each of those agencies attended a training meeting conducted by representatives of Careforce, Psychiatric Services and the Department of Family Services. The training session focused on a kit to be distributed to each household. The contents were:

- a questionnaire which was designed to elicit an appreciation of the degree of stress which the household was experiencing so that it could be determined whether or not further follow up was necessary by a member of the Psychiatric Services;

- some information concerning financial assistance and;

- common emotional responses to disaster.

Within a period of two weeks following the flood, each household in the area was visited. Some community meetings were also arranged where people could direct various concerns and issues which arose because of the floods, to appropriate agencies including this Department, Police 'and the Local Authority. Well attended community meetings were held at Gracemere, Depot Hill and Port Curtis. At each one there was an expression of rather intense emotion, but in the end the outcomes were helpful to local authorities in particular, but also to this Department in reaching people who had otherwise not been contacted.

In relation to one section of the city in particular, the Rockonia Catholic Parish had arranged separately to visit each household to provide some practical assistance. This was well received by the householders, but was not co-ordinated with the rest of the response. This'was a difficulty in that it was unclear to the people providing the support from the co-ordinated group whether or not our approach was necessary. From the householders point of view, it may also have been confusing.

This reinforces the point that it is necessary to coordinate an approach to the disaster affected areas and to preplan the event in some detail recognising what resources and what response may be, provided from other sections of the community. Secondly, it is necessary to ensure that the approach that the coordinated group is making is well publicised so that people can co-ordinate any additional effort through that.

There was significant assistance available to the Rockhampton community from a number of organisations and this indicates that the city is well placed to respond to natural disasters with co-ordination and support from a central point.

PART C

WORKING GROUP REPORTS

SYNOPSIS OF GROUP A WORKSHOP SESSIONS

Water Related Issues

M. Coates and J.P. O'Neill
University of Central Queensland and
Queensland National Parks and Wildlife Service

1. Summary of known impacts

A large number of impacts from flooding that affected the aquatic environment were identified during the course of the day. These impacts were logically divided into two groups, those impacts on the freshwater environment and those impacts on the estuarine and marine environments. The more significant of these impacts, as identified by the discussion group, are listed below.

Freshwater Environment

1. Macrophyte loss.
   Flood waters swept away a large proportion of the existing water plants in the river.

2. Sediment change. --
   There was a general increase in the particle size of the sediments after the flood event. The river banks and bed now contain a larger sand fraction, as opposed to silt, than before the flood.

3. Blue-green algae populations.
   There was a measured increase in both the diversity and abundance of the river's blue-green algae population after the flood.

4. Fish breeding.
   Breeding in shell and fin fish during and after the flood was noticeably increased.

5. Loss of bankside vegetation.
   There was a dramatic loss of bankside vegetation in certain parts of the Fitzroy River.

Estuarine and Marine Environments

1. Pollution.,
   Significant pollution of riverbank downstream of the Rockhampton rubbish tip.

2. Increase in fish catch.
   General increase in size of fish catch (commercial and recreational) in Keppel Bay after the flood.

3. Coral mortality.
   Extensive 'coral mortality around the southern and western sides of the Keppel Islands.

4. Loss to business.
   Loss of business at the Middle Island Underwater Observatory because of closure during the flood and loss of coral subsequently.

5. 'Intertidal organism mortality.
   Differential mortality of intertidal organisms along the mainland Keppel Coast and around the Keppel Islands.

6. Diatom blooms.
   Diatom blooms were observed in the Keppel Bay area toward the end of the flood event.

2. **Causes of impacts**

The size and duration of the 1991 Fitzroy river flood meant that some quite severe environmental impacts were sustained, both within the river catchment and out to sea. In many cases the recorded impacts resulted from the physical forces associated with the floodwaters themselves, and in others it was exposure to less discrete factors, such asreduced salinity and increased turbidity levels. In a number of cases the severity of impact was found to have been directly influenced by the duration of exposure.

Freshwater Environment

1. Macrophyte loss.
   Scouring, fast movement of floodwaters, and deposition all contributed to loss of water, plants in the river and associated waterways.

2. Sediment change.

The change in physical character of **bankside** and riverbed sediments from silt to sand is probably a cyclical process. The faster moving floodwaters are too dynamic to allow settling in the river of the finer suspended fractions. During subsequent drier periods when river flow rates are much reduced, settling of the muddier sediments is again possible. The sands deposited during the flood are therefore likely to again be covered with silt.

The effects that land clearing, stocking and cultivation have had on the relative proportions of sand and silt deposited are not known.

3. Blue-green algae populations.

Increases in the population size and diversity of blue-green **algaes** was a direct response to increases in nutrient levels of the river during the flood. Increases in the levels of C, N, P, Fe, Mn, Cu, and Si were observed.

The influx of nutrients was derived from the natural process of soil loss associated with the flood, from fertilizer use, and from septic and sewage disposal facilities.

4. Fish breeding.

Accumulations of shellfish-aiid crustaceans were observed in the river after the flood. Inundation of large areas (including the Fitzroy River barrage) facilitated the upstream movement of species such as barramundi.

5. Loss of **bankside** vegetation.

Movement of floodwaters and associated scouring and erosion removed large portions of the bank and associated vegetation in some areas.

Estuarine and Marine Environments

1. Pollution.

The siting of the Rockhampton rubbish tip on the floodplain ensures that floodwaters displace large amounts of rubbish downstream. All manner of rubbish, including large volumes of plastics, were deposited in the mangrove areas of the lower Fitzroy River and adjacent estuarine areas.

Drums of chemicals associated with the mining and agricultural industries were found washed ashore many kilometres from the river mouth, along the Keppel coast.

2. Increase in fish catch.

Increases in the recorded commercial fish catch during and immediately after the flood in the Keppel Bay area can be attributed to an increase in catch effort, rather than any particular schooling effect associated with the flood waters. ,

3. Coral mortality.

The extensive coral mortality recorded around the Keppel Islands was the 'result of acute toxic syndrome in the individual coral animals associated with prolonged exposure to low salinity levels. The chance of recovery of bleached, colonies may have been further decreased because of high sediment conditions experienced.

4. Loss to business.

The location of the underwater observatory on Middle Island ensured prolonged exposure to the full effects of the flood plume. The plume remained in concentrated form at this site for a period of more than 14 days in early January, 199 1.

5. Intertidal organism mortality.'

Exposure to low salinity levels for a period of more than 7 **days caused** the mortality of, many, intertidal organisms, particularly at coastal and inshore island sites.

6. Diatom blooms.

Increases in the level of nutrients normally experienced in Keppel Bay supported population explosions of these organisms.

3. Management Response

The response of the scientific and environmental management agencies to what was 'a very important natural event was variable. The 1991 Fitzroy River flood was the **third largest** on record for that catchment, and as such presented an ideal opportunity to study the environmental effects of what was a very large natural perturbation.

Management response to the event evolved after early **enquires** from 'the public; interest from the media, and field reports that suggested large scale environmental effects would be likely. **This** workshop is really the culmination of a response by a number of interested agencies (**Q.NPWS,** GBRMPA and UCQ) to record some physical characteristics of the flood, and the subsequent associated environmental effects. The workshop group felt that the impetus for this response generally came from middle management levels, rather than from a more senior level.

The information collected and presented at this workshop has confirmed a number of preconceptions and will form the basis for future response to similar impact events in this area. The workshop itself has provided a way of disseminating all information collected.

There was a very minimal response in the area of freshwater environmental monitoring, and it was generally felt that more in the way of long term research efforts could be directed toward this area.

4. Alternative Actions

The group believed that the response from the higher levels of management to such natural events is generally poor, and that more initiative from a senior level regarding integration of response to such large exercises, would be beneficial.

The establishment of a contingency plan for rapid response to similar events was also seen as a positive step. A model for such a plan, as appropriate to Marine Park management, is appended.

5. Planning and Research requirements

The following planning and research needs were recognised as being desirable in relation to response to future flood events in the Fitzroy River.

- There is a general lack of baseline data for the area. Long term -environmental monitoring and- -- inventory programs need to be established.
- Data collection aimed toward future modelling of effects might be desirable, but perhaps too expensive.
- More research into the direct effects of factors, such as changes in nutrient and salinity levels, on the physiology of individual animals needs to be undertaken. Critical exposure levels could then be established.
- A contact list for the co-ordination of response needs to be established.
- A response kit for the collection of basic aquatic data needs to be made readily available.
- Information gained from flood impacts should be used for long term management purposes.
- The possibility of using remote sensing technologies in a more integrated fashion for this type of monitoring program requires research.

. Describe actual plume

- position, size, movement, chemical and physical characteristics
- aerial surveys
- vessel surveys (multiple transects across plume)
- river measurements, including sediment load (WRC)

. Dedicated site measurements

- ensure measurements taken at Heron Island, Middle Island Observatory
- establish standard monitoring kits for volunteers

. Background monitoring and site surveys

- establish a number of background monitoring sites to monitor water quality, benthic, biota and plankton
- monitor these background sites closely during flood events

. General information gathering

- gather as much relevant information as possible from fishermen, farmers, tourist operators etc.

SYNOPSIS OF GROUP B WORKSHOP SESSIONS

Land Related Issues

D. Crossman and A. Kay
Queensland National Parks and Wildlife Service

A. Known impacts from 1991 Floods

The flood had a diversity of effects on rural lands and lifestyles at both industry and individual levels. The most significant impacts identified by the discussion group were:

1. Loss of soil and pasture.
   Movement of flood waters caused scour and erosion in many areas removing top soil and destroying existing pasture. Some areas have not yet recovered. Up to 2 800 hectares of pasture was ruined on one property.

2. Loss of fencing
   Flood waters swept away up to 40km of fencing on some properties.

3. Loss of stock
   Flood waters isolated, swept away or drowned stock, primarily cattle. Most stock losses during the flood resulted from prolonged exposure.

4. Loss of access
   Flood waters inundated roads and tracks isolating properties and homesteads. Flooding also cut off certain sections of properties preventing internal access within a holding.

5. Deposition of flood debris and rubbish
   Flood waters moved and deposited a variety of debns. Some areas of pasture were destroyed by deposition of gravels while larger debris such as tree boughs and logs were scattered across floodplains after blocking tracks or roads and becoming wedged in fences. Rubbish from farm dumps was swept away and redeposited elsewhere and carcasses were a problem in some instances.

6. Insect populations
   Increases in insect populations particularly Dawson River Fly caused stock and native

animals to become extremely agitated and distressed. Some cattle were said to have been driven into the river by the hordes of Dawson River Flies,

7. Bank erosion and subsidence
Sections of river banks collapsed and subsided during and after the flood.

8. Extended production loss
Through loss of stock, limited access and disruption of day to day farming activity other businesses within the community linked to primary producers such as abattoirs also experienced a down turn in production.

9. Spread and invasion of weeds
Flooding exacerbated weed problems by disturbing native vegetation and pasture facilitating theinvasion and establishment of weeds. Flood waters also helped spread weed seeds and propagules further. Parthenium is a particular concern.

10. Destruction of levy banks
Flood waters breached and destroyed levy banks on pasture ponds on some properties.

11. Destruction of remnant vegetation
Flooding is believed to have had a serious impact on some of the isolated pockets of native vegetation still remaining on developed floodplain areas.

12. Changes in native species populations
Flooding will have had dramatic effects on native species both positive and negative. For example water bird and some insect populations increased after the flood while it is likely that the other floodplain residentssuch as reptiles and ground dwelling marsupials may have decreased.

B. Cause of impacts

In simple terms the major cause of all these impacts was the flood. There was too much rain in most of the Fitzroy catchment for too long. However a number of other factors were thought to have contributed to the severity of the impacts and are listed in point form below. (The numbers refer to previous points made in 'A' above).

1. Loss of soil and pasture
   - overgrazing and clearing encouraging soil erosion
   - clearing in upper catchment areas leading to increased run off and flow rates
   - pasture location
   - lack of flood tolerant pastures

2. Loss of fencing
   - inappropriate fencing strategies, primarily fence location and orientation

3. Loss of stock
   - delay in flood information preventing timely evacuation of stock

4. Loss of access
   - delay in flood information
   - inappropriate siting and construction of transport corridors and facilities

5. Deposition of rubbish and debris
   - inappropriate siting of urban and private tips

7. Bank erosion and subsidence
   - recreational use of river (speedboats) encouraging bank undercutting

9. Spread and invasion of weeds
   - lack of local control of weed populations

10. Destruction of levy banks
   - location, number and structure

11 & 12. Destruction of remnant vegetation and changes in native species population
   - size of remnant populations and their management

C. Management response

The group reported that the responses to the impacts were only partially successful. Examples discussed were as follows: (The numbers refer to previous points made in 'A' above).

1'. Loss of soil and pasture

- some landholders have attempted to reseed but have not been successful due to lack of rain

2. Loss of fencing

- 'breaks in fences have been successfully'filled with logs in some instances
- cementing in strainer posts prior to the flood helped prevent fence destruction but the immobile posts tend to accumulate more debris and sand

3. Loss of stock

- attempted to obtain advance warnings then moved stock

4. Lack of access

- boats were available but they were not deployed effectively by the local authorities, in general co-ordination was poor and there was a lack of response from the Shire

6. Insect populations

- short term measures used such as spraying dogs to kill and repel insects

7. Bankerosion and subsidence

- some local revegetation programsbegun

D. Related issues

As a result of these discussions the group identified a number of issues that need to be addressed as follows:

1. Lack of integrated catchment management

In particular the poor location of transport corridors with respect to flood patterns, the. Scrubby Creek diversion exaggerating flood effects and the lack of floodplain management were matters of concern.

2. Lack of reliable and thorough information services.

3. Lack of accurate flood mapping and property location definition.

4. Uncoordinated property management.

E. Alternative actions

The following suggestions were made: (The numbers refer to previous points made in 'A above).

1. Loss of soil and pasture
   - establish flood tolerant pastures
   - increase ground cover both grass and trees
   - consider land use alternatives for floodplains

2. Loss of fencing
   - fence parallel to flood flow

3. Loss of stock
   - define high ground refuges linked by stock routes (State Forests etc)
   - provide more tree cover for stock in risk of exposure
   - provide geo coordinate mapping for fodder drops to stock holding paddocks
   - mobilise Army helicopters for quick mustering of stock and rapid relocation

4. Lack of access
   - better co-ordination of emergency access facilities at the local level
   - provide geo coordinate mapping for flood drops to homesteads

7. Bank erosion and subsidence
   - revegetate river banks and fence off
   - regulate river traffic

9. Spread and invasion of weeds
   - better control of weeds at local level and in the upper catchment

Other ideas having a more general application were also put forward:

- provide more reliable rainfall, river and road condition information
- mobilise Defence Forces earlier
- declare 'Flood Zones' to regulate recreational traffic and sightseers particularly aircraft which may disturb stock already at risk
- establish rural self help groups (Land Care groups) to share knowledge

- coordinate property planning
- develop rural response plans to help in equal resource allocation

F. Research and planning needs

1. Research
   - biological **controls** for weeds
   - development of water tolerant pasture species
   - control of insect pests and disease vectors
   - **monitoring** of native species and **remnant** vegetation on **floodplains**
   - stream bank **stabilisation** trails
   - simple **property management techniques** such'as electric fencing

2. Management planning
   - develop Integrated Catchment Management
   - develop local self help **groups**
   - establish geo coordinated database

SYNOPSIS OF GROUP C WORKSHOP SESSIONS

People Related Issues

L. Steadman and D. Marshall
Police Department and
Queensland National Parks and Wildlife Service

REPORT

The discussions within this group focused on the response of the community to the 1991 flood and can basically be summarised under the following headings:

1. Specific Recommendations

2. Managing the 1991 flood emergency

3. Community responses to flooding • a look at the 1918 flood.

4. The response of Government Departments.

5. Planning and Research for future floods.

1. Specific Recommendations

- Planning controls for minimum floor levels in houses located in flood prone areas.

- Co-ordination of disaster planning by local councils (the Fitzroy, Rockhampton, and Livingstone shires) with each other and the Rockhampton Emergency Services for all stages of flood management and in particular the recovery stage.

- A permanent Disaster Operations Centre.

- Information to the general public from respective local authorities in respect to flood prone areas possibly through rates notices.

- a "One-Stop Shop" during a flood, particularly in the recovery stage, to assist in : family services; welfare; sanitation; sand bags; temporary accommodation etc.

- a dedicated path for boats from **Blackall Terrace to** Egans Hill.

- formation of a S.E.S group for Gracemere.

- co-ordination of available facilities for the clean up operations after the flood waters have receded.

- to provide static barriers on the roads to the north and the south of the city.

- ensure that fuel and milk committees **are** able to quickly come into operation in times of flood.

- identification of refugees immediately on evacuation.

- identification of properties in rural areas by grid bearings so that they can be located by **helicopter** for flood relief.

- a common communications network for all parties involved in emergency and relief operations.

2. Managing the 1991 flood emergency

A number of groups were involved in managing the 1991 flood emergency. These groups can be loosely termed as the Rockhampton Emergency Services and involve organisations such as the State Emergency Service; the Police Department; the councils of the Rockhampton, Fitzroy, and Livingstone Shires; Volunteer Groups; the Army; various government departments; and many other organisations.

'The process of responding to and managing an emergency such as the 1991 flood can be divided into a number of phases. These are:

- Prevention
- Preparedness
- Response
- Recovery

a. Prevention

Prevention of disaster caused by flooding involves long term planning. A number of points were raised in relation to this:

- a problem exists in the ability of councils to advise property owners of the specific flood risk of their properties. The Rockhampton Shire Council have flood maps however these are based on the 1954 floods and flood patterns vary significantly between floods. This is aggravated by physical changes to the landscape since previous floods such as the barrage and the railway bank near Yeppen roundabout. The Fitzroy Shire Council have virtually no information on the flood risk of properties in their shire. There is a major problem resulting from the recent phenomenon of people buying small properties in rural areas just outside the town limits. There is little information available on the flood risk for these properties.

- there is a need for long term planning for prevention of flood damage. Tighter controls on building in flood prone areas are needed and a long term goal for phasing out development in particularly flood prone areas needs to be considered by the local councils. Floods are a regular occurrence in the Rockhampton area and this must be accepted by town planners and other organisations involved in the development of the area in and around Rockhampton.

b. Preparedness

- The preparation for floods has a large influence on the ability of the Rockhampton Emergency Services to respond to flood disasters and also on the ability of the Rockhampton community to recover from a flood. A number of points were raised in relation to the preparedness of the Rockhampton community to the 1991 floods:

- The 1991 flood was particularly disastrous for urban people who had moved to the country in recent times. There has been an attitude that country people can look after themselves in times of flood. They generally have appropriate knowledge, equipment, and food reserves to tide them through the critical periods. However, a lot of urban people have taken up residence in rural areas and they are often incapable of self sufficiency during a flood. It was perceived by this group that there was a need to circulate information to residents in the Rockhampton community, particularly the category mentioned above, on how to be prepared for floods and cope during periods when they are cut off from surrounding community support It was noted that there is :a general brochure on floods available from the Bureau of Meteorology and National Disasters It was suggested that this, or a brochure more specific to the Rockhampton area, could be circulated with rates notices'by local councils.

- the flood warning system for the Rockhampton area needs to be improved along the lines of the cyclone warning system.,There is a general impression that the Rockhampton area always has a long period to prepare for a flood however this is not always the case especially if there is heavy local rain.

- further development of State Emergency Services outside the Rockhampton city limits needs to continue. Examples of areas that 'need S.E.S groups include Gracemere and Port Curtis.

- there is a need to make people outside the city limits aware that flooding will restrict transport into Rockhampton as well as affect their properties. There is also a need to be prepared to halt the influx of travellers and tourists into the city when flood waters are rising. In the 1991 flood many buses entered Rockhampton and found they could not continue their journey. This left many tourists stranded in the city and caused problems for the emergency services.

- there was a major problem with halting traffic on the northern and southern approaches to Rockhampton when flood waters covered the highway. Many vehicles just ignored and drove over temporary barriers causing damage to the roads and often necessitating rescue operations by the emergency services for stranded vehicles. The ability to close the approaches to the city, to minimise damage and avoid loss of life, needs to be improved.

- there was a problem with the fuel and milk supplies for the city. Committees for milk and fuel need to installed and operational as soon as it is known that flooding will occur.

c. Response

A number of points were raised in relation to the Rockhampton Emergency Services' ability to respond to crisis in times of floods, They were:

- there was a communications problem between the emergency: services and the army. The army use a different communications system and the emergency services had difficulty gaining access to some of the helicopters that were assisting in flood relief work.

- there was a problem with helicopters locating properties. Many descriptions of the locations of various properties in need of flood relief in rural areas could only be given in terms of road positioning. This was useless to helicopters trying to locate properties under flood water. It has been suggested that each property should have a grid location based on longitude and latitude available to relay to the emergency services during floods. A system has been proposed where tags giving grid references for each property would be supplied and attached to the telephone of each property.

- there were difficulties in the Yeppen area when the flood waters covered the road and people and supplies were being ferried by boats. Obstructions such as fences and other structures often put the operation at risk. It was highlighted that there was a need for a dedicated path for boats between Blackall Terrace and Egans Hill.

- a dry weather road between Stanwell and Waroula? is needed.

- there were some organisational problems during the floods such as the registering of displaced persons. It was noted that evacuations in floods should be kept to a minimum and that evacuees should be relocated with relations or friends or as close to their home as practical. Also family evacuations should be kept together as families. This helps keep the morale of evacuees at a higher level than if families are split up or evacuees arc displaced a large distance from their properties.

- it was noted that there was a need for a permanent Disaster Operations Centre.

- There was a problem for some of the emergency services in evacuating people from flooded houses that were at risk, when the occupants refused to leave.

d. Recovery

The recovery period after a flood is a critical period in flood management. People arc moving into their homes to clean up the flood damage that has occurred. The immediate crisis has past and that often means that the sections of the community that have been most severely affected are forgotten by the rest of the community. Based on the clean up of the 1991 flood in

Rockhampton the group suggested a number of measures that could: improve future **recoveries** from floods. They were:

- to approach flood recovery on a regional basis to stop confusion between different councils **and their** methods of **operation.** It was suggested that regular **meetings** be held by the councils and other groups involved in the clean up to co-ordinate **and standardise** clean up operations.

- that the concept of a "One-Stop Shop" be supported. This shop should provide all services and assistance needed by flood victims during the recovery period.

- that the effort made by the community during the actual flood disaster should be maintained during the recovery period so that flood victims are not forgotten.

- that attention' be focused on the problems of flood victims and **that** there is a co-ordination of community psychiatric services. The promotion of a Mental Health Disaster Team should be encouraged for the trauma management that results from flooding.

3. Community responses to flooding - a look at the 1918 flood.

Barbara Webster from the Central Queensland University gave a presentation on the impacts of the 1918 flood on the Rockhampton community. There were some interesting comparisons between the two floods. The most striking comparison was how similar the two communities responded to the flood. During the crisis period when the flood waters **were** high the two communities pulled together. In the 1918 flood crime actually reduced during the crisis. It was after the flood waters had receded, however, that community disharmony increased. In the 1918 flood recovery period there was a general feeling in the community that government bodies were slow to respond financially to flood victims. There were arguments between councils over their jurisdictional areas. There were arguments between landlords and tenants over who should pay to fix the damage. There were arguments in the flood relief committee over who should get flood relief money and whether it should only go to people from the city or to people in the country as well. This post flood breakdown in co-operation and efficiency would appear to be a common element in disasters.

Barbara also looked at the psychological **response** of the Rockhampton community to the 1918 flood. She found that the town was absolutely fascinated by the spectacle. Sightseers were common and movie footage of the flood was popular in the cinemas.

4. The response of Government Departments

A paper was presented to the group from the Department of Family Services detailing their involvement in the 1991 flood. Under the State Disaster Co-ordination Strategy the Department of Family services has responsibility for the payment of subsistence grants for people who are in hardship as a result of the disaster and for emergency repairs to dwellings. The Department co-ordinated their response with the councils who were responsible for distributing funds from the Flood Relief Appeal. A total of $121000 was distributed by the Department for subsistence grants and at the time of the workshop a total of $82 523 had been distributed for emergency repairs to dwellings.

Under the State Counter Disaster Plan, the Department of Family Services and Aboriginal and Islander Affairs was responsible for co-ordinating support to disaster victims. Prior to the flood the Department had liaised with community organisations to compile a plan to provide counselling and emotional support to victims of disasters. As a result of this planning it was possible for community members to visit each household affected by the flood within two weeks of the flood waters receding. These visits provided welcome support for flood victims and dispersed information on how financial assistance and support could be obtained. There was also a questionnaire used to assess if flood victims were in need of psychiatric help.

5. Planning and Research for Future Floods.

The group noted that Camp, Scott and Furphy Pty Ltd had been appointed to undertake a Rockhampton Flood Management Study. It also noted that a Fitzroy District Disaster Plan had been formulated by the State Emergency Service members in Rockhampton that will provide information, communication, and contacts for use in times of floods. It welds all the disaster plans of the various local authorities together so that a co-ordinated approach to flood crisis management is possible.

APPENDICES

Working Groups - Guidelines for Discussion

1. Summary of Known Impacts from 199 1 Floods.

2. Cause of the Impacts

    specific
    general

    Were they avoidable?

3. Management Response

    How did the managing agency or person in charge respond?
    How successful were their actions?
    Did their action ameliorate the impacts?

4. Alternative Actions

    What options were available other than the action taken?
    Has there been any change in operational procedure since that time?
    What new initiatives have been put in place since the floods to minimise the impacts?
    Who is responsible for the new initiative?

5. Planning and Research Required

    What research is needed prior to introducing new management options?
    Have planning practices been modified to minimise the impacts of flooding?
    Should planning practices or processes be modified to minimise flood impacts?

Workshop Ndminees and Participants

Name	Organisatibn
Peter Baddiley	Meteorology Bureau
Ross Beer	'Police Department
Nev. Bieney	Landholder
Warren **Bolten**	Fitzroy Shire (Health)
Jon Brodie	Great Barrier Reef Marine Park Authority
Lex Burgess	Family Services
Grahame Byron	Queensland, National Parks and Wildlife Service
Mike Coates	University of Central Queensland
Fran Collins	Bouldercome Resident
Dan Connolly	Housing
Clive Cook	Great Barrier Reef Marine Park Authority
Doug **Crossman**	Queensland National Parks and Wildlife Service
Vic Cummins	Department of Primary Industries
Bill Davies	Bouldercome Resident
Quentin Espey	University of Central Queensland
Larelle Fabbro	University of Central Queensland
John Glazebrook	Deakin University
Hugh Griffin	Student University of New England
Graeme **Halford**	**CSIRO**
Chris Head	Honours (biology) University of Central Queensland,
Terry Healy	Queensland Fish Management Authority
Dan Hodda	Family Services
Mark Holding	
Ian Horrocks	
Bob Jeacocke	State Emergency Service
Alice Kay	Queensland National Parks and Wildlife Service
Mike Keane	Water Resources
Glen Knight	Lands Department
David Marshall	Queensland National Parks and Wildlife Service
John McCabe	Capricorn Conservation Council
Nev. Mills	Cattleman's Union:

Vince Mycoe	St Brendan's College
Paul O'Neill	Queensland National Parks and Wildlife Service
Jamie Oliver	Great Barrier Reef Marine Park Authority
Margaret Park	Gogango
Myriam Preker	Heron Island Research Station
Sharon Pretty	Great Barrier Reef Marine Park Authority
David Sargeant	Camp Scott and Furphy
Paul Smith	Camp Scott and Furphy
Laurie Steadman	Police Department
Shane Thomas	
Barbara Webster	University of Central Queensland
Steve Wright	Queensland National Parks and Wildlife Service

Workshop Timetable

8.15 - 8.45	Registration (Room CA 14)
8.45 - 9.00	Official opening, by Mr Jim Pearce, MLA Member for Broadsound
9.00 - 10.00	Introductory Session
	Mr Peter Baddiley, Bureau of Meteorology
	Mr Mike Keane, Water Resources
	Mr Paul O'Neill, Queensland National Parks and Wildlife Service
10.00 - 10.30	Morning Tea
10.30 - 12.00	Workshop Sessions - Short Presentations
Group A (Rm. HS 1.4)	Dr Mike Coates, Chairman Mr Paul O'Neill, Rapporteur
Group B (Rm HS 1.5)	Mr Doug Crossman, Chairman Dr Alice Kay, Rapporteur
Group C (Rm HS 1.2)	Mr Laurie Steadman, Chairman Mr David Marshall, Rapporteur
12.00 - 1.00	Lunch
1.00 - 3.00'	Workshop Sessions - Group Discussions
3.00 - 3.30	Afternoon Tea
3.30 - 4.30	Chairmen Report to Forum (Rm ASF 1.1)