Copyright is owned by the Author of the thesis. Permission is given for a copy to be downloaded by an individual for the purpose of research and private study only. The thesis may not be reproduced elsewhere without the permission of the Author.

SUSPENDED SEDIMENT YIELDS OF NEW ZEALAND RIVERS AND THEIR RELATIONSHIP TO PRECIPITATION CHARACTERISTICS

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

ANTHONY C. STREETER

1982

83_09619

ABSTRACT

Sediment ratings determined by plots of instantaneous suspended sediment concentrations and their associated discharges, were combined with the continuous flow record to give values of suspended sediment yields for 82 catchments throughout New Zealand. A discussion of the errors involved in this determination is undertaken and suggestions as to the best use of the current resources in order to lessen these errors is given.

Multiple regression analysis including flow characteristics and rainfall characteristics (depth, intensity and variation) determined from the wide network of daily storage raingauges, resulted in a national equation of weak prediction identifying 24-hour 5-year return period rainfall as the best explanatory variable of variation in suspended sediment yield. The country was divided into eight regions and the regression rerun revealing mean annual rainfall as the principal predictor in all but one region. The high explanation exhibited in some areas must be rationalised against small sample numbers. A combination of four regions into one gave good prediction, supporting overseas workers' contentions that sediment yield is strongly influenced by rainfall depth and its variability. It is suggested that introduction of a bed material size component into the prediction equation may allow incorporation of at least two further regions into the combined region.

The coefficients of the regional logarithmic equations relating sediment yield to mean annual precipitation are analysed. Important conclusions reached are that in relation to suspended sediment, catchment conditions are not necessarily reflected in rainfall depth or vegetation cover but primarily to the volume of transportable material in storage in the channel subsystem. The volume of sediment in storage in some catchments greatly exceeds annual export,

stressing the limitations in determining erosion rates from sediment yield values. In Region 2 (East Cape) storage is so large that limits on yield are not controlled by the rate of supply but the competence of the rivers to carry it; some of these rivers may well be carrying limiting yields therefore.

Evidence available suggests that a predictive equation derived herein can also be applied to streams draining largely glaciated areas.

ACKNOWLEDGEMENTS

I would like to thank many people who helped in some way in this study. With data collection, I greatly appreciate the assistance given by the New Zealand Meteorological Service, numerous Catchment Boards and Ministry of Works district offices, particularly the staff of the Wanganui Hydrological Survey. Data collection was made easier by the help of John Revfeim (New Zealand Meteorological Service) and George Griffiths (Ministry of Works and Development, Christchurch) who kindly supplied me with drafts of two papers on the topic.

In the aspects of data analysis and presentation, I would like to thank the Department of Geography, Massey University, for the use of their resources. The helpfulness and encouragement of the technical staff in the Department: David Feek, Karen Pulowski, Greer Robertson and Brian Solomon is gretly appreciated, as are the various academic staff I managed to 'quiz' during the course of the study.

In the sphere of data interpretation and a feeling for the wider implications of hydrology I would like to thank my supervisor, Richard Heerdegen, whose approachability made things so much easier.

Lastly, thanks are extended to my parents who over the past two years have not seen much of me, but were still ready to lend their support to provide me with an opportunity they were not able to take.

TABLE OF CONTENTS

		Page
ABSTRACT		ii
ACKNOWLEDGEMENTS		iv
TABLE OF CONTENTS		v
LIST OF ABBREVIATIONS		vii
LIST OF DEFINITIONS		viii
LIST OF FIGURES		ix
LIST OF TABLES		x
CHAPTER 1:	INTRODUCTION	1
1.1	The Problem	1
1.2	An Approach	2
1.3	A Methodology for the Approach	3
CHAPTER 2:	THE RAINFALL-SEDIMENT YIELD MODEL	4
2.1	The Catchment System	4
2.2	Sampling of the System	9
CHAPTER 3:	MAGNITUDE AND FREQUENCY OF HYDROLOGIC EVENTS	11
CHAPTER 4:	MEASUREMENT	16
4.1	Suspended Sediment Yield	16
4.2	Point Rainfall	28
4.3	Areal rainfall	42
CHAPTER 5:	PREDICTION	46
5.1	Correlation and regression analysis	46
5.2	Regionalisation	56

TABLE OF CONTENTS CONTINUED

		Page
CHAPTER 6:	DISCUSSION	63
6.1	Prediction and Sediment Yield	63
6.2	Universal Applications	65
6.3	National Applications	66
CHAPTER 7:	CONCLUSION	78
APPENDIX:	Suspended Sediment Yields Determined by Other workers	84
BIBLIOGRAPHY		86

LIST OF ABBREVIATIONS

In this study, the following abbreviations have been used:

D.S.I.R. - Department of Scientific and Industrial Research

M.O.W.D. - Ministry of Works and Development

N.W.A.S.C.O. - National Water and Soil Conservation Organisation

N.Z. Met. S. - New Zealand Meteorological Service

TIDEDA - Time Department Data. A computer based system for the storage and retrieval of New New Zealand hydrological data

W.M.O. - World Meteorological Organisation

LIST OF DEFINITIONS

In the study the following definitions are applied to the key words:

- bedload: that part of the material load which moves by bouncing (saltation), sliding and rolling along the channel bed.

- solution load, wash load or dissolved load: that part of the material load composed of the very finest particles who have vanishingly low rates of settling.

- specific annual yield: the yield per unit area per unit time. In the study it is given as tonnes per square kilometre per year ($t\ km^{-2}\ yr^{-1}$).

- suspended sediment concentration: the weight of material in suspension per unit volume of water. In the study it is given as grams per cubic metre ($g\ m^{-3}$).

- suspended sediment discharge: the rate of transport of the material in suspension, given as weight per unit time. It is the product of flow discharge and suspended sediment concentration. Customary units are kilograms per second ($kg\ sec^{-1}$).

- suspended sediment load: that part of the material load transported and held in the flow by turbulent mixing processes that prevent the settling of the particle under the influence of gravity.

- yield: the measured quantity of material carried by a river.

LIST OF FIGURES

Figure		Page
2.1	A generalised rainfall-sediment yield model	6
2.2	Canonical structure of the generalised sediment yield model	7
3.1	Sediment rating for Tutaekuri River at Puketapu (23001)	13
4.1	Location of study sites	20,21
4.2	Breakdown of the hydrologic data series showing the status of the annual maximum series	38
5.1	Probability plot of annual rainfall totals for Waiputaputa Station (D97031)	48
5.2a	Plot of sediment yield versus rainfall intensity for 81 New Zealand catchments	51
5.2b	Plot of logarithmically transformed variables of figure 5.2a, suspended yield versus rainfall intensity	52
6.1	Regional plots and equations showing the relationship of sediment yield to mean annual rainfall	64
6.2	Plot of sediment yield versus mean annual rainfall for Region 2 (East Cape), showing tendency towards a limiting yield	68
6.3	Analysis of variance table for the 8 sediment yield regions	74

LIST OF TABLES

Table		Page
4.1	Summary of drainage basin hydrological characteristics	26,27
5.1	Correlation matrix for logarithms of characteristics	50
5.2	Preliminary regional specific annual suspended sediment yield prediction equations	59
5.3	Final regional specific annual suspended sediment yield prediction equations	62
6.1	Values of regional regression line coefficients indicating catchment condition and rainfall influence indexes	69