COFFS HARBOUR CITY COUNCIL

MOONEE CREEK
FLOOD STUDY

FINAL REPORT

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TABLE OF CONTENTS **PAGE NUMBER**

TABLE OF CONTENTS CONT. **PAGE NUMBER**

TABLES

TABLE OF CONTENTS CONT.

FIGURES

APPENDICES

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FOREWORD

The New South Wales Floodplain Development Manual (Ref.1) has been prepared to assist councils in the development of management plans for flood-liable lands. The principal objective of the floodplain management process is to reduce the impact of flooding and flood liability on individual owners and occupiers and to reduce private and public losses resulting from floods.

The floodplain management process comprises the following activities:

- establishment of a Floodplain Management Committee;
- development and implementation of an Interim Local Policy;
- completion of a Flood Study;
- selection of an appropriate Flood Standard;
- preparation of a Floodplain Management Study;
- adoption of a Floodplain Management Plan; and
- implementation of the Floodplain Management Plan.

This report, the Moonee Creek Flood Study, thus completes the third activity in the process.

The Moonee Creek Flood Study has been prepared by Paterson Consultants Pty Limited on behalf of Coffs Harbour City Council and has been jointly funded by the NSW Government through the Department of Land and Water Conservation and Coffs Harbour City Council.

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GLOSSARY - Terms and Abbreviations

Australian Height Datum (AHD): a common national plane of level corresponding approximately to mean sea level.

Reduced Level (RL): a measured height above Australian Height Datum.

Annual Exceedence Probability (AEP): the probability of an event (say a flood) occurring or being exceeded in any one year.

Average Recurrence Interval (ARI): the average period between events exceeding a given magnitude. The periods between events are generally randomly distributed, hence ARI does not denote a fixed or regular interval between events.

Probable Maximum Precipitation (PMP): the rainfall calculated to be the maximum which is likely to occur.

Probable Maximum Flood (PMF): the flood resulting from the PMP Storm.

Manual or *Floodplain Development Manual*: The New South Wales Government publication "Floodplain Development Manual", 1986.

Local Environmental Plan (LEP) is a planning instrument made by the Minister under Section 570 of the Environmental Planning and Assessment Act currently in force. The LEP document sets out the boundaries for different land use categories.

Development Control Plan (DCP) is a statement of policy of Council for development in accordance with the LEP. The DCP provides more detailed provisions than are contained in the LEP.

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SUMMARY

The Moonee Creek study area extends from Emerald Beach village to Sapphire village, some 7.5 km to the south. The study area is drained by Moonee Creek and three major tributary creeks and several minor tributaries. The major creeks are:

- Moonee Creek, which discharges to the Pacific Ocean at Moonee Beach village;
- Sugarmill Creek, which flows into Moonee Creek immediately upstream of the entrance;
- Cunninghams Creek, which joins Moonee Creek approximately 2 km from the entrance; and
- Skinners Creek, which joins Moonee Creek approximately 3.5 km from the entrance.

The study area is predominantly rural in character. Residential development is confined to the villages of Sapphire, Moonee Beach and Emerald Beach with rural and some rural-residential housing scattered throughout the remainder of the study area. The "Heritage Park" rural-residential subdivision comprising some 100 proposed 1 ha sized lots is included in the study area.

A small number of flood studies covering various portions of the study area have been completed over the past 12 years. This study draws on information collected in these previous studies and additional data collected for the current study.

The purpose of the Moonee Creek Flood Study is to define flood behaviour and to determine design flood levels throughout the study area for interim floodplain management.

RORB rainfall-runoff models have been established for each of the major creek catchments. The RORB models have been used with design rainfalls determined in accordance with the 1987 edition of Australian Rainfall and Runoff in order to determine design flood discharge hydrographs.

A MIKE-11 unsteady flow hydraulic model of Moonee Creek and the major and minor tributaries and floodplain overflows has been established. The design flood hydrographs from the hydrologic modelling phase have been routed through the hydraulic model in order to determine design flood levels.

The peak design flood levels in the tidal reaches of the creek occur during the 9 hour duration storm, while peak design flood levels elsewhere result from the 2 hour duration storm.

Regional parameter estimates have been adopted for the RORB models and roughness factors for the MIKE-11 model have been based on site inspection and reference to "text-book" estimates. Calibration of the modelling was based on peak flood levels for the November 1996 flood event.

The study area can be divided into four separate regions based on flood behaviour:

- tidal reaches of Moonee Creek and major tributaries, where flood levels are influenced by ocean water levels;
- the Moonee Creek floodplain between the Pacific Highway and Moonee Creek, where flooding is controlled by the culverts under the highway;
- the Moonee Creek floodplain to the west (upstream) of the Pacific Highway, where flooding is determined by runoff and the capacity of the culverts under the highway; and
- upper reaches of Sugarmill Creek and tributaries, where flooding is determined solely by runoff.

The Pacific Highway embankment and culverts provide a significant degree of storage routing. Similarly, channel storage routing effects in the tidal reaches of Moonee Creek also significantly influence flood behaviour.

The design flood levels determined by the hydraulic model are significantly different to those determined in the previous studies, due to the following factors:

- different peak discharges determined by the different hydrologic models used;
- different ocean water levels adopted for the different studies; and
- floodplain and channel storage effects not incorporated into steady-state hydraulic models used in the previous studies.

The design flood levels determined in the current study are based on the most detailed hydrologic modelling and unsteady flow hydraulic modelling and are thus based on the best information available at the current time.

The limited floor level survey undertaken for the study identified only one rural house which has the main floor below the 1% AEP design flood level.

The velocity of floodwaters varies between 0.2 - 0.5 m/s on the floodplain to 0.8 - 2.4 m/s in the creek channels.

Preliminary assessment of flood hazard, based on the depth and velocity of floodwaters, indicates that "High Hazard - Floodway" areas are generally confined to the creek channels and immediately adjacent areas, with "High Hazard - Flood Storage" areas located in the tidal reaches and on the floodplain in the vicinity of the Gun Club near the upstream limit of the study area.

The bulk of the area inundated in the 1% AEP design flood can be classified "Low Hazard - Flood Storage" and "Low Hazard - Flood Fringe".

The sensitivity of the design flood levels has been tested for variation in the following:

- channel and floodplain hydraulic roughness;
- ocean water level;
- design rainfall; and
- "Greenhouse" elevation of ocean water levels.

The uncertainty associated with the design water levels is 0.15 m on the floodplain and in the non-tidal reaches of the creeks and 0.2 m in the tidal reaches. The uncertainty in the tidal reaches is related to possible elevation of the ocean water level in response to the "Greenhouse Effect".

The Flood Study defines flood behaviour within the study area and thus provides a technical basis for interim management of the floodplain, pending preparation of a formal floodplain management plan for the area.

The flood behaviour is presented in a series of flood profiles and flood extent plans.

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1. INTRODUCTION

The Moonee Creek study area extends from the southern fringes of Emerald Beach village to the northern fringes of Sapphire village some 7.5 km to the south, as shown on Figure 1.

There are four principal creeks and several minor tributaries which drain the study area to a common outlet to the Pacific Ocean at Moonee Beach village. The principal streams are:

- Moonee Creek, the major tributary with a catchment area of 21.5 km^2
- Sugarmill Creek, which joins Moonee Creek immediately upstream of the mouth and has a catchment area of 9.4 km^2
- Cunninghams Creek, which joins Moonee Creek 2 km from the mouth and has a catchment area of 4.4 km^2
- Skinners Creek, which joins Moonee Creek approximately 3.5 km from the mouth and has a catchment area of 6.75 km^2

The catchments of various creeks are predominantly rural in character with vegetation comprising hardwood forests, rainforest, banana plantations, cleared grazing land and mangrove forest. The village of Moonee Beach is contained within the catchment while portions of the villages of Emerald Beach and Sapphire are also included in the catchment.

The study area includes the "Heritage Park" rural-residential subdivision containing 100 proposed 1 ha sized lots which is being developed in stages. There are a number of rural and rural-residential properties within the study area.

A number of flood studies covering various parts of the study area have been completed over the past 12 years. These studies determined estimated design flood levels using steady-state HEC-2 hydraulic models. These studies are summarised in Chapter 2.

This study draws on the information presented in the previous studies and augments this information with new data.

The objectives of the Moonee Creek Flood Study are:

- definition of flood behaviour within the study area; and
- preparation of a study report suitable for interim floodplain management purposes.

The flood study comprises the following primary activities which are described in subsequent chapters:

- review of previous studies
- hydrologic modelling to determine flood runoff hydrographs from recorded and design storm events.
- hydraulic modelling to define flood behaviour, including flood levels, flows, depth and velocity of floodwaters.

2. AVAILABLE DATA

2.1 Review of Previous Studies

A number of flood studies have been completed for different areas within the Moonee Creek study area. The study area has not been investigated as a whole prior to this current flood study.

The following studies have been reviewed in order to obtain as much information as possible on flooding within the study area. Design flood levels obtained from these earlier studies are compared with those derived in the current study in Section 5.2

Moonee Development Area Flood Study Report, *Antony Tod & Partners, August 1983* (Ref.2)

This study was undertaken in order to define 1% and 5% AEP flood extents throughout the Moonee Development Area. The study area extended from Sapphire village north to Skinners Creek and approximately 1 km west of the Pacific Highway. The boundaries of the study area are shown on Figure 2.

RORB rainfall-runoff models were established for the Moonee Creek, Sugarmill Creek North and Sugarmill Creek South catchment areas. Design flood peak discharges were estimated for 1% and 5% AEP events.

Design flood profiles were determined for Moonee Creek, Skinners Creek, Cunninghams Creek, Sugarmill Creek and seven (7) other tributaries and their sub-tributaries using the peak discharge estimates as input to HEC-2 steady-state hydraulic models.

Flood extent plans were prepared, based on the calculated flood profiles, cross-section survey, orthophoto contour mapping and additional ground survey adjacent to Moonee Beach village.

Preliminary Assessment for Flood Investigation of Proposed Marlin Resort at Pacific Highway, Moonee, *Geoff Slattery & Partners, 1987* (Ref.3)

This study estimated 1% AEP ponding levels for a proposed residential subdivision and tourist complex on the site of the "Heritage Park" rural residential subdivision, which is located on the northern bank of Skinners Creek, on the western side of the Pacific Highway. The location of the study area is shown on Figure 2.

Peak flood discharges for Skinners Creek and three (3) sub-catchments which are drained by culverts under the Pacific Highway, were determined by Rational Method analysis. Ponding levels were determined by culvert analysis, assuming inlet control.

The report presents a description of the general drainage pattern within the study area.

Forest Glen Estate Flood Study, Kinhill Engineers Pty Ltd, March 1990 (Ref.4)

This flood study was undertaken in order to determine 1% and 5% AEP flood levels and extents for a rural-residential development off Old Bucca Road. The study area drains to Skinners Creek via Yellow Waterholes Creek which flows through State Forest land.

The estate is located within the study area for the earlier Moonee Development Area Flood Study, but is separated from the current study area by State Forest land. The location of the estate is shown on Figure 2.

A WBNM model of the Skinners Creek catchment was established and design flood discharges determined for the 1% and 5% AEP events for pre- and post-development conditions. The WBNM model results were compared with peak discharge estimates determined by the Probabilistic Rational Method (PRM).

Moonee Creek Flood Study, Gutteridge Haskins and Davey Pty Ltd, June 1994 and amended report October 1995. (Ref.5)

This study investigated flooding of the "Heritage Park" estate site shown on Figure 2.

A WBNM hydrology model of the full Moonee Creek catchment was established and used to estimate design flood discharges for the 1% and 5% AEP events. These design discharges were compared with estimates determined using the Probabilistic Rational Method and RAFTS hydrology model.

The design peak discharges were input to HEC-2 steady-state hydraulic models in order to determine design flood levels and extents within the estate area.

A trunk drainage system was designed with additional channel storage provisions in order to limit flows east of the Pacific Highway to pre-development values.

2.2 Rainfall Data

There are no official rain gauges within the Moonee Creek catchment. The Bureau of Meteorology maintains a pluviometer at Coffs Harbour Airport, some 12 km south of Moonee Beach village. Limited daily rainfall data is available from privately owned rain gauges.

Rainfall data collected for previous studies and for studies on nearby catchments has been extracted for "significant" flood events.

A review of the daily rainfall record for Coffs Harbour revealed that rainfall has exceeded 200 mm on only two occasions since 1970, prior to the November 1996 storm. The records also show that May 1996 was the first time since December 1991 that rainfall exceeded 150 mm.

Thus, it can be concluded that floods are a relatively infrequent occurrence in the greater Coffs Harbour area. It is purely by chance that the highest rainfall for more than 5 years occurred

following the completion of the initial drainage works for the "Heritage Park" subdivision adjacent to Skinners Creek. The perception, held by some residents, that this development has increased the likelihood of flooding, cannot be supported by hydrologic examination and is considered to be due to the unfamiliarity of the residents with flood behaviour as a result of the infrequency of flood producing rainfall and their relatively short term of residence in the area.

A severe storm caused major flooding in Coffs Harbour on 23 November 1996. The rainfall recorded at a number of locations in the Coffs Harbour area exceeded the 100 year ARI (Average Recurrence Interval) design rainfall (Ref. 10).

The rainfall over the Moonee Creek catchment was generally much less intense than that recorded in Coffs Harbour. The rainfall reported at various locations within the Moonee Creek catchment and at nearby locations is presented in Table 2.1.

Table 2.1

Recorded Rainfall, November 1996 Storm

Location	Rainfall (mm)
Emerald Beach	96, 119
Tiki Road	205
Sapphire	253
Woolgoolga	82, 97
Sandy Beach	104, 377
Bucca Road	229
Korora	230, 384, 451, 471

The rainfall recorded at Sapphire exceeded the 100 year ARI design rainfall for a 4 hour storm duration, though it was only slightly greater than the 20 year ARI design rainfall for a 2 hour duration. The rainfall at Emerald Beach was equivalent to the 5 year ARI design rainfall for a 4 hour duration and less than the 2 year ARI design rainfall for a 2 hour storm duration.

2.3 Flood Level Data

There is very little flood level data available from Council or RTA records for historical flood events. RTA drawings for the Pacific Highway show highest reported flood levels at a number of locations. The dates for these events are not known.

An interview survey of residents living near the various creeks, undertaken at the beginning of the study, failed to produce sufficient flood level information for calibration purposes. This is primarily due to the fact that the urban areas and the rural-residential houses have not been affected by previous floods.

The highest recorded flood levels shown on the RTA drawings and the flood levels indicated by residents are shown on Figure 3.

Peak flood levels were obtained at a number of locations within the study area following the November 1996 flood. This information was sufficient to enable the hydraulic model to be calibrated. The locations of the flood levels are listed in Table 2.2 and shown on Figure 4.

Table 2.2

Recorded Flood Levels, November 1996 Storm

Location	Peak Flood Level (m AHD)
u/s Emerald Beach Residential Area	8.52
Entry to 10 Beacon Terrace	8.28
u/s entry road "Heritage Park"	5.85
Skinner Creek gauge	<2.5
end Woodhouse Road	3.53
60 m u/s Sugarmill Creek footbridge	1.97
Sugarmill Creek footbridge	1.5±
Split Solitary Caravan Park (South)	3.85
Split Solitary Caravan Park (North)	3.70

2.4 Survey Data

Extensive cross-section survey was undertaken for the 1983 Moonee Development Area Flood Study. Additional cross-section survey was carried out for the 1994 Moonee Creek Flood Study. This cross-section survey data has been used for the hydraulic modelling phase of the current study.

The cross-section survey data available from the earlier studies was supplemented by limited cross-section data extracted from available ground survey and contour mapping for properties adjacent to the Coffs Harbour Zoo.

Additional cross-section survey was undertaken in the northern sector of the study area for the current study.

The locations of all surveyed cross-sections and those extracted from contour mapping are shown on Figure 5.

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3. HYDROLOGIC MODELLING

3.1 Overview

A variety of rainfall-runoff models were developed for the previous studies and used to estimate design flood discharges. The various models include RORB, RAFTS, and WBNM hydrologic models and the Probabilistic Rational Method (PRM). The estimated design peak discharges determined for the previous studies are summarised in Table 3.1. The tributary catchments are shown on Figure 1.

Table 3.1

Estimated Design Flood Peak Discharges - Previous Studies

Study		1983	1990	1994		
Model		RORB	RAFTS	WBNM	RAFTS	PRM
Catchment	AEP					
Skinners Creek	1%	66.0	112	118.1	N/A	N/A
	5%	49.4	80	86.2	N/A	N/A
Cunninghams Creek	1%	111.6 *	N/A	90.4 *	N/A	N/A
	5%	91.9 *	N/A	67.2 *	N/A	N/A
Moonee Creek	1%	281.2	N/A	511.5	N/A	N/A
	5%	203.5	N/A	379.6	N/A	N/A
Sugarmill Creek	1%	132.0 *	N/A	173.1	N/A	N/A
	5%	99.4 *	N/A	127.3	N/A	N/A
Total Catchment	1%	413.2 *	N/A	655	595	580
	5%	302.9 *	N/A	485	430	400

* Arithmetic summation of contributing sub-catchments

The peak discharge rates determined for the 1994 study using the WBNM model are generally 30 - 80% greater than the 1983 study estimates determined using RORB models. However, the peak discharge estimate for the Cunninghams Creek catchment is some 20% less than previously estimated.

The 1983 study adopted impervious area fractions of 25 - 35% for the bulk of the Cunninghams Creek and Sugarmill Creek catchments, reflecting full urbanisation of future development areas.

The Skinners Creek and Upper Moonee Creek catchments were assumed to remain predominantly rural in character. Thus, the estimated peak discharges for Cunninghams Creek and Sugarmill Creek catchments were some 50% greater than for rural conditions.

The 1994 study adopted much lower urbanisation factors consistent with the existing rural nature of the catchments. Thus, the design peak discharges for the Cunninghams Creek catchment are significantly less than the 1983 study estimates.

It would be expected that the design peak discharges for the Sugarmill Creek catchment would also be less than the 1983 study estimates, due to the significant reduction in impervious area fraction adopted for the 1994 study. However, the latter study produced peak discharges some 30% greater, not less, than the previous study.

This anomaly is due to the different size, structure and type of hydrologic models used in the two studies.

The 1983 study developed separate models for the two main tributaries of the Sugarmill Creek catchment and for the Moonee Creek catchment. The 1994 study developed a single model for the total catchment area.

The 1994 study model had a more detailed structure covering the Skinners Creek catchment and adjacent development site with a very coarse structure for the Sugarmill Creek catchment. The primary purpose of the model was to determine runoff hydrographs for the proposed development site. Thus, model results can be considered to be reliable for the Skinners Creek catchment and less reliable for the other tributary catchments.

The Moonee Creek catchment can be divided into two principal sub-catchments which have a common outlet:

- Moonee Creek, catchment area 32.6 km^2
- Sugarmill Creek, catchment area 9.4 km^2

Separate rainfall-runoff models are required for both of these catchment areas in order to avoid discrepancies in the relative channel storage routing characteristics, which can occur when catchments having significantly different characteristics are lumped together in one model.

Due to the significant variation in design discharge estimates from the previous studies and reservations regarding the structure of the WBNM model used for the 1994 study, it was decided to develop RORB models for each of the major sub-catchments.

3.2 The RORB Rainfall-Runoff Model

RORB is a general runoff and streamflow computer model which calculates discharge hydrographs from rainfall and other channel inputs. The model is already distributed, non-linear and applicable to urban and rural catchments.

The model subtracts losses from rainfall to produce rainfall-excess which is routed through the catchment storage to produce a runoff hydrograph, the storage routing procedure is based on continuity and a storage function of the form:

$$S = 3600\ k\ Q^m$$

where

S is the storage (m^3)
Q is the discharge (m^3/s)
m is a dimensionless exponent
k is a dimensional empirical coefficient

The coefficient k is formed as the product of two factors:

$$k = k_c k_r$$

where

k_c is an empirical coefficient, applicable to the entire catchment
k_r is the relative delay time, applicable to an individual reach storage

In general, the relative delay time is based on the ratio of the channel reach length to the channel distance from the centroid of the catchment to the outlet. However, in cases of extreme variation in channel slope, or where channel slopes are very low (less than 0.5/km), the relative delay time may be modified to allow for the slope of the channel reaches.

Thus, the RORB model has two parameters which may be determined by calibration against recorded flood data. Where no recorded flood data are available, regional estimates of the parameters can be used.

The two model parameters are:

k_c - a measure of the catchment channel storage
m - a measure of the nonlinearity of the rainfall-runoff behaviour of the catchment

Australian Rainfall and Runoff (Ref.6) recommends the following regional estimates for the RORB model parameters for coastal New South Wales.

$$m = 0.8$$
$$k_c = 1.22\ A^{0.46}$$

where

A is the catchment area in km^2

The total Moonee Creek catchment can be considered to comprise the following principal tributary catchments which discharge into the tidal reaches of the lower Moonee Creek:

(i) Upper Moonee Creek, upstream of the Skinners Creek confluence
(ii) Skinners Creek
(iii) Cunninghams Creek
(iv) Sugarmill Creek

As discussed above, the channel routing carried out by the RORB model is dependent on the parameters 'k_c' and 'm' and the relative delay time, which is related to the channel distance from the centroid of the catchment to the outlet, 'd_{av}'.

Because of the interaction between the parameter 'k_c' and 'd_{av}', the RORB model for a total catchment may provide skewed discharge hydrographs for tributary catchments located near the outlet. It was anticipated that this would occur with the Sugarmill Creek catchment and possibly with the Cunninghams Creek catchment.

RORB models were developed for the total catchment and for the various sub-catchments and compared to assess the consistency of the storage routing characteristics. The comparison of relevant catchment characteristics and RORB model parameter k_c is summarised in Table 3.2.

Table 3.2

RORB Model Comparison

Catchment	Area (km^2)	k_c	d_{av} (km)	$\frac{k_c}{d_{av}}$
Upper Moonee Creek	19.21	4.75	5.50	0.95
Skinners Creek	6.73	2.9	3.19	0.91
Cunninghams Creek	4.39	2.4	1.44	1.67
Moonee Creek	32.59	6.1	6.53	0.93
Sugarmill Creek	9.4	3.4	2.39	1.43
Total Catchment	41.99	6.8	6.28	1.07

Comparison of the ratio k_c/d_{av} (Column 5 of Table 3.2) indicates that the RORB models for the Upper Moonee Creek, Skinners Creek and Moonee Creek catchments are relatively consistent. The values for Cunninghams Creek and Sugarmill Creek are substantially different. The data also indicates significant differences between the various tributary RORB models and the RORB model of the total catchment.

The inconsistency between the tributary RORB models and the total catchment models is demonstrated in Table 3.3 which shows the peak discharge determined for the various tributary catchments by the different RORB models for the 100 year ARI (Average Recurrence Interval) 3 hour storm for existing catchment conditions.

Table 3.3

Comparison of RORB Models in 100 year ARI 3 Hour Storm

CATCHMENT	Peak Discharge m^3/s		
	Tributary Models	Moonee Creek Model	Total Catchment Model
Upper Moonee	224.3	211.7	189.8
Skinners	109.1	107.1	97.2
Cunninghams	69.7	96.9	89.5
Moonee	374.3	374.3	332.8
Sugarmill	124.4	N/A	148.2
Total Catchment	494.7	N/A	444.5

The data presented in Table 3.2 indicates how the model results can be skewed when catchments with significantly different hydrologic parameters are lumped into a larger model. The peak discharges determined by the full catchment model for Cunninghams Creek and Sugarmill Creek are increased by 20 - 30 percent while peak discharges for Upper Moonee Creek and Skinners Creek are reduced by 10 - 15 percent relative to the peak discharges determined by the individual sub-catchment models.

Given the discrepancies outlined above, separate RORB models have been adopted for each catchment in order to determine inflow hydrographs to be input to the hydraulic model.

3.3 Catchment Development

The Moonee Creek - Sugarmill Creek catchment is predominantly rural in character, comprising hardwood forest, rainforest, banana plantations, cleared grazing, agricultural and rural - residential land, mangroves, and residential development at Sapphire, Moonee Beach and Emerald Beach villages.

The current Development Control Plan (DCP) for the area allows for extensive residential, medium density residential accommodation and tourist facility development and rural - residential development within the study area.

The land use zonings under the current DCP are shown on Figure 6.

The impervious area factors adopted for the various development types are set out in Table 3.4.

Table 3.4

Adopted Impervious Area Factors

Type of Development	Factor
Rural - Residential	0.03
Residential (Detached)	0.30
Medium Density Residential and Tourist Facilities	0.45

The factors given in Table 3.4 have been adopted for those lands which are appropriately zoned under the DCP in order to estimate ultimate design flows for input to the hydraulic model.

The development of the study area, as envisaged in the current DCP, was found to increase peak runoff rates by less than 1 percent. The minimal change in peak flow reflects the relatively low infiltration rates compared to design rainfall, and the minor increase in the ratio of impervious area to total catchment area.

Design inflow hydrographs used as inputs to the hydraulic model were determined for post-development catchment conditions.

The individual catchment RORB models are discussed below. The layout of the RORB models and schematic representations are shown on Figures 7 and 8. The RORB model data files are presented in Appendix A.

3.4 Moonee Creek

Moonee Creek has a catchment area of 32.59 km^2, extending from the Pacific Ocean to the mountain ranges some 5 km to the west. The catchment area comprises four (4) major sub-catchments:

- upper Moonee Creek (catchment area 19.21 km^2)
- Skinners Creek (catchment area 6.73 km^2)
- Cunninghams Creek (catchment area 4.39 km^2)
- tidal reaches of Moonee Creek (catchment area 2.26 km^2)

The Pacific Highway traverses the catchment from north to south 1.5 - 2 km from the Pacific Ocean.

The upper reaches of the catchment are relatively steep and rugged while the middle and lower reaches are located on gently undulating to flat coastal plain.

The vegetation of the catchment comprises hardwood forests, rainforest, banana plantations and cleared grazing, agricultural and rural - residential land with hardwood forest and mangroves on the Moonee Beach Nature Reserve located between Moonee Creek and the Pacific Ocean and extending approximately 3 km along the coast north from the creek entrance.

The southern fringes of Emerald Beach village and the greater part of Moonee Beach village are located within the catchment.

The current DCP for the area allows for residential development over much of the land located south of Skinners Creek between the Pacific Highway and Moonee Creek and adjacent to Old Bucca Road. The DCP allows for rural - residential type development of a large tract of land located north of Skinners Creek between the Pacific Highway and the Orara East State Forest. The remainder of the catchment is zoned for rural, open space and environmental protection purposes.

The estimated impervious area fraction for full future development varies from 3% for rural - residential development areas to 30% for residential areas.

There are two large farm dams located adjacent to Smiths Road and the Pacific Highway. The storage routing effects have not been included in the RORB model due to the lack of adequate storage and discharge data. The catchment areas for each of the dams is relatively small and the assumption of the dams being full prior to the commencement of rainfall is considered to have a minor impact on the modelling of flood behaviour.

Similarly, the storage routing effects of the culverts under the Pacific Highway have not been included in the RORB model as this is to be incorporated into the hydraulic model.

Separate RORB models were developed for the upper Moonee Creek, Skinners Creek, and Cunninghams Creek catchments in order to determine runoff hydrographs for each sub-catchment for input to the hydraulic model. Runoff hydrographs into the tidal reaches of Moonee Creek were determined using the RORB model for Moonee Creek.

The regional estimates for the channel storage parameter 'k_c' adopted for each model are given in Table 3.5. The channel storage was distributed on the basis of reach length.

Table 3.5

Adopted k_c Estimates - Moonee Creek Sub-catchments

Sub-catchment	k_c
Upper Moonee Creek	4.8
Skinners Creek	2.9
Cunninghams Creek	2.4
Moonee Creek	6.1

3.5 Sugarmill Creek

The Sugarmill Creek catchment extends over an area of 9.4 km^2 between the Pacific Ocean and the mountain ranges some 3 km to the west. The Pacific Highway traverses the catchment from north to south, separating the steeper, more rugged upper reaches from the much flatter coastal plain reaches.

The vegetation to the west of the Pacific Highway comprises banana plantations, hardwood forests, rainforest and cleared grazing, agricultural and rural - residential land. To the east of the Pacific Highway, the vegetation comprises mainly hardwood forest and cleared land with mangroves along the lower tidal reaches.

The southern fringes of Moonee Creek village and the northern fringes of Sapphire village are also located within the catchment.

Runoff from the western catchment sub-areas flows through six (6) culvert structures under the Pacific Highway. The storage routing effects of these culverts was not incorporated into the RORB model as these culverts were to be included into the hydraulic model.

The current DCP allows for development of medium-density residential accommodation and tourist facilities over a significant area of land which is currently rural in nature.

The estimated impervious area for full future development of the sub-areas located to the east of the Pacific Highway varies between 8% and 25%.

The regional estimate for the channel storage parameter 'k_c' adopted for the model is 3.4 and is distributed on the basis of reach length.

3.6 Historical Flood Events

Rainfall data for the severe storm event on 23 November 1996 was collected from official and private raingauges throughout the greater Coffs Harbour area, extending from Bonville in the

south to Woolgoolga in the north and west to Coramba on the western side of the coastal ranges. The rainfall recorded in and adjacent to the Moonee Creek catchment is listed in Table 2.1.

Unfortunately, the rainfall data is generally limited to the coastal strip within the Moonee Creek catchment area. The recorded rainfalls decreased from 250 mm at Sapphire to 120 mm at Emerald Beach.

The recorded rainfall data in the greater Coffs Harbour area indicated that significantly more rain fell at the base and on the slopes of the coastal ranges. On the basis of this general rainfall gradient, the rainfall for the uppermost sub-areas within the Sugarmill Creek sub-catchment were increased by 60%. This difference in rainfall was typical of the rainfall variation between gauges located approximately 2 - 3 km from the coast and those located within 1 km of the coastline.

The rainfall adopted for the uppermost sub-areas of the Cunninghams Creek, Skinners Creek and Moonee Creek sub-catchments were also increased by 30 to 60% in order to allow for the probable higher rainfall on the slopes of the coastal range.

Limited anecdotal information obtained from long-term residents indicates that the most severe flooding occurred in March 1974 when 305 mm of rainfall was recorded for one day and 580 to 600 mm of rainfall was recorded over a three day period. The 1983 flood study attempted to obtain flood level information for this event without success.

Daily rainfall data had been collected for the 1983 flood study and for the Lower Coffs Creek Flood Study (Ref. 9). The latter study also obtained pluviograph data from the Coffs Harbour Airport and Upper Orara pluviometers.

3.7 Design Flood Events

One of the principal objectives of the study is the definition of design flood levels and extents along each of the tributary creeks for a range of exceedence probabilities. Therefore, design flood hydrographs were determined for 1%, 5% and 20% AEP and the Probable Maximum Flood (PMF) events.

Design rainfall intensities were determined for a range of storm durations in accordance with the 1987 edition of Australia Rainfall and Runoff. The design rainfall data is presented in Table 3.6.

Table 3.6

Design Rainfall Intensities (mm/hr)

STORM DURATION (hours)	AVERAGE RECURRENCE INTERVAL (years)		
	5	20	100
1	60.4	78.9	103.4
1.5	47.7	62.7	82.6
2	40.2	53.0	70.1
3	31.5	41.8	55.6
4.5	24.8	33.1	44.3
6	20.7	27.8	37.3
9	16.3	22.1	29.7
12	13.6	18.5	25.1

The critical storm duration for the individual tributary creek catchments and for the total catchment is likely to vary between 1 hour and 3 hours, based on catchment areas. However, peak flood levels can be produced by longer duration events, when channel and floodplain storage effects are taken into account.

Therefore, design flood hydrographs were determined for a range of storm durations up to 12 hours. The calculated peak discharges for the 100 year ARI design rainfall for different storm durations are presented in Table 3.7. The "TOTAL CATCHMENT" discharges are determined by addition of the hydrographs for Moonee Creek and Sugarmill Creek.

The design flood discharge hydrographs were determined on the basis of full development of the catchments in accordance with the current DCP as outlined in the preceding sections. An initial loss of nil and a continuing loss of 2.5 mm/hr were adopted for the hydrologic modelling of the design floods.

Table 3.7

Estimated 1% AEP Design Flood Discharges (m^3/s)

Catchment	Storm Duration (hrs)						
	1.5	2	3	4.5	6	9	12
Upper Moonee Creek	209.1	222.5	224.4	224.6	236.4	**257.4**	215.7
Skinners Creek	104.5	**111.4**	109.1	106.1	110.3	105.3	93.2
Cunninghams Creek	67.7	**72.6**	68.7	70.7	69.3	68.1	62.3
Moonee Creek	321.2	355.7	374.5	376.0	385.6	**413.7**	343.3
Sugarmill Creek	107.4	118.7	124.5	124.2	126.2	**126.9**	109.1
TOTAL CATCHMENT	422.9	469.1	496.5	482.4	510.2	**538.7**	447.1

(Note: Maximum discharge shown in **bold**)

The data presented in Table 3.6 shows that the 2 hour storm produces the maximum peak discharge for the Skinners Creek and Cunninghams Creek catchments, while the 9 hour storm produces the maximum peak discharge for the Moonee Creek and Sugarmill Creek catchments.

The 1% and 5% AEP design flood discharges for the major tributary catchments are compared in Table 3.8 with the discharge estimates determined in the previous studies and with peak discharge estimates determined using the Probabilistic Rational Method (PRM). The "TOTAL CATCHMENT" discharges were determined by addition of Moonee Creek and Sugarmill Creek flows or by total catchment models, depending on the particular studies and models used.

Table 3.8

Comparison of Design Flood Discharges (Full Development)

Tributary	1% AEP				5% AEP			
	1983	1994	PRM	1996	1983	1994	PRM	1996
Upper Moonee Creek	159.8	243.3	316.5	257.4	117.2	174.9	218.6	189.1
Skinners Creek	66	118.1	140.2	111.4	49.4	86.2	96.5	80.4
Cunninghams Creek	84	90	94.5	72.6	63	66	65.1	53.3
Moonee Creek	281.2	511.5	468.7	413.7	203.5	364.9	320.1	302.3
Sugarmill Creek	132	173.1	167.6	126.9	99	127.2	114.9	93.8
TOTAL CATCHMENT	413	655	601.4	538.7	302	464.2	410.7	396.1

The design flood discharges presented in Table 3.8 show significant variation between the various hydrologic models.

There are significant differences between the results determined by the RORB models used for the 1983 study and for the current study. These differences can be attributed to the following factors:

(i) Storage parameters k_c have been estimated differently with the regional estimates being significantly less than the 1983 study estimates.

(ii) Design rainfall intensity-frequency-duration data has been revised in the 1987 edition of Australian Rainfall and Runoff with 100 year ARI design rainfall estimates some 15% greater than previously estimated.

(iii) The impervious area factor adopted for the 1983 study was greater than that determined for the current study.

(iv) The RORB model structures are different.

The estimated peak discharges for the Sugarmill Creek and Cunninghams Creek catchments are respectively 5% and 15% lower than the earlier (1983) study estimates. The peak discharges for the Upper Moonee Creek, Skinners Creek and Moonee Creek catchments are approximately 35% higher.

The peak discharges estimated by the WBNM model used in the 1994 study reflect the skewed results obtained from a total catchment model which does not have similar characteristics to the individual tributary catchments, as discussed in Section 3.2. The estimated peak discharge for the upper Moonee Creek catchment is relatively lower for the WBNM model while the peak discharges for the lower tributary catchments are relatively higher, reflecting the skewed results.

The WBNM model was primarily used for investigation of a development site adjacent to Skinners Creek and the middle reaches of Moonee Creek. The estimated peak discharges for Skinners Creek determined by the WBNM are approximately 7% higher than the RORB model estimates.

A WBNM model of Skinners Creek was also developed for the 1990 flood study undertaken for the Forest Glen estate, which is located adjacent to Yellow Water Holes Creek which joins Skinners Creek immediately upstream of the Pacific Highway. The 1% and 5% AEP design flood discharges at the mouth of Skinners Creek, determined by this WBNM model are 111 m^3/s and 80 m^3/s respectively. These results are the same as those obtained from the current RORB model.

The peak discharge estimates obtained from the PRM model are 10 - 30% greater than the RORB model results. The PRM results are primarily dependent on the probabilistic runoff coefficient adopted for the catchment. This coefficient is a "best estimate" only, and is based on interpolation/extrapolation of limited data over a wider geographic area.

There is no flow data available for calibration of the hydrologic models. The current RORB modelling is considered to provide appropriate design flood hydrology because:

- tributary catchments have been modelled separately;
- regional parameter estimates have been adopted; and
- similar results have been obtained for Skinners Creek catchment using WBNM models developed for other studies.

3.8 Probable Maximum Flood

The 1% AEP peak discharge estimates set out in Table 3.7 indicate that the critical storm duration is 2 hours for Skinners Creek and Cunninghams Creek and is 9 hours for the remainder of the study area.

Probable Maximum Precipitation (PMP) estimates for storm durations of 2 hours and 6 hours were determined in accordance with the procedures set out in Bulletin 53 (Ref.7). The PMP for a 24 hour duration was determined using the Generalised Storm Method developed by Kennedy and Hart (Ref.8). The 9 hour PMP estimate was obtained by interpolation between the 6 hour and 24 hour PMP estimates.

The estimated 2 hour PMP is 460 mm, equivalent to 3.3 times the 100 year ARI rainfall. The estimated 9 hour PMP is 800 mm, equivalent to 3 times the 100 year ARI rainfall.

The estimated Probable Maximum Flood (PMF) peak discharges for the major tributaries are listed in Table 3.9.

Table 3.9

Estimated Probable Maximum Flood (PMF) Peak Discharge

Catchment	Peak Discharge m^3/s	
	2 Hour Storm	9 Hour Storm
Upper Moonee	892	596
Skinners Creek	411	226
Cunninghams Creek	260	143
Moonee Creek	1,451	989
Sugarmill Creek	482	297
Total Catchment	2,031	1,281

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4. HYDRAULIC MODELLING

4.1 Overview

The implementation of appropriate floodplain management measures requires knowledge of flood levels and velocities and the extent of flooding within the study area. There is insufficient flood information for the study area available from historical flood events to enable flood behaviour to be predicted using recorded data alone.

Computer-based hydraulic models have been developed in order to provide reliable simulation of flood behaviour using topographic information and runoff data generated by hydrologic modelling.

The model parameters are usually calibrated using recorded flood data for one or more historical flood events. The model is then verified by comparison with recorded data for a flood event which has not been used in the calibration process.

An interview survey of long-term residents of the study area yielded limited anecdotal flood data for the March 1974 flood. This was the largest flood to have occurred in the past 30 years. The 1967 design drawings for the Pacific Highway indicate "Highest Flood Level" at a number of sites, though no date is given for these events.

Peak flood level information was obtained at a number of locations in the study area for the November 1996 storm event. The rainfall over the Moonee Creek catchment was much less intense than that experienced in Coffs Harbour, with the result that minor flooding only was reported north of Moonee Beach. Flooding was more significant in the southern portion of the study area, with the "Split Solitary" caravan park suffering extensive inundation and damage to caravans and cabins.

Sufficient flood level information was collected to enable calibration of the hydraulic model.

Design flood levels have been estimated for various regions of the study area in previous studies. These design flood levels were determined using a steady-state backwater model and discharges determined by a variety of hydrologic models.

There is considerable variation in the design flood levels determined in the earlier studies where the modelling overlaps. This variation is due to two principal factors:

- different design flood discharges; and
- different ocean water levels at the entrance of Moonee Creek.

The steady-state backwater hydraulic models used for the previous study do not allow for floodplain storage routing effects. There is considerable floodplain storage available throughout the study area which has not been incorporated into the previous modelling.

Thus, a MIKE-11 computer hydraulic model of the study area was established in order to determine flood levels, flows, velocities, and flood extents throughout the study area.

MIKE-11 is a one-dimensional, link-node type of numerical model for unsteady flow, which was developed by the Danish Hydraulics Institute. The model comprises a network of branches (links) connecting junctions (nodes). The junctions are generally located where flow splits or converges, with the stream channel and floodplains being the branches.

Breakout flows from the creek channels onto the floodplain can be modelled using notional weirs. The model can also accommodate structures such as culverts and weirs.

4.2 The Hydraulic Model

The hydraulic model extent and configuration is shown on Figure 10, while the model is presented schematically on Figure 11.

The model comprises the following elements:

- 70 channel branches
- 214 cross-sections
- 53 junctions
- 17 culverts
- 33 weirs
- 1 tailwater boundary
- 40 inflow hydrographs

Cross-section survey data was obtained from the previous studies, with additional ground survey being undertaken for the upper reaches of Moonee Creek. This data was supplemented with cross-sections obtained from detailed survey mapping of land adjacent to the Coffs Harbour Zoo.

The locations of the cross-sections are shown on Figure 5.

4.3 Calibration

Calibration of the hydraulic model was based on flood level data collected following the November 1996 storm. The rainfall recorded in the study area varied from 250 mm at Sapphire to 120 mm at Emerald Beach at the southern and northern limits of the study area. Rainfall on the slopes of the coastal range in the upper portions of the catchment are considered to have been 30 - 60% greater than that recorded on the coast.

The November 1996 storm is considered to be greater than the 20 year ARI rainfall over the Moonee Creek, Skinners Creek and Cunningham Creek sub-catchments, and greater than the 100 year ARI rainfall over the Sugarmill Creek sub-catchment.

The results of the model calibration for this event are summarised in Table 4.1. In general, the modelled peak flood levels were within 0.1 m of the recorded flood levels. This is considered to be an acceptable calibration, given the sparsity of recorded rainfall data available for the event.

Table 4.1

November 1996 Flood Calibration

Location	Recorded Level (m AHD)	Calculated Level (m AHD)
u/s Emerald Beach Residential Area	8.52	8.60
Entry to 10 Beacon Terrace	8.28	8.25
u/s entry road "Heritage Park"	5.85	5.82
Skinner Creek gauge	<2.5	2.43
end Woodhouse Road	3.53	3.46
60 m u/s Sugarmill Creek footbridge	1.97	2.00
Sugarmill Creek footbridge	1.5±	1.58
Split Solitary Caravan Park (South)	3.85	3.78
Split Solitary Caravan Park (North)	3.70	3.46

The only other reliable flood level was provided by a long-term resident of Emerald Beach village for the March 1974 flood. This level at RL 8.37 m AHD was recorded in Moonee Creek, some 400 m downstream of the Pacific Highway. Limited anecdotal advice on flood behaviour was provided by residents at other locations, though flood marks could not be identified with any degree or certainty.

The March 1974 flood was caused by persistent rainfall of some 600 mm over a three day period. The most intense 2 hour duration burst of rainfall was equivalent to the 8 year ARI design rainfall although the one day rainfall was equivalent to the 20 year design rainfall. This event is generally considered to be the largest flood event in the past 30 years.

For this historical event, the depth of continuous rainfall over a period of 36 hours was more significant than the intensity of any short burst of heavy rainfall.

The March 1974 flood was modelled in order to test the model performance against the anecdotal evidence. The modelled flood level is 0.03 m below the only recorded flood level for this event.

The channel and floodplain roughness coefficients adopted for the model calibration and subsequent use in design flood modelling are summarised in Table 4.2.

Table 4.2

Adopted Roughness Coefficients

Type of Reach		Mannings 'n'
Floodplain	- grassed	0.05, 0.06
	- light timber	0.08
	- heavy timber	0.10
Creek Channels	- non-tidal	0.05 - 0.08
	- tidal	0.035

4.4 Design Flood Modelling

Design flood hydrographs for 1%, 5% and 20% AEP and PMF events were determined for storm durations between 2 hours and 12 hours and routed through the hydraulic model in order to determine the envelope of design flood levels at all locations within the study area.

The RORB model results indicated that the critical storm duration varies from 2 hours for Skinners Creek and Cunninghams Creek catchments to 9 hours for Sugarmill Creek and Moonee Creek catchments (Table 3.6).

The design 1% and 5% AEP ocean water level hydrographs derived for the Lower Coffs Creek Flood Study (Ref.9) were adopted for the tailwater boundary to the hydraulic model. The estimated 20% AEP ocean water level hydrograph was derived by extrapolation of the storm surge and set-up data for the 1%, 2% and 5% events determined for the former study. The peak water levels adopted for the design flood events are presented in Table 4.3.

Table 4.3

Design Ocean Storm Water Levels

AEP (%)	Peak Level (m AHD)
1	2.4
5	2.1
20	1.7

The 1% AEP ocean water level stage hydrograph was also adopted for the PMF event.

The timing of the ocean water level hydrographs was set such that the peak ocean water level approximately coincided with the time of the peak discharge at the creek entrance. The adopted timing of the ocean stage hydrographs relative to the start of the storm rainfall is presented in Table 4.4.

Table 4.4

Adopted Timing of Ocean Storm Hydrograph

Storm Duration (hrs)	Time of Ocean Peak (hrs)
2	2
3	3
4.5	4
6	5
9	7
12	8

The estimated peak flood levels at various locations throughout the study area for different storm durations is summarised in Tables 4.5 to 4.8.

These results show that peak flood levels in the tidal reaches of the creeks generally occur during the 9 hour storm events, while peak flood levels elsewhere generally occur in the 2 hour storm events.

The hydraulic modelling also indicates that the Pacific Highway embankment and culverts provide a significant degree of storage routing, particularly for Moonee Creek and the various floodplain channels which drain to Moonee Creek to the north of Moonee Beach village. This storage routing effect is most significant at the northern limit of the study area.

The model results show that the culverts generally have adequate capacity to pass the 1% AEP flood with overtopping of the highway occurring at only 3 of the 25 culvert locations.

These culverts are located approximately 2 and 3 km south and 0.1 km north of the Moonee Beach Road intersection. Floodwaters would be up to 0.5 m over the highway for a period of less than 2 hours.

The Pacific Highway near Emerald Beach village is located on a 2 m high embankment, some 800 m long, which crosses Moonee Creek and the adjacent floodplain. There is a two cell 2.4 m x 1.8 m box culvert at Moonee Creek and 9 culverts comprising a total of 66 pipes at 1.2 m diameter and 8 pipes at 1.8 m diameter on the floodplain.

The highway embankment provides an extensive floodplain storage with a restricted outlet at the Moonee Creek channel, which passes through the residential development downstream. The extensive floodplain culverts discharge floodwaters across the floodplain, returning to Moonee Creek some 0.75 km south of the residential area. Thus, most of the floodwaters are diverted away from the residential area with the result that the 1% AEP flood is confined to the narrow channel through the residential area and flood levels in this reach vary by approximately 0.1 m between 20% AEP and 1% AEP design events.

The storage routing effect of the Pacific Highway culverts is less significant at the other sites. However, the depth of floodwaters on the floodplain between the Pacific Highway and Moonee Creek is significantly less than to the west (upstream) of the highway. The range of flood levels is also much less immediately downstream of the highway culverts.

Thus, it can be concluded that the culverts under the pacific Highway are the primary hydraulic control for flood levels on the floodplain both upstream and downstream. The Moonee Creek floodplain is generally perched 2 m or higher above the normal dry weather water levels in the creek. Thus, tidal behaviour does not affect flood behaviour away from the estuary region of the creek.

Table 4.5

1% AEP Calculated Peak Flood Levels (m AHD)

Location	Storm Duration (hrs)					
	2	3	4.5	6	9	12
MOONEE CREEK						
d/s Pacific Highway	**10.06**	10.06	10.05	10.05	10.05	10.03
at Tidal Limit	4.22	4.07	4.44	4.47	**4.57**	4.40
at Skinners Creek	2.80	2.65	2.78	2.18	**2.88**	2.83
at Cunninghams Creek	2.64	2.50	2.62	2.62	**2.69**	2.62
at Sugarmill Creek	2.41	2.41	2.41	2.41	**2.41**	2.41
at Entrance	2.40	2.40	2.40	2.40	**2.40**	2.40
SKINNERS CREEK						
u/s Pacific Highway	**3.90**	3.86	3.83	3.86	3.83	3.66
CUNNINGHAMS CREEK						
u/s Pacific Highway	**2.83**	2.67	2.71	2.67	2.76	2.74
SUGARMILL CREEK						
d/s Pacific Highway	**7.36**	7.29	7.32	7.30	7.24	7.15
at Tidal Limit	2.75	2.65	2.73	2.71	**2.79**	2.71
u/s Moonee Beach Village	2.71	2.61	2.70	2.69	**2.75**	2.68
"SAPPHIRE" TRIBUTARY						
d/s Pacific Highway	**7.04**	7.04	7.04	7.04	7.03	7.02
at Tidal Limit	2.76	2.66	2.74	2.73	**2.80**	2.73
"RUSHTON" TRIBUTARY						
d/s Pacific Highway	**6.38**	6.34	6.36	6.33	6.30	6.26
u/s Moonee Beach Village	**3.95**	3.90	3.92	3.89	3.83	3.75

Peak values shown in **bold**

Table 4.6

5% AEP Calculated Peak Flood Levels (m AHD)

Location	Storm Duration (hrs)					
	2	3	4.5	6	9	12
MOONEE CREEK						
d/s Pacific Highway	10.02	10.02	10.02	10.02	**10.02**	10.00
Tidal Limit	3.79	3.95	4.03	4.08	**4.21**	4.06
at Skinners Creek	2.34	2.43	2.42	2.43	**2.52**	2.46
at Cunninghams Creek	2.23	2.30	2.29	2.29	**2.35**	2.29
at Sugarmill Creek	2.11	2.11	2.11	2.11	**2.11**	2.11
at Entrance	2.10	2.10	2.10	2.10	**2.10**	2.10
SKINNERS CREEK						
u/s Pacific Highway	**3.52**	3.51	3.49	3.51	3.49	3.38
CUNNINGHAMS CREEK						
u/s Pacific Highway	**2.52**	2.48	2.47	2.44	2.48	2.45
SUGARMILL CREEK						
d/s Pacific Highway	**7.11**	7.07	7.08	7.05	7.02	6.96
at Tidal Limit	2.40	2.45	2.43	2.43	**2.49**	2.42
u/s Moonee Beach Village	2.33	2.40	2.39	2.38	**2.44**	2.36
"SAPPHIRE" TRIBUTARY						
d/s Pacific Highway	**7.01**	7.00	7.00	7.00	7.00	6.97
at Tidal Limit	2.38	2.45	2.45	2.44	**2.51**	2.45
"RUSHTON" TRIBUTARY						
d/s Pacific Highway	**6.24**	6.21	6.23	6.21	6.18	6.13
u/s Moonee Beach Village	**3.78**	3.74	3.76	3.74	3.70	3.64

Peak values shown in **bold**

Table 4.7

20% AEP Calculated Peak Flood Levels (m AHD)

Location	Storm Duration (hrs)					
	2	3	4.5	6	9	12
MOONEE CREEK						
d/s Pacific Highway	9.98	9.98	9.98	9.98	**9.98**	9.95
at Tidal Limit	3.29	3.46	3.58	3.64	**3.77**	3.65
at Skinners Creek	2.04	2.02	2.02	2.02	**2.10**	2.05
at Cunninghams Creek	1.92	1.90	1.90	1.90	**1.95**	1.89
at Sugarmill Creek	1.71	1.71	1.71	1.71	**1.71**	1.71
at Entrance	1.70	1.70	1.70	1.70	**1.70**	1.70
SKINNERS CREEK						
u/s Pacific Highway	**3.26**	3.23	3.22	3.22	3.18	3.09
CUNNINGHAMS CREEK						
u/s Pacific Highway	**2.31**	2.22	2.23	2.18	2.18	2.12
SUGARMILL CREEK						
d/s Pacific Highway	**6.93**	6.90	6.91	6.89	6.86	6.80
at Tidal Limit	**2.18**	2.16	2.14	2.14	2.19	2.10
u/s Moonee Beach Village	2.04	2.05	2.05	2.04	**2.09**	1.99
"SAPPHIRE" TRIBUTARY						
d/s Pacific Highway	6.94	6.93	6.94	**6.94**	6.93	6.90
at Tidal Limit	2.13	2.15	2.16	2.16	**2.19**	2.14
"RUSHTON" TRIBUTARY						
d/s Pacific Highway	**6.10**	6.06	6.08	6.05	6.02	5.98
u/s Moonee Beach Village	3.63	3.61	3.61	3.59	3.57	3.53

Peak values shown in **bold**

Table 4.8

PMF Calculated Peak Flood Levels (m AHD)

Location	Storm Duration (hrs)	
	2	9
MOONEE CREEK		
d/s Pacific Highway	**10.44**	10.14
at Tidal Limit	**5.81**	5.47
at Skinners Creek	4.05	**4.09**
at Cunninghams Creek	3.66	**3.67**
at Sugarmill Creek	2.52	**2.52**
at Entrance	2.40	**2.40**
SKINNERS CREEK		
u/s Pacific Highway	**5.80**	4.85
CUNNINGHAMS CREEK		
u/s Pacific Highway	**3.90**	3.73
SUGARMILL CREEK		
d/s Pacific Highway	**8.26**	7.76
at Tidal Limit	**3.97**	3.54
at Caravan Park	**3.93**	3.50
"SAPPHIRE" TRIBUTARY		
d/s Pacific Highway	7.18	**7.19**
at Tidal Limit	**3.99**	3.57
"RUSHTON" TRIBUTARY		
d/s Pacific Highway	**7.23**	6.70
us Moonee Beach Village	**4.92**	4.36

Peak values shown in **bold**

The impact of the storage routing effect of the Pacific Highway culverts and the channel routing effects of the tidal reaches is demonstrated in Table 4.9 which compares the RORB hydrologic model peak discharges with the resultant MIKE-11 hydraulic model peak discharges for the 1% AEP 2 hour design flood.

Table 4.9

Comparison of Hydrologic and Hydraulic Model Peak Flows

Catchment	Peak Discharge (m^3/s)	
	RORB	MIKE-11
Upper Moonee Creek	222.5	133.6
Skinners Creek	111.4	100.3
Cunninghams Creek	72.6	68.0
Moonee Creek	355.7	258.0
Sugarmill Creek	118.7	88.0
Total Catchment	469.1	347.8

The data presented in Table 4.9 shows that channel and floodplain storage effects are significant for Moonee Creek and Sugarmill Creek.

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5. DESIGN FLOOD LEVELS AND EXTENTS

5.1 Design Flood Levels

The proposed design flood levels for the 1%, 5% and 20% AEP and PMF events are presented in Appendix D. The channel distances refer to the surveyed cross-sections shown on Figure 5. These design flood levels represent the envelope of peak flood levels for storm durations between 2 hours and 9 hours. The design flood profiles are plotted on Figures 12 and 13.

The approximate extent of inundation in the 1% AEP design flood is shown on Figures 14 and 15. These extents have been defined at the surveyed cross-sections and interpolated between cross-sections based on available contour mapping. The 1% AEP design flood contours are also shown on flood extent maps.

Figure 14 shows that Moonee Creek has an extensive floodplain upstream from Cunninghams Creek and a large tidal estuary between Cunninghams Creek and the entrance. Sugarmill Creek has an extensive floodplain in the lower reaches.

Skinners Creek and Cunninghams Creek have relatively confined floodplains and the channel storage effects are much less for these two creeks.

The hydraulic modelling indicates that the velocity of floodwaters is generally 0.8 to 2.4 m/sec in the creek channels and 0.2 to 0.5 m/sec on the floodplain. Typical flow velocities at the flood peak are shown on Figures 16 and 17.

5.2 Comparison with Previous Studies

The 1983 and 1994 flood studies used HEC-2 steady-state hydraulic models with peak discharges determined by hydrologic models in order to estimate design flood levels at various locations in the study area.

The data presented in Table 4.7 shows that channel and floodplain storage effects are significant, with peak discharges being reduced by 25 - 40% for Moonee Creek and Sugarmill Creek. Thus, steady state models produce higher design flood level estimates in the tidal reaches of the creeks where the routing is most significant.

The estimated design flood levels obtained from the steady-state HEC-2 models used in the previous studies are compared with those obtained from the MIKE-11 unsteady flow hydraulic model in Table 5.1.

As shown in Table 5.1, there are significant differences between the peak discharges derived in the previous studies and the discharges determined by hydraulic modelling. The variations in hydrologic modelling are discussed in Section 3.1.

Table 5.1

Comparison of Design Flood Data from Previous Studies

LOCATION	1% AEP Design Flood Data					
	1983 STUDY		1994 STUDY		MIKE-11 MODEL	
	Peak Level (m AHD)	Discharge (m^3/s)	Peak Level (m AHD)	Discharge (m^3/s)	Peak Level (m AHD)	Discharge (m^3/s)
MOONEE CREEK						
at Skinners Creek	3.01	233	3.68	439	2.88	225
at Cunninghams Creek	2.73	281	3.38	504	2.69	269
at Sugarmill Creek	2.60	655	2.60	655	2.41	380
at Entrance	2.60	412	2.60	655	2.40	380
SKINNERS CREEK						
"Heritage Park"	N/A	N/A	12.15	57	12.83	76
u/s Pacific Highway	3.74	72	3.78	103	3.90	89
CUNNINGHAMS CREEK						
at Study Limit	11.86	54	N/A	N/A	11.98	41
u/s Pacific Highway	3.12	61	N/A	N/A	2.83	52
SUGARMILL CREEK						
d/s Pacific Highway	6.95	30	N/A	N/A	7.36	43
u/s Caravan Park	2.60	134	N/A	N/A	2.75	88
"SAPPHIRE" TRIBUTARY						
d/s Pacific Highway	7.17	12	N/A	N/A	7.04	3
at Caravan Park	3.96	23	N/A	N/A	3.78	12
"HERITAGE PARK" DRAIN						
u/s Top Weir	N/A	N/A	9.02	32	8.30	13
u/s Pacific Highway	N/A	N/A	5.35	20	5.23	19

The 1983 study adopted an ocean water level at RL 2.4 m AHD for the HEC-2 modelling and a 1% AEP design ocean water level at RL 2.6 m AHD. The design flood levels adopted in the study for the lower estuary were set at the greater of the HEC-2 calculated flood level or the 1% AEP design ocean water level.

The 1994 study adopted the 1% AEP design ocean water level at RL 2.6 m AHD as the tailwater level for the HEC-2 modelling. This design ocean water level had been determined in the 1986 study of elevated ocean water levels at Coffs Harbour (Ref.8).

A 1% AEP design ocean water level at RL 2.4 m AHD has been adopted for the current hydraulic modelling. This design ocean water level was derived for the Lower Coffs Creek Flood Study completed in 1992.

Thus, the variation in design flood levels determined in the previous study and by the current modelling is due to three principal factors:

- different design discharges produced by the different hydrologic models used
- different design ocean water levels adopted for the different studies, and
- channel and floodplain storage effects not incorporated into the steady-state hydraulic models used in the previous studies.

The current study has used detailed hydrologic modelling and unsteady flow hydraulic modelling to determine design flood levels throughout the study area. The resultant design flood levels are thus based on the best information currently available.

5.3 Flood Hazard Assessment

The New South Wales Floodplain Development Manual recognizes three categories of flood-liable land, as follows:

1. Floodways - those areas where a significant volume of water flows during floods, where flow velocities are generally high and deeper flow may occur.
2. Flood Storage - those areas of the floodplain which provide temporary storage of floodwaters and flow velocities are generally low.
3. Flood Fringe - those areas of the floodplain not included in floodways or flood storage area.

Floodways are generally aligned with naturally defined channels and if partially blocked, can cause a significant redistribution of flood flow. The Manual also defines floodways as those areas where the product of depth and velocity of floodwaters exceeds 1.0 m^2/s.

The Manual also provides for two categories of flood hazard.

1. High Hazard - where floodwaters could cause structural damage to buildings, where floodwaters could present a danger to life and limb and where the resultant social disruption and financial losses could be great.

2. Low Hazard - where potential damages and risk to life and limb would be low.

The flood hazard classification incorporates assessment of the depth and velocity of floodwaters, effective evacuation time and evacuation difficulties.

A preliminary assessment of hazard is generally determined on the basis of the depth and velocity of the floodwaters. This preliminary assessment of hazard may be revised following a review of other factors including warning times, flood awareness, rate of rise of floodwaters and evacuation difficulties.

The preliminary assessment of flood hazard, based on the depth and velocity of floodwaters is shown on Figures 18 and 19. This assessment indicates that the "High Hazard" is confined to the creek channel areas, while the floodplain can generally be classified as "Low Hazard".

6. SENSITIVITY ANALYSES

The hydrologic and hydraulic models could not be calibrated independently. Therefore, regional parameter estimates have been adopted for the RORB hydrologic model with text-book roughness coefficients based on site inspection, adopted for the MIKE-11 hydraulic model. Calibration of the hydraulic model has been based on the November 1996 flood event.

The modelling results are based on the best available theoretical estimates for all parameters, the design flood levels are considered to be the best estimates currently available.

The sensitivity of the 1% AEP design flood levels has been tested for variation in the adopted modelling parameters, as discussed below.

The results of the sensitivity analyses are summarised in Table 6.1.

6.1 Channel and Floodplain Roughness

The channel and floodplain roughness coefficients adopted for the hydraulic model varied from 0.035 to 0.10 and 0.05 to 0.10 respectively, based on site inspection and calibration against November 1996 peak flood levels. These roughness coefficients were increased by 20% in order to test the sensitivity of the design flood levels to change in the roughness factors.

The increase in roughness coefficients produced increases in the 1% AEP design flood level less than 0.05 m in the tidal reaches and 0.05 - 0.15 m on the floodplain.

6.2 Ocean Water Level

The hydraulic modelling was based on the coincidence of flood producing rainfall and an elevated ocean water level of equivalent probability. This assumption is not unreasonable, given that elevated ocean water levels in the region are generally caused by meteorological conditions, particularly tropical cyclones which also produce intense rainfall.

However, maximum ocean water levels usually occur when the cyclone is located out to sea, whereas the heaviest rainfall frequently occurs after the cyclone has crossed the coastline. Thus, while cyclones can be the cause of flood rains and elevated ocean levels, there may be great differences in the probabilities of the rainfall and ocean water level in any cyclone event.

The sensitivity of the 1% AEP design flood levels to ocean water levels was tested by adopting normal spring tidal ocean water level at the entrance.

This analysis showed that the ocean water level affects flood levels within the tidal reaches and for a short distance upstream of the tidal limit. The influence of ocean water levels is generally limited to flood levels below approximately RL 4.0 m AHD.

The 1% AEP flood profile along Moonee Creek for normal spring tide conditions is compared with the design profile for ocean storm surge conditions on Figure 20.

6.3 Rainfall

The hydraulic modelling indicates that channel and floodplain storage effects and the hydraulic control exerted by the numerous culverts are the principal factors which determine flood behaviour throughout the study area. Thus, the volume of floodwaters and not only the peak discharge of the flood determine the peak flood levels.

The inflow hydrographs input to the hydraulic model generally represent runoff from sub-areas within the hydraulic model extent which are less than 120 ha in area. There are 10 inflow hydrographs which represent runoff from upstream catchment areas generally less than 200 ha in area, excluding the upper Moonee Creek catchment which extends over some 900 ha.

As stated in Section 4.4 the Pacific Highway embankment and culverts provide significant storage routing with the hydraulic capacity of the culverts determining downstream flows.

Changes in the channel storage parameters adopted for the individual catchment RORB models will alter the timing and resultant peak discharge for the catchments. However, the volume of runoff will be unaffected. The resultant variation in timing and magnitude of the peak of the runoff from the individual sub-areas is likely to be absorbed in the channel and floodplain storage routing in the hydraulic model.

Therefore, in order to test the sensitivity of the design flood levels to hydrologic uncertainties, the design rainfall was increased by 10% and the resultant hydrographs routed through the model.

The increased rainfall produced increases in the design flood level which were generally less than 0.1 m in the tidal reaches and on the floodplain. Flood levels in the upper reaches of Skinners Creek, Cunninghams Creek and Moonee Creek in the vicinity of the tidal limit were found to increase by approximately 0.15 m.

The rainfall for the November 1996 storm recorded at a number of locations in the Coffs Harbour area exceeded the 100 year ARI design rainfall for durations of up to 18 hours, although the storm lasted for only 7 hours. The rainfall for durations less than 6 hours greatly exceeded the design rainfall.

The November 1996 storm has raised some concerns as to the accuracy of the design rainfall estimates prepared by the Bureau of Meteorology. The design rainfalls are based on the analysis of rainfall records at Coffs Harbour and other rainfall stations, which form a very sparse network for the collection of rainfall data. There is a concern that the design rainfall may significantly under-estimate the rainfall for low probability events due to the lack of data available from the records.

The 1% AEP design flood levels have been adopted by Coffs Harbour City Council as the Flood Standard for planning purposes. These flood levels are generally derived from the 100 year ARI design rainfall estimates where there is insufficient data available for the flood levels to be determined by analysis of the record of historical flood levels.

In order to test the sensitivity of the 1% AEP design flood levels to possible increases in the 100 year ARI design rainfall as a result of further analysis of the November 1996 storm, flood profiles were determined using the 500 year ARI design rainfall estimates. These rainfalls are some 25% greater than the current 100 year ARI design rainfall.

It is noted that the current 100 year ARI design rainfall estimates are approximately 15% greater than the design rainfall estimates prepared some 15 years ago.

Peak flood levels for this scenario were found to be 0.2 - 0.3 m above the 1% AEP flood levels in the upper reaches of Moonee Creek, Skinners Creek and Cunningham Creek, and 0.1 - 0.2 m higher on the floodplain. The peak flood levels along the tidal reaches of these creeks ranged from 0.2 m near the tidal limit to less than 0.1 m within 1 km of the Moonee Creek entrance.

The peak flood levels in the upper reaches of Sugarmill Creek and tributary stream were 0.1 - 0.2 m higher than the 1% AEP design flood levels, while the difference in levels in the lower reaches was less than 0.1 m.

The variation in peak flood levels relative to the 1% AEP design flood levels at selected locations are presented in Table 6.1.

Thus, it is considered that the 1% AEP design flood levels are unlikely to be increased by more than 0.25 m adjacent to the upper reaches of the creeks or by more than 0.15 m on the floodplain or adjacent to the tidal reaches of the creek as a result of any revision of the design rainfalls.

6.4 "Greenhouse" Ocean Level Rise

There is some uncertainty as to the magnitude of any elevation of the ocean level resulting from the long-term global warming or "Greenhouse" effect. Therefore, in order to test the sensitivity of the design flood levels to possible increases in mean sea level and resultant design ocean levels, the 1% AEP design ocean level was raised to RL 2.6 m AHD.

This represents an increase of 0.2 m over the ocean levels adopted for the hydraulic model. This increase is widely considered to be possible within the next 50 years.

The resultant increases in design flood level were confined to the tidal reaches, consistent with the results obtained for testing the sensitivity of flood levels to ocean storm water levels. The 1% AEP flood profile with "Greenhouse" ocean storm surge conditions is plotted on Figure 20.

6.5 Conclusions

The sensitivity analyses indicate that substantial changes in the parameters and variables adopted in the modelling process produce relatively minor variations in the calculated design flood levels.

The uncertainty in the design flood levels is considered to be generally less than 0.15 m on the floodplain and in the non-tidal reaches of the creeks and 0.2 m in the tidal reaches to allow for possible "Greenhouse" ocean water level increases.

Table 6.1

Summary of Sensitivity Analyses

LOCATION	Variation in 1% AEP Design Flood Level (m)				
	20% Increase in Roughness	No Ocean Storm Surge	10% Increase in Rainfall	Greenhouse Ocean Rise	ARI 500 Rainfall
MOONEE CREEK					
d/s Pacific Highway	+ 0.07	-	+ 0.01	-	+ 0.01
at Tidal Limit	+ 0.12	- 0.01	+ 0.14	+ 0.01	+ 0.26
at Skinners Creek	+ 0.02	- 0.28	+ 0.06	+ 0.19	+ 0.22
at Cunninghams Creek	+ 0.01	- 0.42	+ 0.05	+ 0.19	+ 0.15
at Sugarmill Creek	-	- 1.34	-	+ 0.20	+ 0.01
at Entrance	-	- 2.12	-	+ 0.20	+ 0.01
SKINNERS CREEK					
u/s Pacific Highway	+ 0.17	- 0.02	+ 0.14	+ 0.02	+ 0.34
CUNNINGHAMS CREEK					
u/s Pacific Highway	+ 0.11	- 0.16	+ 0.09	-	+ 0.17
SUGARMILL CREEK					
d/s Pacific Highway	+ 0.16	-	+ 0.09	-	+ 0.20
at Tidal Limit	+ 0.04	- 0.23	+ 0.05	+ 0.15	+ 0.07
u/s Caravan Park	+ 0.03	- 0.32	+ 0.06	+ 0.17	+ 0.06
"SAPPHIRE" TRIB.					
d/s Pacific Highway	+ 0.01	-	+ 0.02	-	+ 0.04
at Caravan Park	+ 0.01	- 0.02	+ 0.03	-	+ 0.08
at Tidal Limit	+ 0.04	- 0.24	+ 0.06	+ 0.15	+ 0.09
"RUSHTON" TRIB.					
d/s Pacific Highway	+ 0.09	-	+ 0.06	-	+ 0.12
u/s Moonee Beach Village	- 0.03	- 0.03	+ 0.07	+ 0.15	+ 0.14

7. CONCLUSIONS

There is very little recorded flood information available for the Moonee Creek study area. Therefore the MIKE-11 hydraulic model was calibrated against one recorded event.

Regional parameter estimates for the channel storage parameter "k_c" and catchment non-linearity exponent "m" were adopted for each of the RORB models. Design flood modelling was based on full development of the catchment in accordance with the current Development Control Plan.

Future residential and rural-residential development within the catchment was found to produce less than 1.5% increase in peak discharges for the design flood events. Therefore, future development is unlikely to cause any significant change in general flood behaviour. The design flood flows and levels have been determined on the basis of full development in accordance with the current DCP.

Roughness coefficients for the creek channels and floodplain were determined by site inspection and reference to "text-book" estimates.

Modelled flood levels are generally within 0.1 m of reported flood levels for the November 1996 event used for calibration. The hydraulic modelling of the March 1974 event agreed with the anecdotal evidence on flood behaviour which was provided by long-term residents of the study area.

The hydraulic modelling showed that floodplain and channel storage routing is significant throughout the study area. The Pacific Highway embankment and culverts provide the hydraulic control for the Moonee Creek floodplain branches.

The design flood levels determined using the MIKE-11 unsteady flow hydraulic model are significantly different from the design flood levels determined in the previous studies. These differences are due to the following factors:

- different design flood discharges produced by the different hydrologic models used;
- floodplain and channel storage effects; and
- different design ocean water levels adopted for the different studies.

Sensitivity testing of the design flood levels indicates that uncertainty is generally less than 0.15 m on the floodplain and in the non-tidal reaches of the creeks and 0.2 m in the tidal reaches. The uncertainty in the tidal reaches is due to possible elevation of the ocean water level due to "Greenhouse" effects.

Limited flood level survey of properties adjacent to the major flow paths indicates that the Emerald Beach residential area and most of the rural houses are located above the 1% AEP

design flood level. Only one rural house was identified as having the main floor below the 1% AEP design flood level.

Review of the hydraulic modelling results shows that the study can be split into four separate regions, based on flood behaviour, as follows:

- tidal reaches of the major tributaries, where flood levels are influenced by ocean water levels as well as discharge;
- the Moonee Creek floodplain between the Pacific Highway and Moonee Creek, where flood levels are primarily controlled by the culverts under the highway;
- the Moonee Creek floodplain west of the Pacific Highway, where flood levels are determined by discharge and may be influenced by the capacity of the culverts under the highway; and
- the upper reaches of the Sugarmill Creek tributaries, where flood levels are primarily determined by discharge.

The hydraulic modelling indicates that the culverts under the Pacific Highway can discharge the 1% AEP design flood with overtopping of the highway at only 3 locations.

The design flood levels have been determined using the most detailed hydrologic modelling and unsteady flow modelling and are thus based on the best information currently available.

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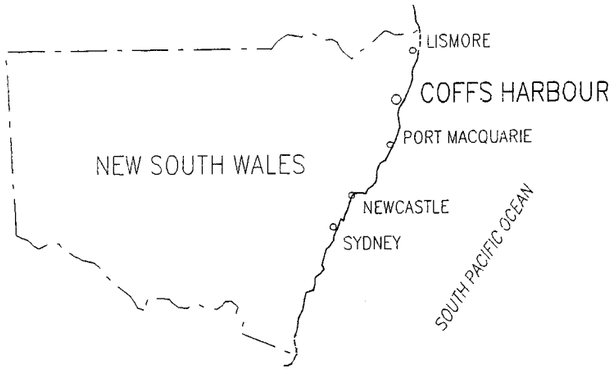
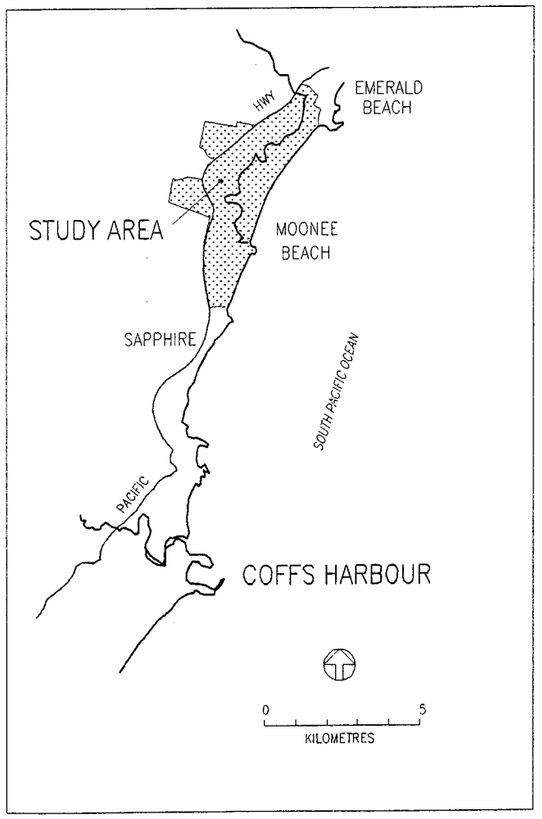
4. Forest Glen Estate Flood Study" - Kinhill Engineers Pty Ltd, Mar 1990
5. "Moonee Creek Flood Study" - Gutteridge Haskins and Davey Pty Ltd, June 1994, amended Oct 1995
6. "Australian Rainfall and Runoff" - Institution of Engineers, Australia 1987
7. "The Estimation of Probable Maximum Precipitation in Australia for Short Durations and Small Areas" - Bureau of Meteorology Bulletin 53, Aug 1984
8. "The Estimation of Probable Maximum Precipitation in Australia" - M R Kennedy and T L Hart, Civil Eng. Trans I E Aust Vol CE26, 1984
9. "Lower Coffs Creek Flood Study" - NSW Public Works, Jan 1992
10. "Coffs Harbour Flood of 23 November 1996 - Data Collection" Webb McKeown & Assocs, Jun 1997

FIGURES

DISK REF: 96025 R1
FILE NAME: 96025#1

MOONEE CREEK FLOOD STUDY





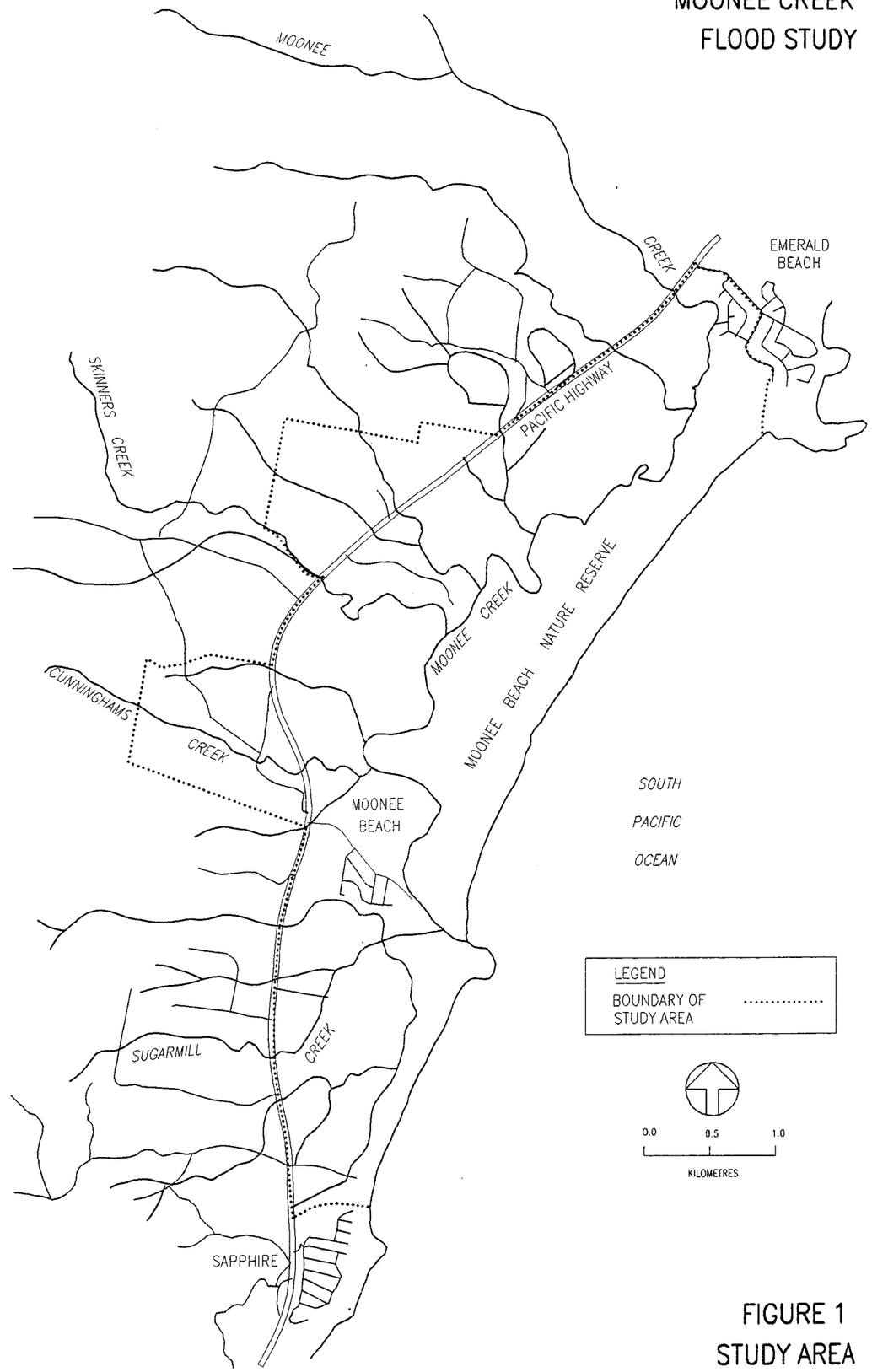


FIGURE 1
STUDY AREA

MOONEE CREEK FLOOD STUDY

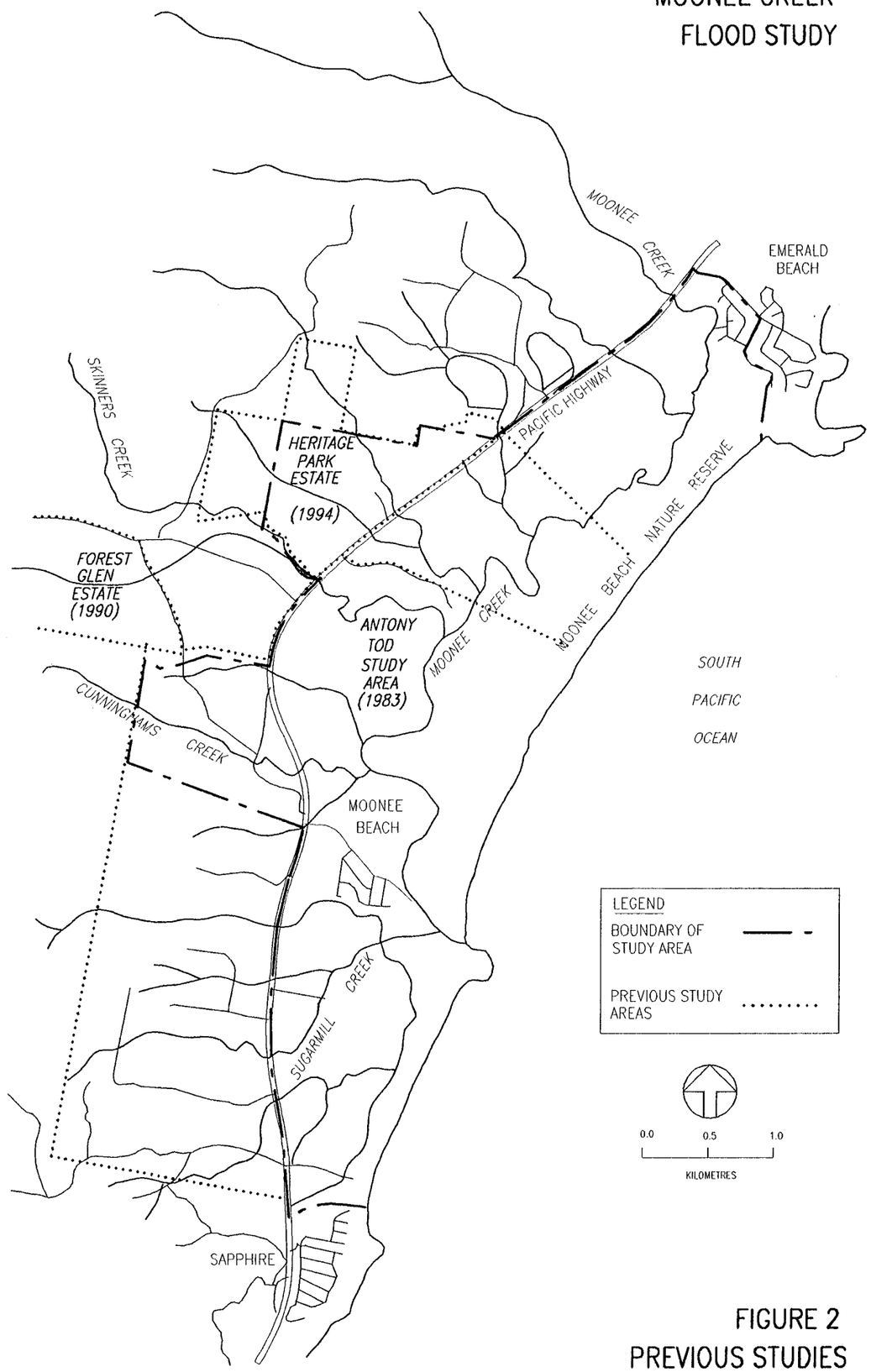


FIGURE 2
PREVIOUS STUDIES

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FILE NAME: 96025#2

MOONEE CREEK FLOOD STUDY

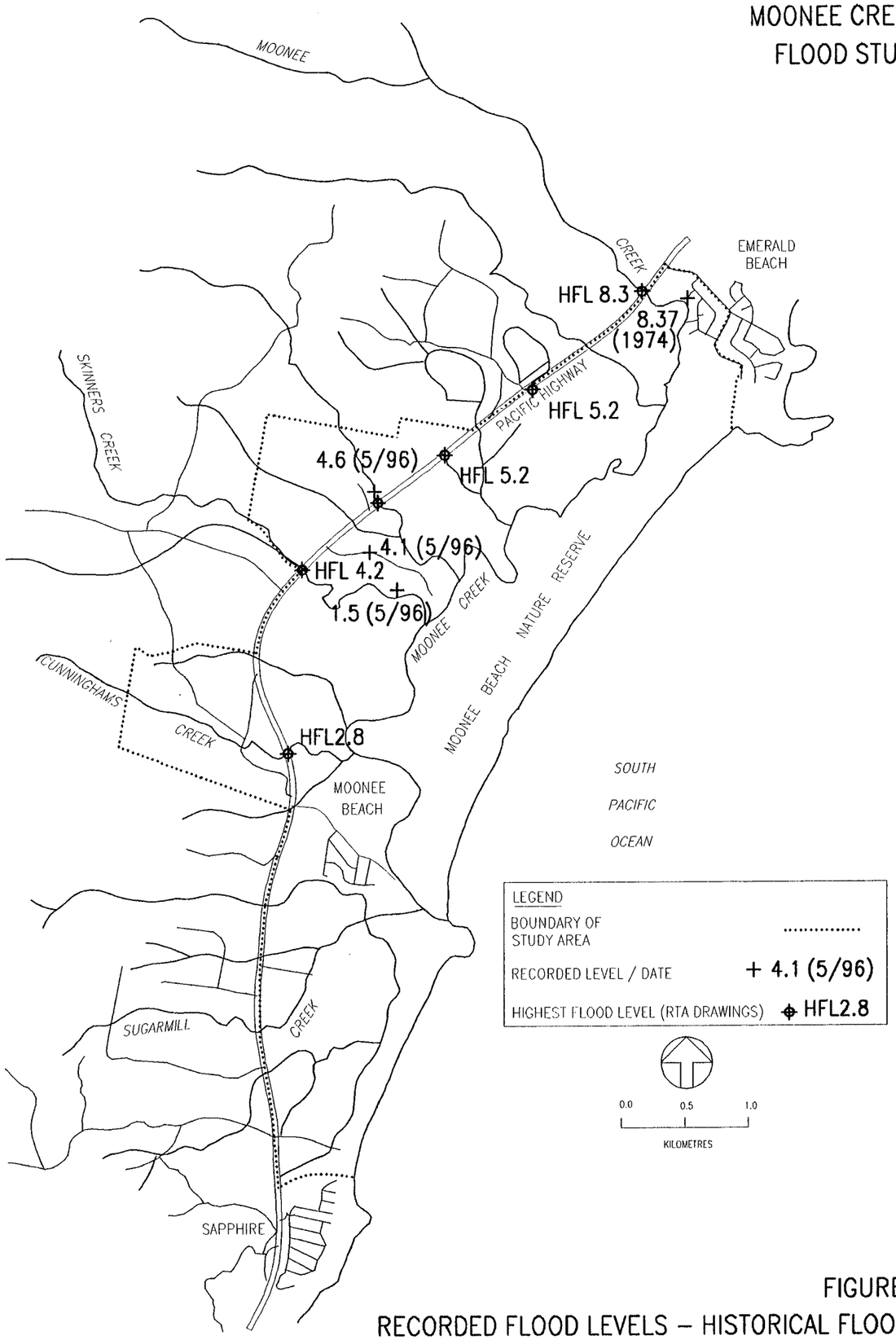

FIGURE 3
RECORDED FLOOD LEVELS – HISTORICAL FLOODS

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FILE NAME: 96025#3

MOONEE CREEK
FLOOD STUDY

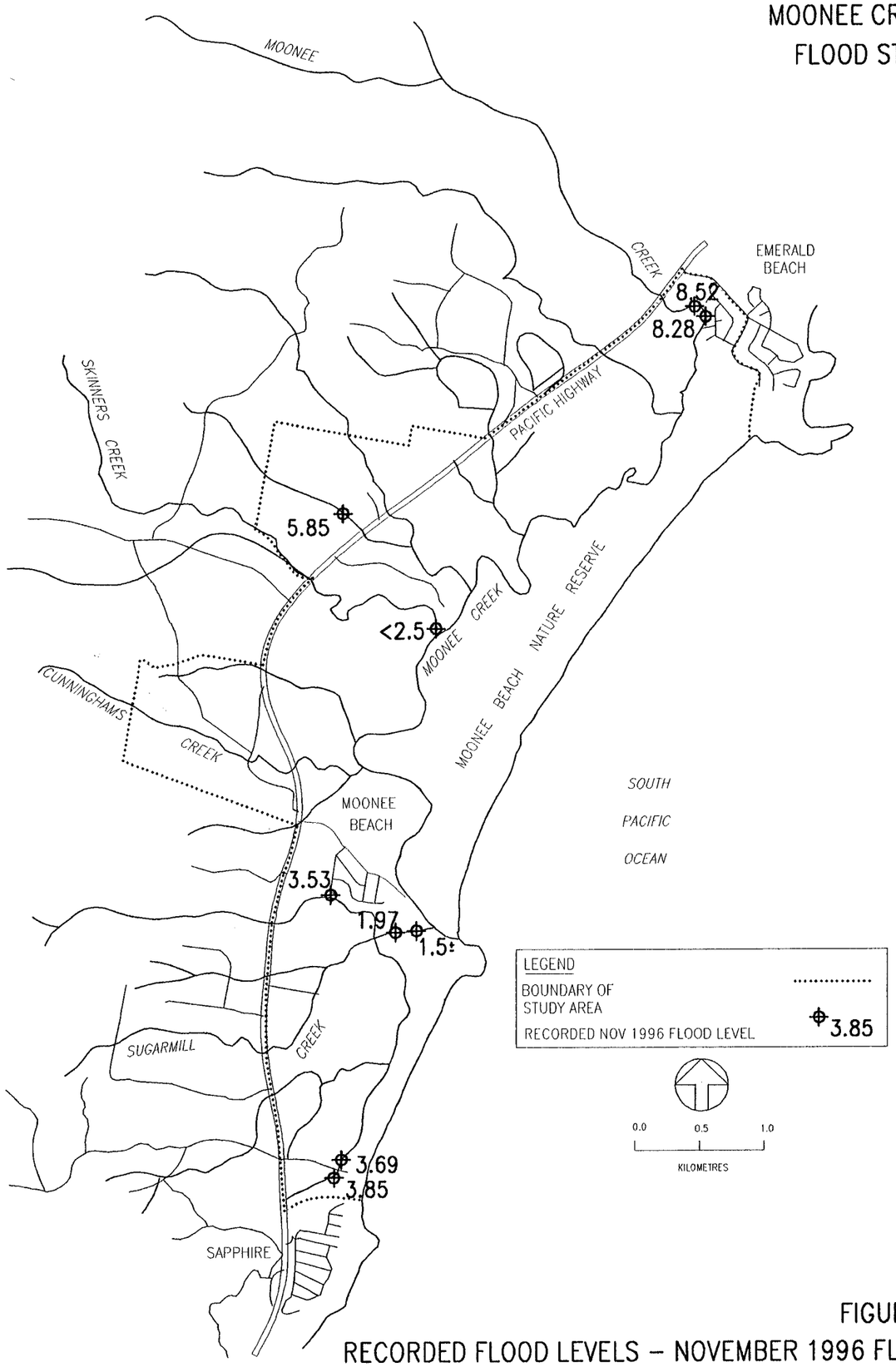

FIGURE 4
RECORDED FLOOD LEVELS – NOVEMBER 1996 FLOOD

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FILE NAME: 96025#4

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FILE NAME: 96025#5

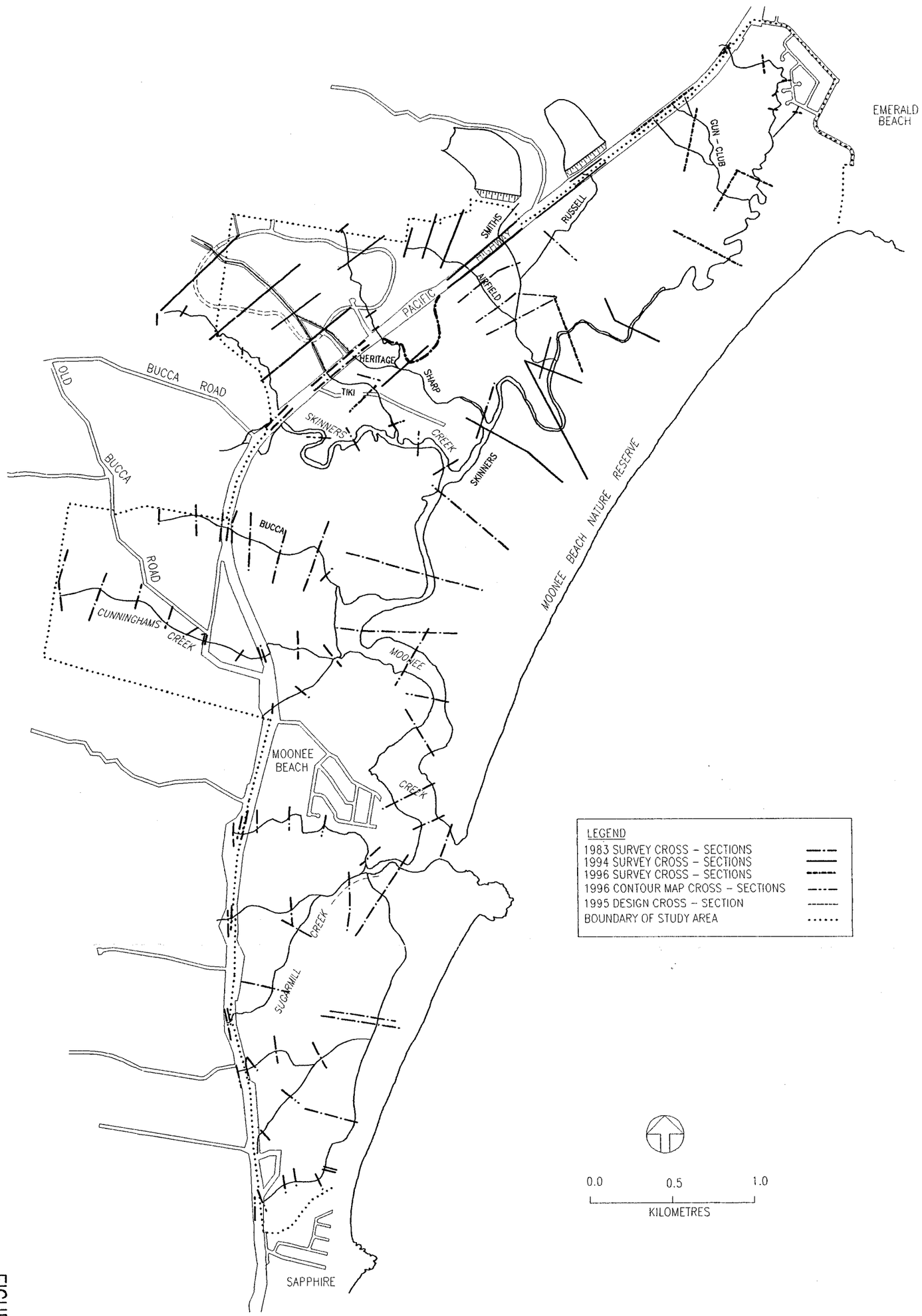

FIGURE 5
EXTENT OF SURVEYS

MOONEE CREEK
FLOOD STUDY

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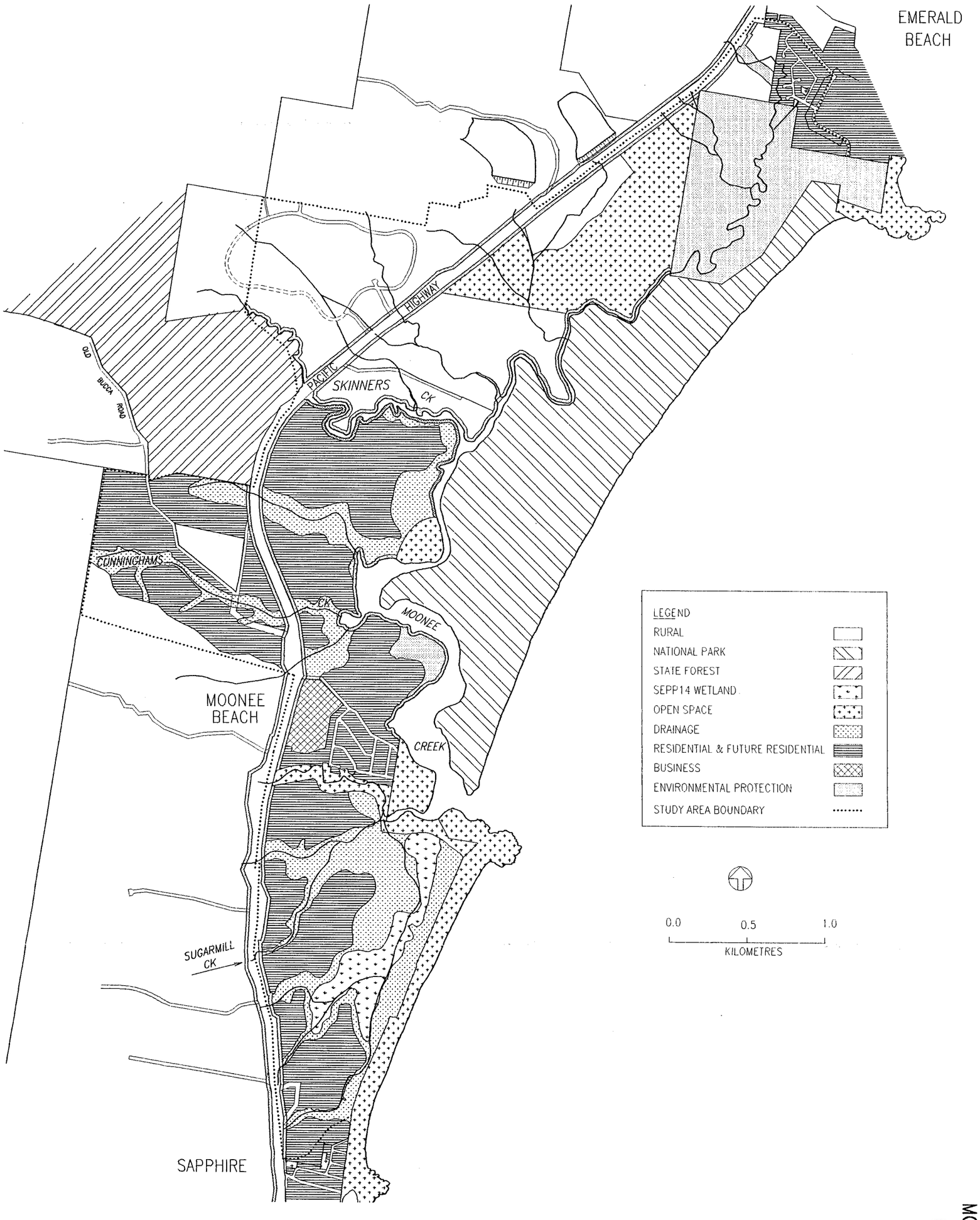

FIGURE 6
LAND – USE ZONINGS

MOONEE CREEK
FLOOD STUDY

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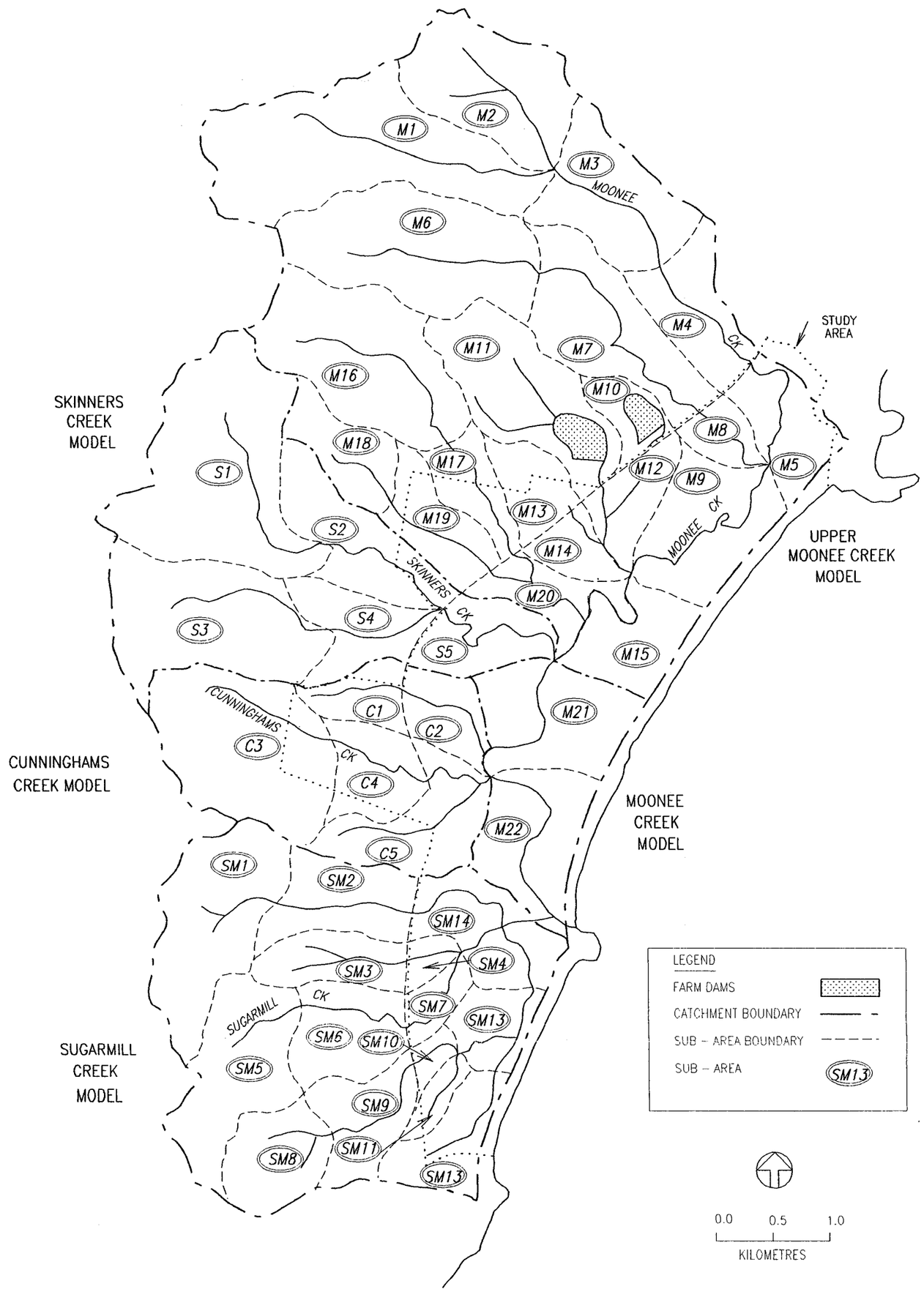

FIGURE 7
RORB MODEL LAYOUT

MOONEE CREEK
FLOOD STUDY

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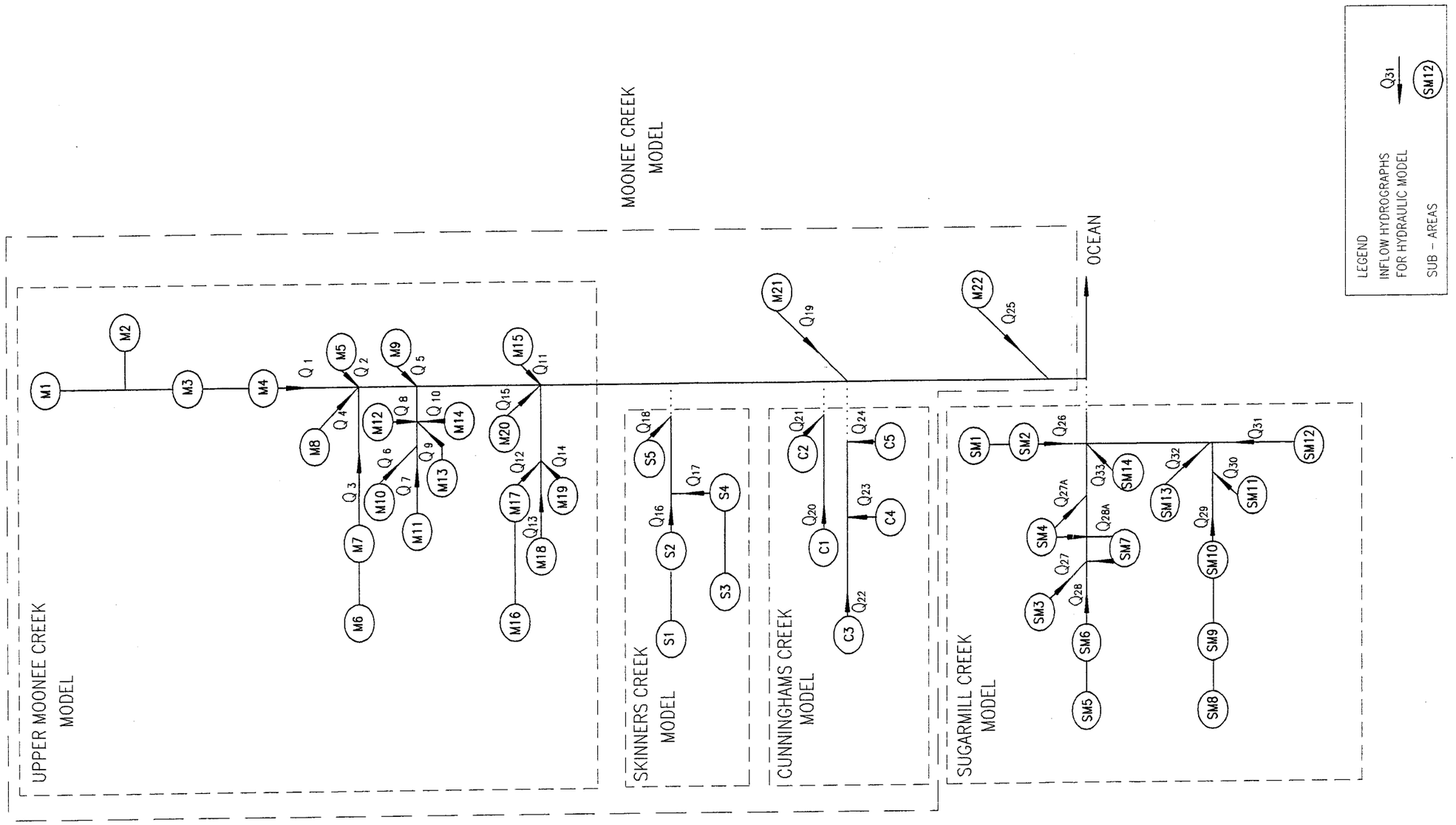

FIGURE 8
RORB MODEL SCHEMATIC

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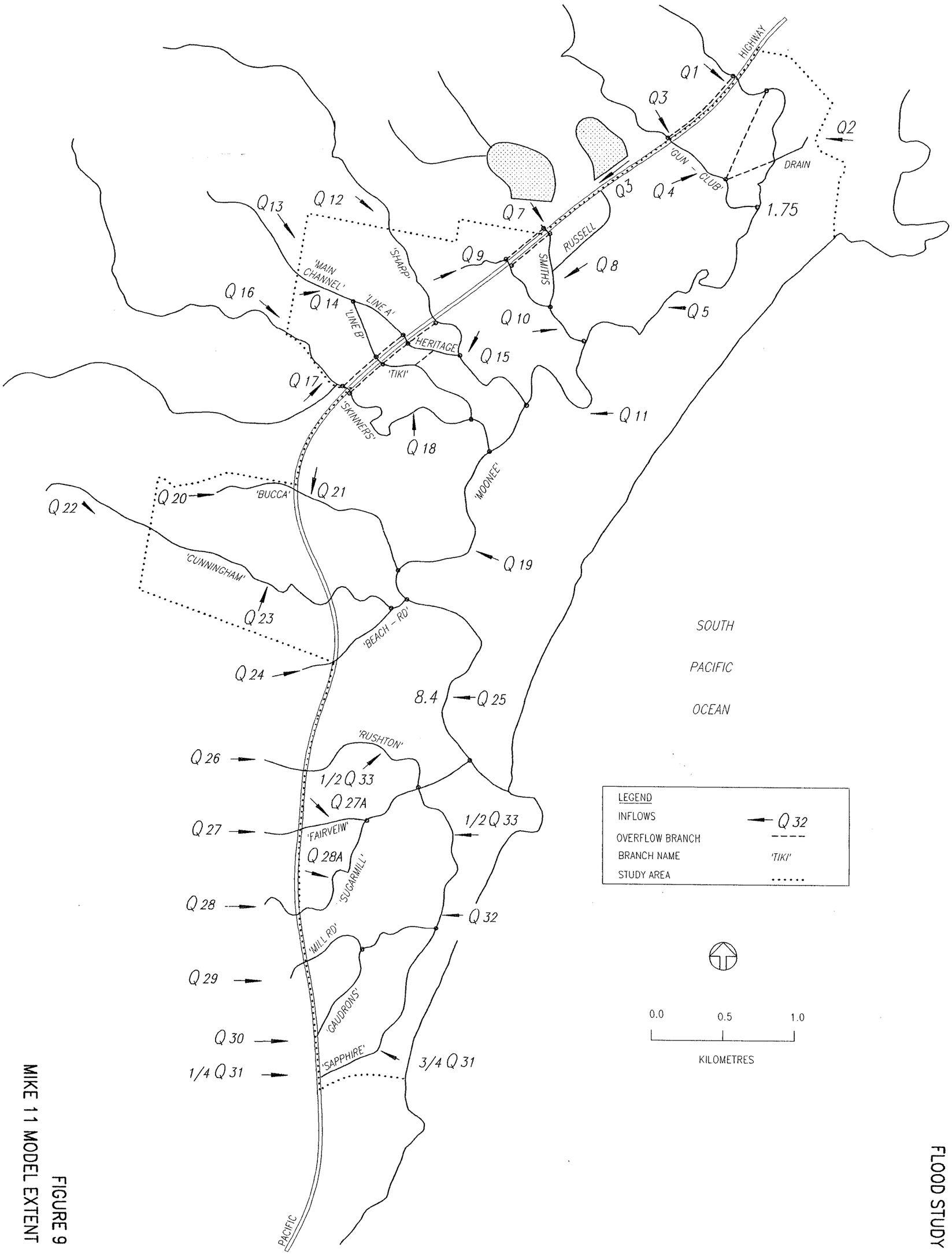

FIGURE 9
MIKE 11 MODEL EXTENT

MOONEE CREEK
FLOOD STUDY

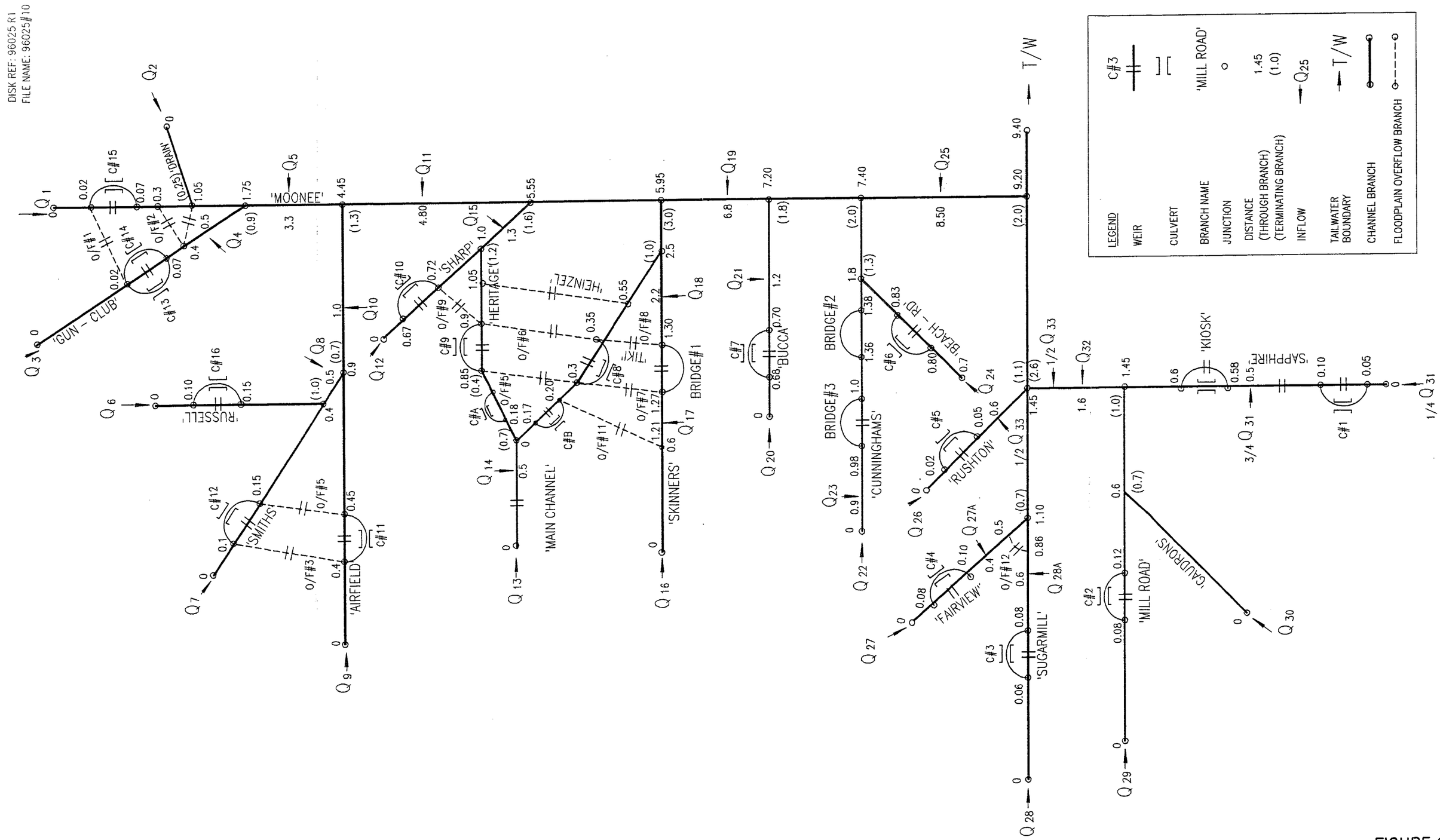

FIGURE 10
MIKE 11 SCHEMATIC

MOONEE BEACH
FLOOD STUDY

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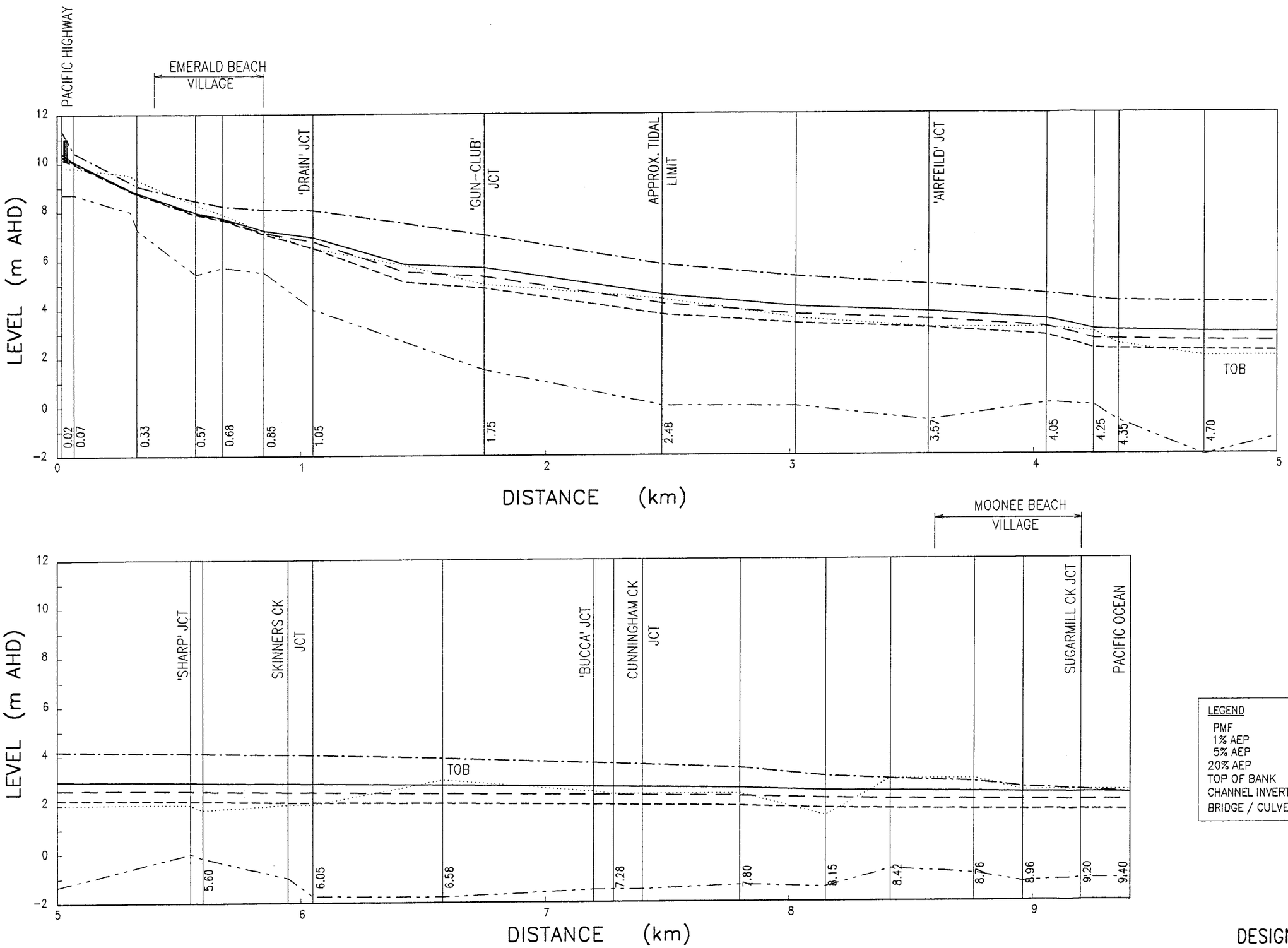

FIGURE 11
DESIGN FLOOD PROFILES
MOONEE CREEK

MOONEE BEACH
FLOOD STUDY

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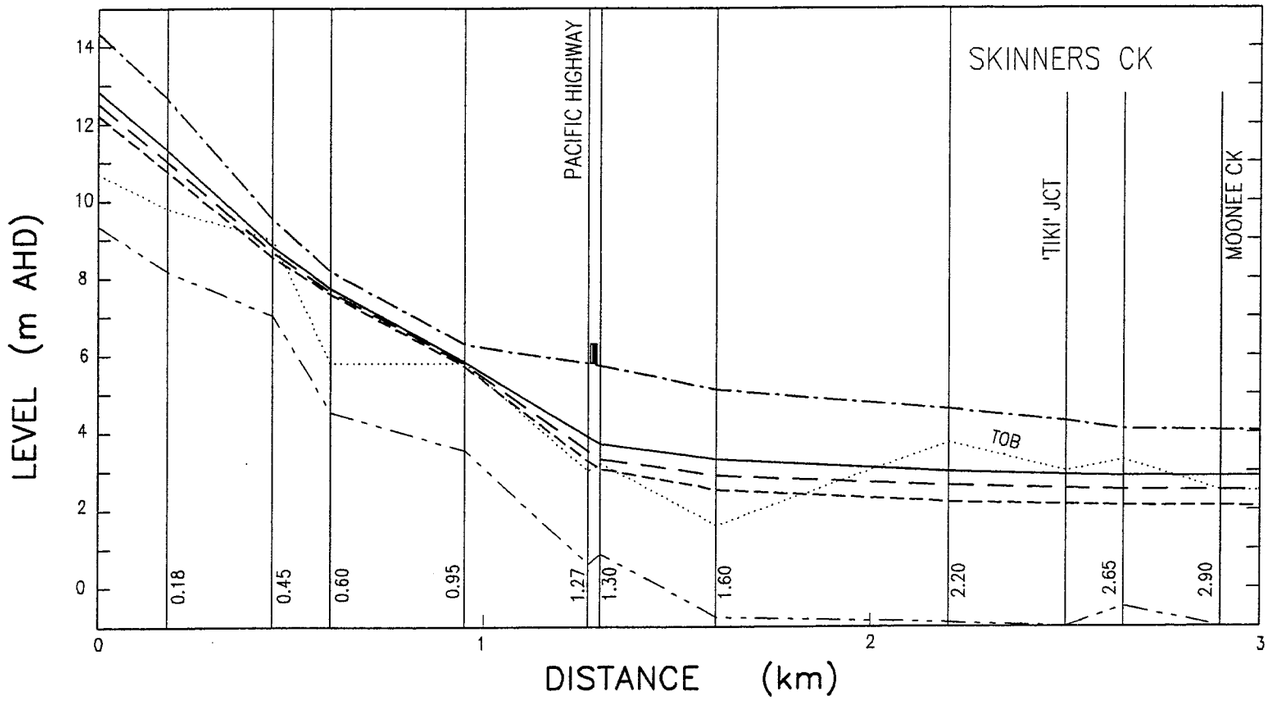

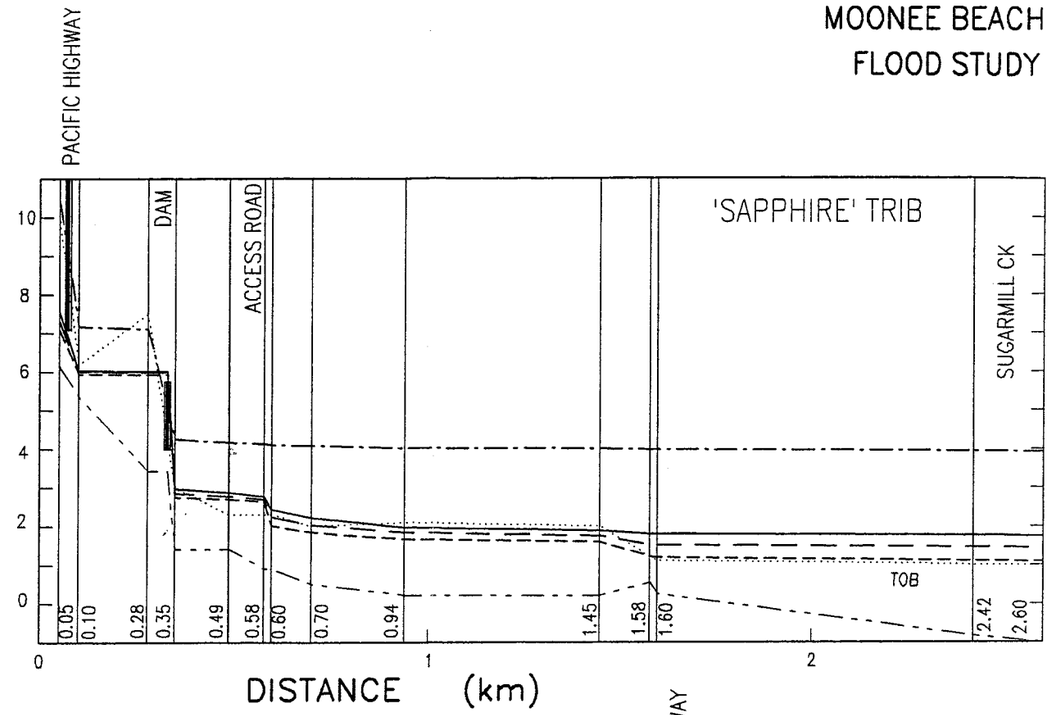

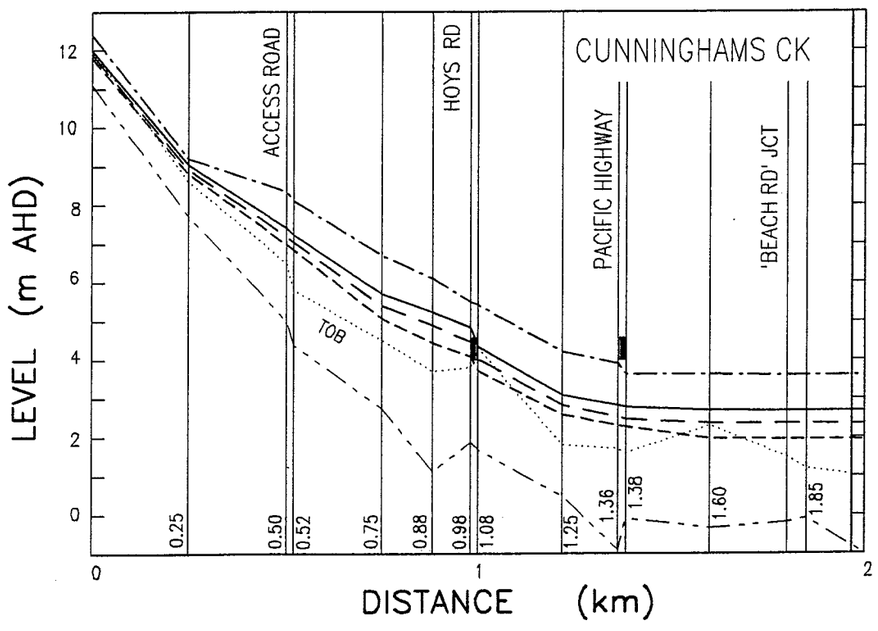

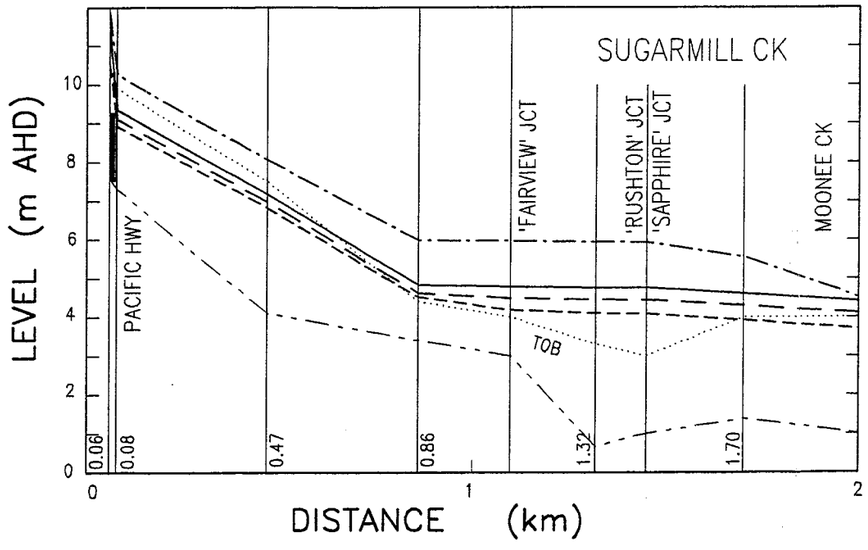

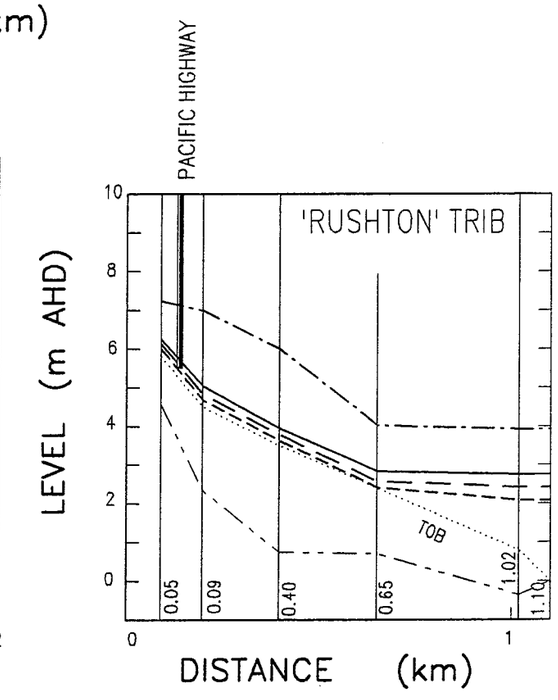

LEGEND

- PMF
- 1% AEP
- 5% AEP
- 20% AEP
- TOP OF BANK (TOB)
- CHANNEL INVERT
- BRIDGE / CULVERT

FIGURE 12
DESIGN FLOOD PROFILES
TRIBUTARY CREEKS

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MOONEE CREEK FLOOD STUDY

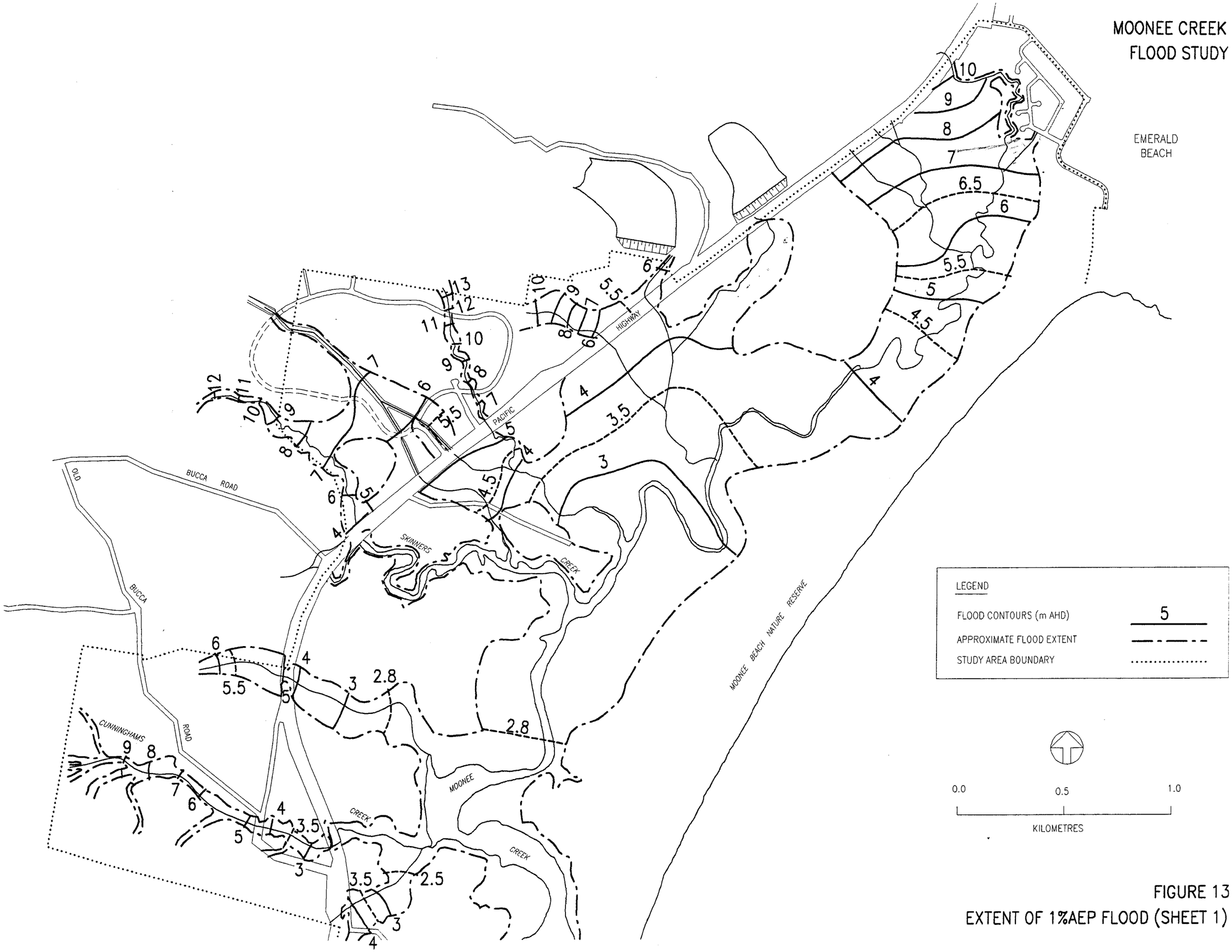

FIGURE 13
EXTENT OF 1%AEP FLOOD (SHEET 1)

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FILE NAME: 96025#14

MOONEE CREEK
FLOOD STUDY

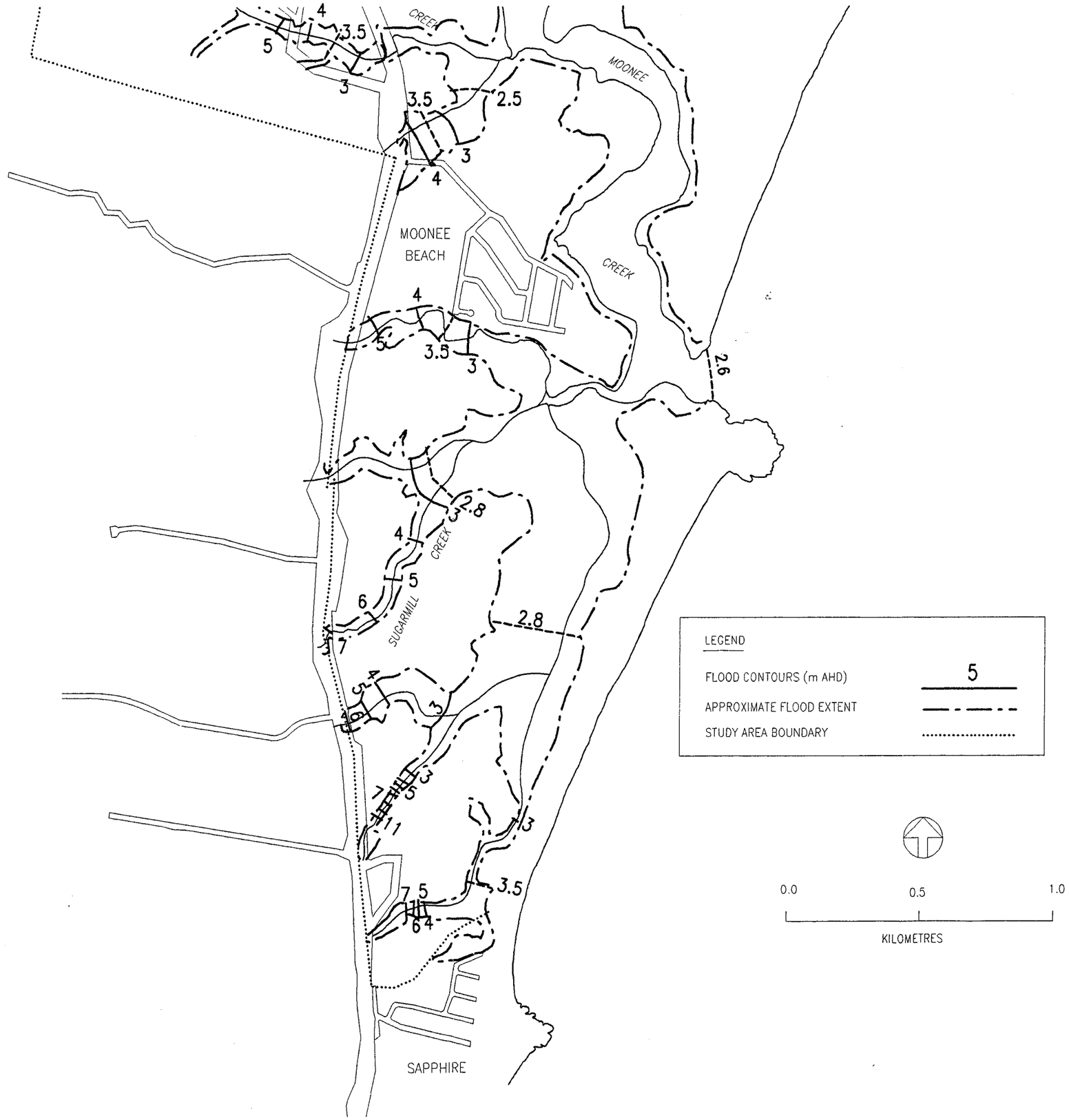

FIGURE 14
EXTENT OF 1% AEP FLOOD (SHEET 2)

DISK REF: 96025 R1
FILE NAME: 96025#15

MOONEE CREEK
FLOOD STUDY

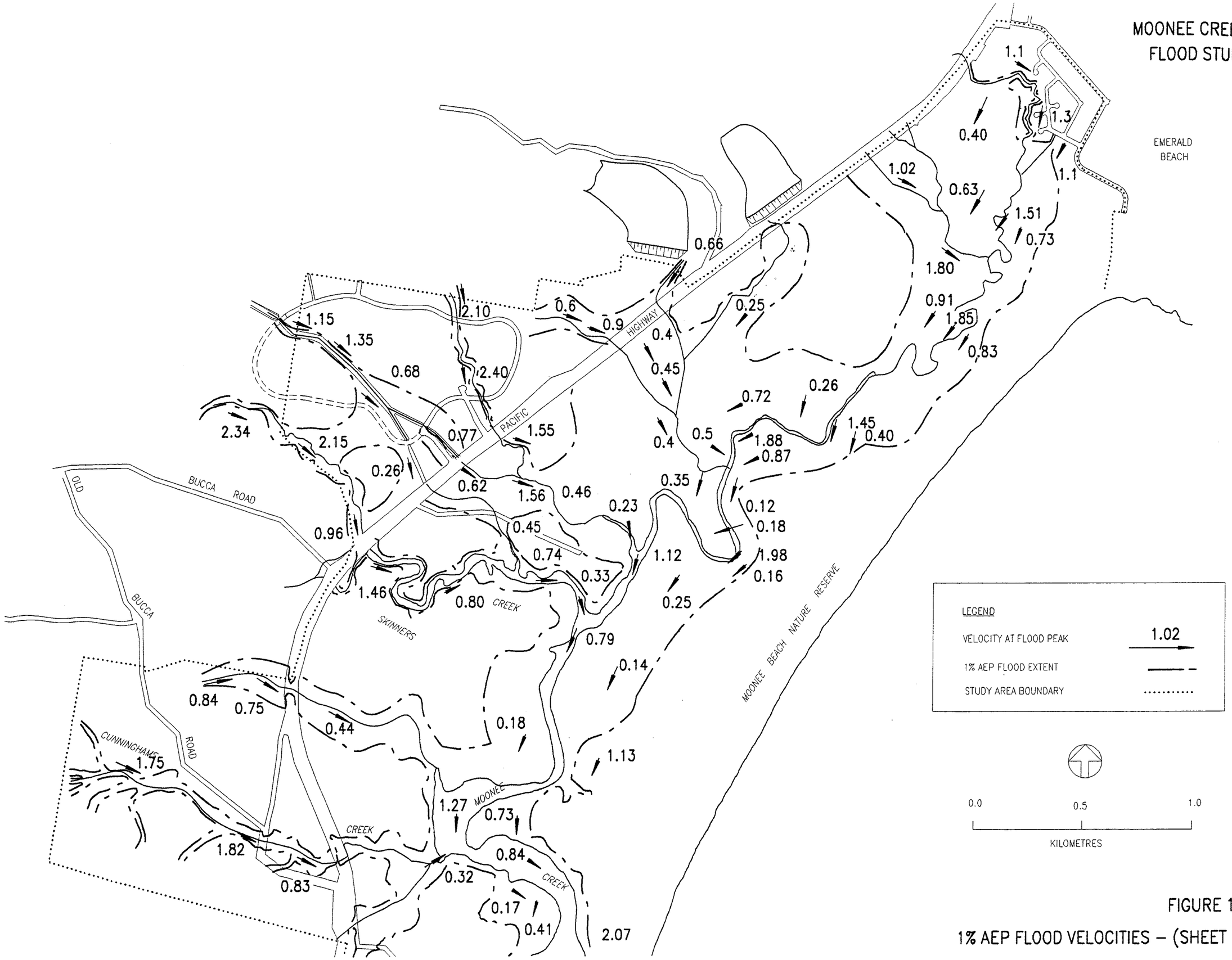

FIGURE 15

1% AEP FLOOD VELOCITIES – (SHEET 1)

MOONEE CREEK
FLOOD STUDY

DISK REF: 96025-R1
FILE NAME: 96025#16

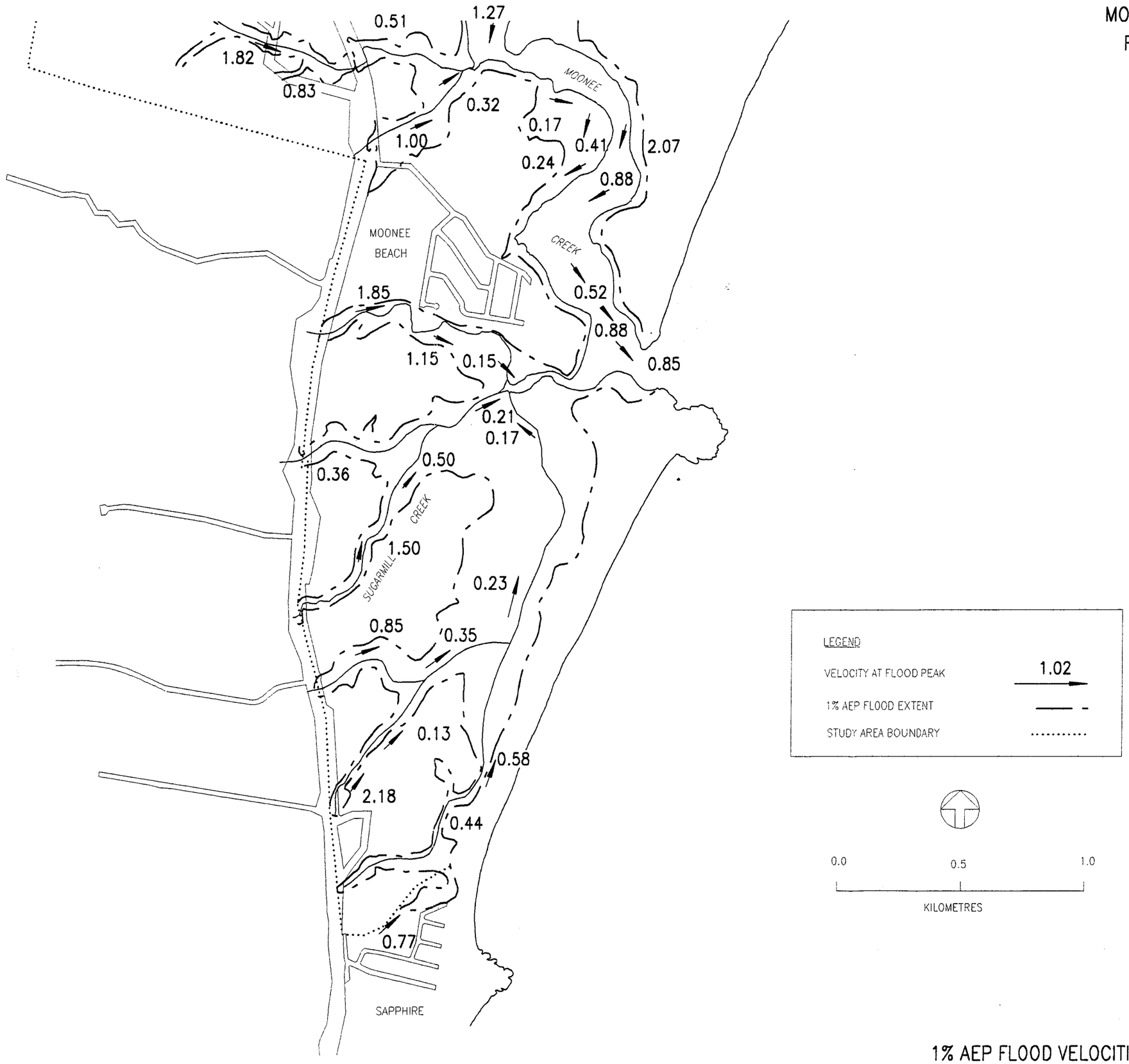

FIGURE 16
1% AEP FLOOD VELOCITIES (SHEET 2)

MOONEE BEACH FLOOD STUDY

DISK REF: DCAD 96025
FILE NAME: 96025#17

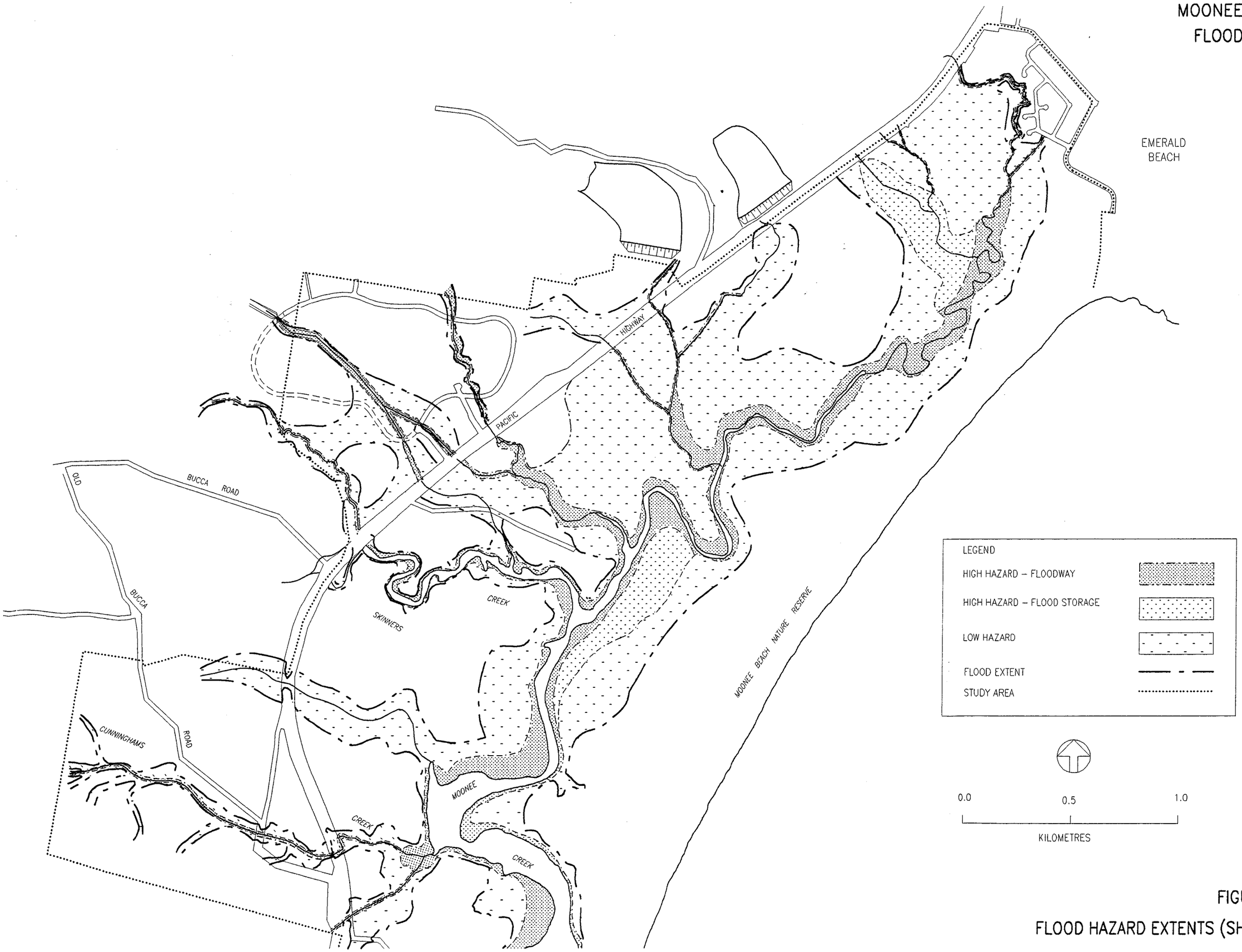

FIGURE 17

FLOOD HAZARD EXTENTS (SHEET 1)

MOONEE BEACH
FLOOD STUDY

DISK REF: DCAD 96025
FILE NAME: 96025#17

LEGEND

HIGH HAZARD – FLOODWAY

HIGH HAZARD – FLOOD STORAGE

LOW HAZARD

FLOOD EXTENT

STUDY AREA

0.0 0.5 1.0

KILOMETRES

FIGURE 18
FLOOD HAZARD EXTENTS (SHEET 2)

MOONEE CREEK
FLOOD STUDY

DISK REF: DCAD 96025
FILE NAME: 96025#18

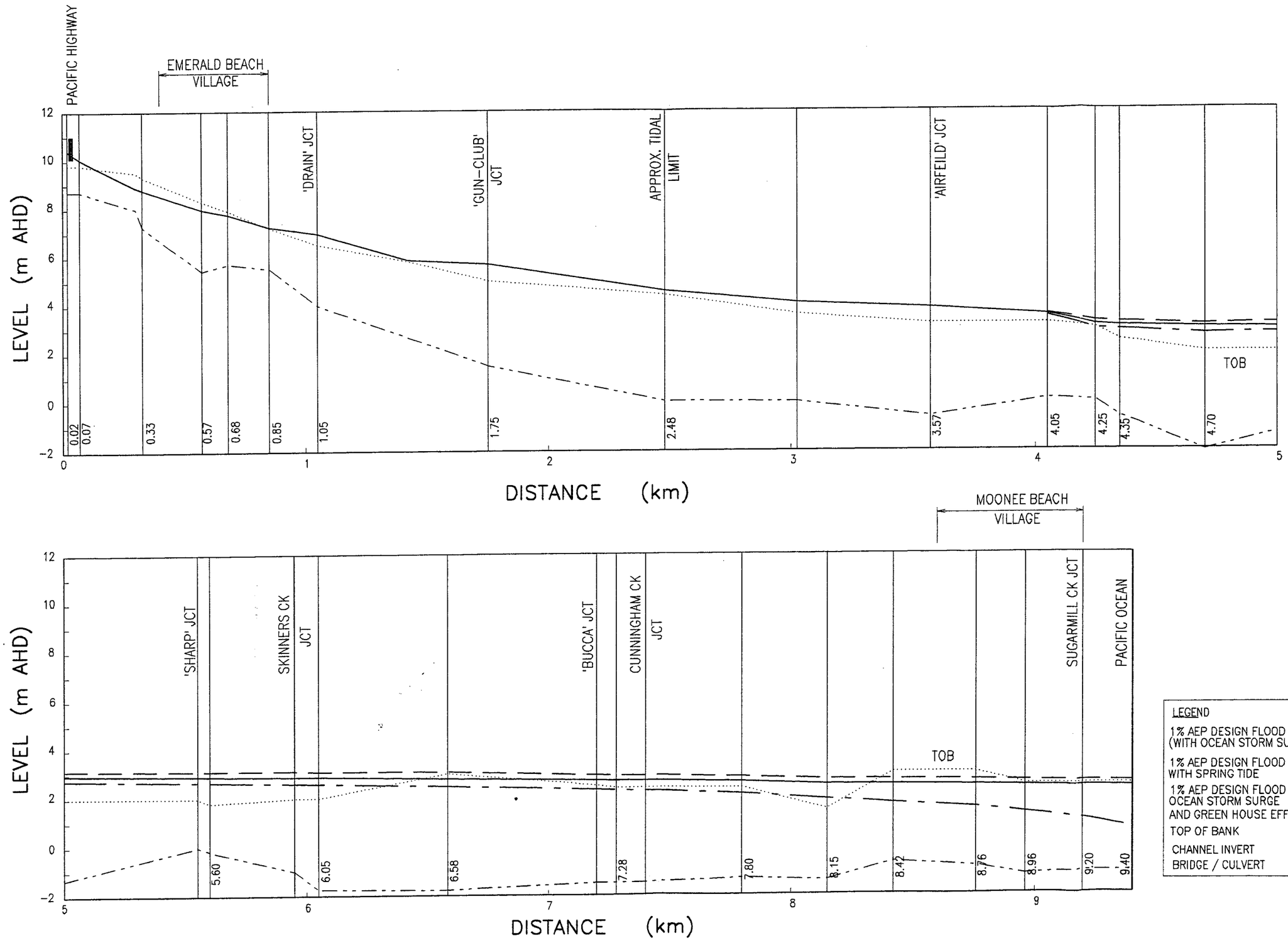

FIGURE 19
EFFECT OF OCEAN WATER LEVELS
MOONEE CREEK

APPENDICES

APPENDIX A

RORB Model Data

```
UPPER MOONEE CREEK
1
1 1.6 -99        M1
3
1 0.8 -99        M2
4
5 0.7 -99
2 1.3 -99        M3
2 0.8 -99        M4
7
INFLOW1
5 1.6 -99
3
1 0.5 -99       M5
7
INFLOW2
4
3
1 2.1 -99        M6
2 1.2 -99        M7
7
INFLOW3
5 0.9 -99
3
1 0.6 -99        M8
7
INFLOW4
4
4
5 2.5 -99
3
1 0.9 -99       M9
7
INFLOW5
4
3
1 1.1 -99      M10
7
INFLOW6
3
1 1.0 -99      M11
7
INFLOW7
4
5 0.5 -99
3
1 0.5 -99      M12
7
INFLOW8
4
3
1 0.3 -99      M13
7
INFLOW9
5 0.5 -99
3
1 0.3 -99      M14
7
INFLOW10
4
4
5 0.4 -99
```

```
4
5 1.2 -99
3
1 0.6 -99      M15
7
INFLOW11
4
3
1 1.7 -99      M16
2 0.7 -99      M17
7
INFLOW12
3
1 1.6 -99      M18
7
INFLOW13
3
1 0.5 -99      M19
7
INFLOW14
4
4
5 1.0 -99
3
1 0.6 -99      M20
7
INFLOW15
4
4
5 0.4 -99
7
UPPER MOONEE CREEK
0
C SUB-AREAS
2.40 1.36 1.12 0.80 0.72 1.98 1.36 0.32 1.19 0.34 1.47
0.55 0.47 0.28 0.74 1.88 0.49 0.61 0.65 0.48 -99
C IMPERVIOUS FRACTIONS
1 0 0 0 0 0.06 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 -99
5 ARI 2HR STORM
DESIGN
0.25 48 1 4 1 -99
0 18
90MIN PATTERN
23.3 37.5 15.4 11.6 7.6 4.6 0 0
0 0 0 0 0 0 0 0 0 0 -99
2HR PATTERN
10.9 19.2 33.9 11.0 9.1 7.0 4.9 4.0
0 0 0 0 0 0 0 0 0 0 -99
3HR PATTERN
5.7 16.8 23.4 8.7 11.8 7.8 5.8 6.7 4.8 3.8 2.8 1.9
0 0 0 0 0 0 -99
4.5HR PATTERN
1.6 5.4 9.8 7.6 17.8 12.9 4.7 3.4 6.8 5.6 4.5 3.7
3.8 2.7 3.8 2.7 1.6 1.6 -99
C 90MIN RAINFALL
C71.6 71.6 71.6 71.6 71.6 71.6 71.6 71.6
C71.6 71.6 71.6 71.6 71.6 71.6 71.6 71.6
C71.6 71.6 71.6 71.6 -99
C 2HR RAINFALL
C80.4 80.4 80.4 80.4 80.4 80.4 80.4 80.4
C80.4 80.4 80.4 80.4 80.4 80.4 80.4 80.4
```

```
C80.4 80.4 80.4 80.4 -99
C 3HR RAINFALL
C166.8 166.8 166.8 166.8 166.8 166.8 166.8 166.8
C166.8 166.8 166.8 166.8 166.8 166.8 166.8 166.8
C166.8 166.8 166.8 166.8 -99
C 4.5HR RAINFALL
C111.6 111.6 111.6 111.6 111.6 111.6 111.6 111.6
C111.6 111.6 111.6 111.6 111.6 111.6 111.6 111.6
C111.6 111.6 111.6 111.6 -99
C REFERENCE PATTERN
2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 -99


5 ARI 9HR STORM
DESIGN
0.5 36 1 3 1 -99
0 24
6HR PATTERN
4.1 8.0 11.0 23.3 15.3 8.1 7.0 7.0 5.1
6.1 3.1 1.9 0 0 0 0 0 0 0 0 0 0 0 0 -99
9HR PATTERN
2.4 6.3 4.4 4.5 3.4 10.5 2.8 4.7 7.4
17.6 13.1 6.5 5.4 3.5 2.4 2.5 1.3 1.3
0 0 0 0 0 0 -99
12HR PATTERN
1.6 4.5 3.5 1.6 0.6 2.6 2.6 4.7 3.6 2.6 3.6 7.0
9.2 15.8 3.5 0.6 4.8 11.3 6.0 4.9 1.6 2.7 0.6 0.5 -99
C 6HR RAINFALL
C124.2 124.2 124.2 124.2 124.2 124.2 124.2 124.2
C124.2 124.2 124.2 124.2 124.2 124.2 124.2 124.2
C124.2 124.2 124.2 124.2 -99
C 9HR RAINFALL
C146.7 146.7 146.7 146.7 146.7 146.7 146.7 146.7
C146.7 146.7 146.7 146.7 146.7 146.7 146.7 146.7
C146.7 146.7 146.7 146.7 -99
C 12HR RAINFALL
C163.2 163.2 163.2 163.2 163.2 163.2 163.2 163.2
C163.2 163.2 163.2 163.2 163.2 163.2 163.2 163.2
C163.2 163.2 163.2 163.2 -99
C REFERENCE PATTERN
2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 -99


20 ARI 2HR STORM
DESIGN
0.25 48 1 4 1 -99
0 18
90MIN PATTERN
23.3 37.5 15.4 11.6 7.6 4.6 0 0
0 0 0 0 0 0 0 0 0 0 -99
2HR PATTERN
10.9 19.2 33.9 11.0 9.1 7.0 4.9 4.0
0 0 0 0 0 0 0 0 0 0 -99
3HR PATTERN
5.7 16.8 23.4 8.7 11.8 7.8 5.8 6.7 4.8 3.8 2.8 1.9
0 0 0 0 0 0 -99
4.5HR PATTERN
1.6 5.4 9.8 7.6 17.8 12.9 4.7 3.4 6.8 5.6 4.5 3.7
3.8 2.7 3.8 2.7 1.6 1.6 -99
C 90MIN RAINFALL
C94.1 94.1 94.1 94.1 94.1 94.1 94.1 94.1
C94.1 94.1 94.1 94.1 94.1 94.1 94.1 94.1
```

```
C94.1 94.1 94.1 94.1 -99
C 2HR RAINFALL
C106.0 106.0 106.0 106.0 106.0 106.0 106.0 106.0
C106.0 106.0 106.0 106.0 106.0 106.0 106.0 106.0
C106.0 106.0 106.0 106.0 -99
C 3HR RAINFALL
C125.4 125.4 125.4 125.4 125.4 125.4 125.4 125.4
C125.4 125.4 125.4 125.4 125.4 125.4 125.4 125.4
C125.4 125.4 125.4 125.4 -99
C 4.5HR RAINFALL
C149.0 149.0 149.0 149.0 149.0 149.0 149.0 149.0
C149.0 149.0 149.0 149.0 149.0 149.0 149.0 149.0
C149.0 149.0 149.0 149.0 -99
C REFERENCE PATTERN
2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 -99


20 ARI 9HR STORM
DESIGN
0.5 36 1 3 1 -99
0 24
6HR PATTERN
4.1 8.0 11.0 23.3 15.3 8.1 7.0 7.0 5.1
6.1 3.1 1.9 0 0 0 0 0 0 0 0 0 0 0 0 -99
9HR PATTERN
2.4 6.3 4.4 4.5 3.4 10.5 2.8 4.7 7.4
17.6 13.1 6.5 5.4 3.5 2.4 2.5 1.3 1.3
0 0 0 0 0 0 -99
12HR PATTERN
1.6 4.5 3.5 1.6 0.6 2.6 2.6 4.7 3.6 2.6 3.6 7.0
9.2 15.8 3.5 0.6 4.8 11.3 6.0 4.9 1.6 2.7 0.6 0.5 -99
C 6HR RAINFALL
C166.8 166.8 166.8 166.8 166.8 166.8 166.8 166.8
C166.8 166.8 166.8 166.8 166.8 166.8 166.8 166.8
C166.8 166.8 166.8 166.8 -99
C 9HR RAINFALL
C198.9 198.9 198.9 198.9 198.9 198.9 198.9 198.9
C198.9 198.9 198.9 198.9 198.9 198.9 198.9 198.9
C198.9 198.9 198.9 198.9 -99
C 12HR RAINFALL
C222.0 222.0 222.0 222.0 222.0 222.0 222.0 222.0
C222.0 222.0 222.0 222.0 222.0 222.0 222.0 222.0
C222.0 222.0 222.0 222.0 -99
C REFERENCE PATTERN
2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 -99


100 ARI 2HR STORM
DESIGN
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0 18
90MIN PATTERN
23.3 37.5 15.4 11.6 7.6 4.6 0 0
0 0 0 0 0 0 0 0 0 0 -99
2HR PATTERN
10.9 19.2 33.9 11.0 9.1 7.0 4.9 4.0
0 0 0 0 0 0 0 0 0 0 -99
3HR PATTERN
5.7 16.8 23.4 8.7 11.8 7.8 5.8 6.7 4.8 3.8 2.8 1.9
0 0 0 0 0 0 -99
4.5HR PATTERN
1.6 5.4 9.8 7.6 17.8 12.9 4.7 3.4 6.8 5.6 4.5 3.7
```

```
3.8 2.7 3.8 2.7 1.6 1.6 -99
C 90MIN RAINFALL
C123.8 123.8 123.8 123.8 123.8 123.8 123.8 123.8
C123.8 123.8 123.8 123.8 123.8 123.8 123.8 123.8
C123.8 123.8 123.8 123.8 -99
C 2HR RAINFALL
C140.3 140.3 140.3 140.3 140.3 140.3 140.3 140.3
C140.3 140.3 140.3 140.3 140.3 140.3 140.3 140.3
C140.3 140.3 140.3 140.3 -99
C 3HR RAINFALL
C166.8 166.8 166.8 166.8 166.8 166.8 166.8 166.8
C166.8 166.8 166.8 166.8 166.8 166.8 166.8 166.8
C166.8 166.8 166.8 166.8 -99
C 4.5HR RAINFALL
C199.1 199.1 199.1 199.1 199.1 199.1 199.1 199.1
C199.1 199.1 199.1 199.1 199.1 199.1 199.1 199.1
C199.1 199.1 199.1 199.1 -99
C 2HR RAINFALL +10%
C154.3 154.3 154.3 154.3 154.3 154.3 154.3 154.3
C154.3 154.3 154.3 154.3 154.3 154.3 154.3 154.3
C154.3 154.3 154.3 154.3 -99
C REFERENCE PATTERN
2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 -99


100 ARI 9HR STORM
DESIGN
0.5 36 1 3 1 -99
0 24
6HR PATTERN
4.1 8.0 11.0 23.3 15.3 8.1 7.0 7.0 5.1
6.1 3.1 1.9 0 0 0 0 0 0 0 0 0 0 0 0 -99
9HR PATTERN
2.4 6.3 4.4 4.5 3.4 10.5 2.8 4.7 7.4
17.6 13.1 6.5 5.4 3.5 2.4 2.5 1.3 1.3
0 0 0 0 0 0 -99
12HR PATTERN
1.6 4.5 3.5 1.6 0.6 2.6 2.6 4.7 3.6 2.6 3.6 7.0
9.2 15.8 3.5 0.6 4.8 11.3 6.0 4.9 1.6 2.7 0.6 0.5 -99
C 6HR RAINFALL
C223.8 223.8 223.8 223.8 223.8 223.8 223.8 223.8
C223.8 223.8 223.8 223.8 223.8 223.8 223.8 223.8
C223.8 223.8 223.8 223.8 -99
C 9HR RAINFALL
C267.6 267.6 267.6 267.6 267.6 267.6 267.6 267.6
C267.6 267.6 267.6 267.6 267.6 267.6 267.6 267.6
C267.6 267.6 267.6 267.6 -99
C 12HR RAINFALL
C301.0 301.0 301.0 301.0 301.0 301.0 301.0 301.0
C301.0 301.0 301.0 301.0 301.0 301.0 301.0 301.0
C301.0 301.0 301.0 301.0 -99
C REFERENCE PATTERN
2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 -99


500 ARI 2HR STORM
DESIGN
0.25 48 1 4 1 -99
0 18
90MIN PATTERN
23.3 37.5 15.4 11.6 7.6 4.6 0 0
0 0 0 0 0 0 0 0 0 0 -99
```

```
2HR PATTERN
10.9 19.2 33.9 11.0 9.1 7.0 4.9 4.0
0 0 0 0 0 0 0 0 0 0 -99
3HR PATTERN
5.7 16.8 23.4 8.7 11.8 7.8 5.8 6.7 4.8 3.8 2.8 1.9
0 0 0 0 0 0 -99
4.5HR PATTERN
1.6 5.4 9.8 7.6 17.8 12.9 4.7 3.4 6.8 5.6 4.5 3.7
3.8 2.7 3.8 2.7 1.6 1.6 -99
C 200ARI 2HR RAINFALL
C155.4 155.4 155.4 155.4 155.4 155.4 155.4 155.4
C155.4 155.4 155.4 155.4 155.4 155.4 155.4 155.4
C155.4 155.4 155.4 155.4 -99
C 500ARI 2HR RAINFALL
176.2 176.2 176.2 176.2 176.2 176.2 176.2 176.2
176.2 176.2 176.2 176.2 176.2 176.2 176.2 176.2
176.2 176.2 176.2 176.2 -99
C REFERENCE PATTERN
2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 -99


500 ARI 9HR STORM
DESIGN
0.5 36 1 3 1 -99
0 24
6HR PATTERN
4.1 8.0 11.0 23.3 15.3 8.1 7.0 7.0 5.1
6.1 3.1 1.9 0 0 0 0 0 0 0 0 0 0 0 0 -99
9HR PATTERN
2.4 6.3 4.4 4.5 3.4 10.5 2.8 4.7 7.4
17.6 13.1 6.5 5.4 3.5 2.4 2.5 1.3 1.3
0 0 0 0 0 0 -99
12HR PATTERN
1.6 4.5 3.5 1.6 0.6 2.6 2.6 4.7 3.6 2.6 3.6 7.0
9.2 15.8 3.5 0.6 4.8 11.3 6.0 4.9 1.6 2.7 0.6 0.5 -99
C 200ARI 9HR RAINFALL
C297.0 297.0 297.0 297.0 297.0 297.0 297.0 297.0
C297.0 297.0 297.0 297.0 297.0 297.0 297.0 297.0
C297.0 297.0 297.0 297.0-99
C 9HR RAINFALL
339.3 339.3 339.3 339.3 339.3 339.3 339.3 339.3
339.3 339.3 339.3 339.3 339.3 339.3 339.3 339.3
339.3 339.3 339.3 339.3 -99
C REFERENCE PATTERN
2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 -99
```

```
SKINNERS CREEK CATCHMENT
1
1 1.7 -99      S1
2 0.8 -99      S2
7
INFLOW16
3
1 1.3 -99      S3
2 0.8 -99      S4
7
INFLOW17
4
5 1.6 -99
3
1 0.7 -99      S5
7
INFLOW18
4
7
SKINNERS CREEK
0
C SUB-AREAS
2.48 1.05 1.79 0.67 0.74 -99
C IMPERVIOUS FRACTIONS
0 -99
5 ARI 2HR STORM
DESIGN
0.25 48 1 4 1 -99
0 18
90MIN PATTERN
23.3 37.5 15.4 11.6 7.6 4.6 0 0
0 0 0 0 0 0 0 0 0 0 -99
2HR PATTERN
10.9 19.2 33.9 11.0 9.1 7.0 4.9 4.0
0 0 0 0 0 0 0 0 0 0 -99
3HR PATTERN
5.7 16.8 23.4 8.7 11.8 7.8 5.8 6.7 4.8 3.8 2.8 1.9
0 0 0 0 0 0 -99
4.5HR PATTERN
1.6 5.4 9.8 7.6 17.8 12.9 4.7 3.4 6.8 5.6 4.5 3.7
3.8 2.7 3.8 2.7 1.6 1.6 -99
C 90MIN RAINFALL
C71.6 71.6 71.6 71.6 71.6 -99
C 2HR RAINFALL
C80.4 80.4 80.4 80.4 80.4 -99
C 3HR RAINFALL
C94.5 94.5 94.5 94.5 94.5 -99
C 4.5HR RAINFALL
C111.6 111.6 111.6 111.6 111.6 -99
C REFERENCE PATTERN
2 2 2 2 2 -99


5 ARI 9HR STORM
DESIGN
0.5 36 1 3 1 -99
0 24
6HR PATTERN
4.1 8.0 11.0 23.3 15.3 8.1 7.0 7.0 5.1
6.1 3.1 1.9 0 0 0 0 0 0 0 0 0 0 0 -99
9HR PATTERN
2.4 6.3 4.4 4.5 3.4 10.5 2.8 4.7 7.4
```

```
17.6 13.1 6.5 5.4 3.5 2.4 2.5 1.3 1.3
0 0 0 0 0 0 -99
12HR PATTERN
1.6 4.5 3.5 1.6 0.6 2.6 2.6 4.7 3.6 2.6 3.6 7.0
9.2 15.8 3.5 0.6 4.8 11.3 6.0 4.9 1.6 2.7 0.6 0.5 -99
C 6HR RAINFALL
C124.2 124.2 124.2 124.2 124.2 -99
C 9HR RAINFALL
C146.7 146.7 146.7 146.7 146.7 -99
C 12HR RAINFALL
C163.2 163.2 163.2 163.2 163.2 -99
C REFERENCE PATTERN
2 2 2 2 2 -99


20 ARI 2HR STORM
DESIGN
0.25 48 1 4 1 -99
0 18
90MIN PATTERN
23.3 37.5 15.4 11.6 7.6 4.6 0 0
0 0 0 0 0 0 0 0 0 0 -99
2HR PATTERN
10.9 19.2 33.9 11.0 9.1 7.0 4.9 4.0
0 0 0 0 0 0 0 0 0 0 -99
3HR PATTERN
5.7 16.8 23.4 8.7 11.8 7.8 5.8 6.7 4.8 3.8 2.8 1.9
0 0 0 0 0 0 -99
4.5HR PATTERN
1.6 5.4 9.8 7.6 17.8 12.9 4.7 3.4 6.8 5.6 4.5 3.7
3.8 2.7 3.8 2.7 1.6 1.6 -99
C 90MIN RAINFALL
C94.1 94.1 94.1 94.1 94.1 -99
C 2HR RAINFALL
C106.0 106.0 106.0 106.0 106.0 -99
C 3HR RAINFALL
C125.4 125.4 125.4 125.4 125.4 -99
C 4.5HR RAINFALL
C149.0 149.0 149.0 149.0 149.0 -99
C REFERENCE PATTERN
2 2 2 2 2 -99


20 ARI 9HR STORM
DESIGN
0.5 36 1 3 1 -99
0 24
6HR PATTERN
4.1 8.0 11.0 23.3 15.3 8.1 7.0 7.0 5.1
6.1 3.1 1.9 0 0 0 0 0 0 0 0 0 0 0 0 -99
9HR PATTERN
2.4 6.3 4.4 4.5 3.4 10.5 2.8 4.7 7.4
17.6 13.1 6.5 5.4 3.5 2.4 2.5 1.3 1.3
0 0 0 0 0 0 -99
12HR PATTERN
1.6 4.5 3.5 1.6 0.6 2.6 2.6 4.7 3.6 2.6 3.6 7.0
9.2 15.8 3.5 0.6 4.8 11.3 6.0 4.9 1.6 2.7 0.6 0.5 -99
C 6HR RAINFALL
C166.8 166.8 166.8 166.8 166.8 -99
C 9HR RAINFALL
C198.9 198.9 198.9 198.9 198.9 -99
C 12HR RAINFALL
```

```
C222.0 222.0 222.0 222.0 222.0 -99
C REFERENCE PATTERN
2 2 2 2 2 -99


100 ARI 2HR STORM
DESIGN
0.25 48 1 4 1 -99
0 18
90MIN PATTERN
23.3 37.5 15.4 11.6 7.6 4.6 0 0
0 0 0 0 0 0 0 0 0 0 -99
2HR PATTERN
10.9 19.2 33.9 11.0 9.1 7.0 4.9 4.0
0 0 0 0 0 0 0 0 0 0 -99
3HR PATTERN
5.7 16.8 23.4 8.7 11.8 7.8 5.8 6.7 4.8 3.8 2.8 1.9
0 0 0 0 0 0 -99
4.5HR PATTERN
1.6 5.4 9.8 7.6 17.8 12.9 4.7 3.4 6.8 5.6 4.5 3.7
3.8 2.7 3.8 2.7 1.6 1.6 -99
C 90MIN RAINFALL
C123.8 123.8 123.8 123.8 123.8 -99
C 2HR RAINFALL
C140.3 140.3 140.3 140.3 140.3 -99
C 3HR RAINFALL
C166.8 166.8 166.8 166.8 166.8 -99
C 4.5HR RAINFALL
C199.1 199.1 199.1 199.1 199.1 -99
C 2HR RAINFALL + 10%
C154.3 154.3 154.3 154.3 154.3 -99
C REFERENCE PATTERN
2 2 2 2 2 -99


100 ARI 9HR STORM
DESIGN
0.5 36 1 3 1 -99
0 24
6HR PATTERN
4.1 8.0 11.0 23.3 15.3 8.1 7.0 7.0 5.1
6.1 3.1 1.9 0 0 0 0 0 0 0 0 0 0 0 0 -99
9HR PATTERN
2.4 6.3 4.4 4.5 3.4 10.5 2.8 4.7 7.4
17.6 13.1 6.5 5.4 3.5 2.4 2.5 1.3 1.3
0 0 0 0 0 0 -99
12HR PATTERN
1.6 4.5 3.5 1.6 0.6 2.6 2.6 4.7 3.6 2.6 3.6 7.0
9.2 15.8 3.5 0.6 4.8 11.3 6.0 4.9 1.6 2.7 0.6 0.5 -99
C 6HR RAINFALL
C223.8 223.8 223.8 223.8 223.8 -99
C 9HR RAINFALL
C267.6 267.6 267.6 267.6 267.6 -99
C 12HR RAINFALL
C301.0 301.0 301.0 301.0 301.0 -99
C REFERENCE PATTERN
2 2 2 2 2 -99


500 ARI 2HR STORM
DESIGN
0.25 48 1 4 1 -99
```

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0 18
90MIN PATTERN
23.3 37.5 15.4 11.6 7.6 4.6 0 0
0 0 0 0 0 0 0 0 0 0 -99
2HR PATTERN
10.9 19.2 33.9 11.0 9.1 7.0 4.9 4.0
0 0 0 0 0 0 0 0 0 0 -99
3HR PATTERN
5.7 16.8 23.4 8.7 11.8 7.8 5.8 6.7 4.8 3.8 2.8 1.9
0 0 0 0 0 0 -99
4.5HR PATTERN
1.6 5.4 9.8 7.6 17.8 12.9 4.7 3.4 6.8 5.6 4.5 3.7
3.8 2.7 3.8 2.7 1.6 1.6 -99
C 200ARI 2HR RAINFALL
C155.4 155.4 155.4 155.4 155.4 -99
C 500ARI 2HR RAINFALL
176.2 176.2 176.2 176.2 176.2 -99
C REFERENCE PATTERN
2 2 2 2 2 -99


500 ARI 9HR STORM
DESIGN
0.5 36 1 3 1 -99
0 24
6HR PATTERN
4.1 8.0 11.0 23.3 15.3 8.1 7.0 7.0 5.1
6.1 3.1 1.9 0 0 0 0 0 0 0 0 0 0 0 0 -99
9HR PATTERN
2.4 6.3 4.4 4.5 3.4 10.5 2.8 4.7 7.4
17.6 13.1 6.5 5.4 3.5 2.4 2.5 1.3 1.3
0 0 0 0 0 0 -99
12HR PATTERN
1.6 4.5 3.5 1.6 0.6 2.6 2.6 4.7 3.6 2.6 3.6 7.0
9.2 15.8 3.5 0.6 4.8 11.3 6.0 4.9 1.6 2.7 0.6 0.5 -99
C 200ARI 9HR RAINFALL
C297.0 297.0 297.0 297.0 297.0 -99
C 500ARI 9HR RAINFALL
339.3 339.3 339.3 339.3 339.3 -99
C REFERENCE PATTERN
2 2 2 2 2 -99
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CUNNINGHAMS CREEK CATCHMENT
1
1 1.2 -99      C1
7
INFLOW20
3
1 0.6 -99     C2
7
INFLOW21
4
7
BUCCA CREEK
3
1 1.0 -99      C3
7
INFLOW22
3
1 0.3 -99      C4
7
INFLOW23
4
5 1.0 -99
3
1 0.6 -99      C5
7
INFLOW24
4
5 0.1 -99
7
CUNNINGHAMS CREEK
4
0
C SUB-AREAS
0.41 0.47 1.90 0.63 0.98 -99
C IMPERVIOUS FRACTIONS
0 -99
5 ARI 2HR STORM
DESIGN
0.25 48 1 4 1 -99
0 18
90MIN PATTERM
23.3 37.5 15.4 11.6 7.6 4.6 0 0
0 0 0 0 0 0 0 0 0 0 -99
2HR PATTERN
10.9 19.2 33.9 11.0 9.1 7.0 4.9 4.0
0 0 0 0 0 0 0 0 0 0 -99
3HR PATTERN
5.7 16.8 23.4 8.7 11.8 7.8 5.8 6.7 4.8 3.8 2.8 1.9
0 0 0 0 0 0 -99
4.5HR PATTERN
1.6 5.4 9.8 7.6 17.8 12.9 4.7 3.4 6.8 5.6 4.5 3.7
3.8 2.7 3.8 2.7 1.6 1.6 -99
C 90MIN RAINFALL
C71.6 71.6 71.6 71.6 71.6 -99
C 2HR RAINFALL
C80.4 80.4 80.4 80.4 80.4 -99
C 3HR RAINFALL
C94.5 94.5 94.5 94.5 94.5 -99
C 4.5HR RAINFALL
C111.6 111.6 111.6 111.6 111.6 -99
C REFERENCE PATTERN
2 2 2 2 2 -99
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5 ARI 9HR STORM
DESIGN
0.5 36 1 3 1 -99
0 24
6HR PATTERN
4.1 8.0 11.0 23.3 15.3 8.1 7.0 7.0 5.1
6.1 3.1 1.9 0 0 0 0 0 0 0 0 0 0 0 0 -99
9HR PATTERN
2.4 6.3 4.4 4.5 3.4 10.5 2.8 4.7 7.4
17.6 13.1 6.5 5.4 3.5 2.4 2.5 1.3 1.3
0 0 0 0 0 0 -99
12HR PATTERN
1.6 4.5 3.5 1.6 0.6 2.6 2.6 4.7 3.6 2.6 3.6 7.0
9.2 15.8 3.5 0.6 4.8 11.3 6.0 4.9 1.6 2.7 0.6 0.5 -99
C 6HR RAINFALL
C124.2 124.2 124.2 124.2 124.2 -99
C 9HR RAINFALL
C146.7 146.7 146.7 146.7 146.7 -99
C 12HR RAINFALL
C163.2 163.2 163.2 163.2 163.2 -99
C REFERENCE PATTERN
2 2 2 2 2 -99


20 ARI 2HR STORM
DESIGN
0.25 48 1 4 1 -99
0 18
90MIN PATTERM
23.3 37.5 15.4 11.6 7.6 4.6 0 0
0 0 0 0 0 0 0 0 0 0 -99
2HR PATTERN
10.9 19.2 33.9 11.0 9.1 7.0 4.9 4.0
0 0 0 0 0 0 0 0 0 0 -99
3HR PATTERN
5.7 16.8 23.4 8.7 11.8 7.8 5.8 6.7 4.8 3.8 2.8 1.9
0 0 0 0 0 0 -99
4.5HR PATTERN
1.6 5.4 9.8 7.6 17.8 12.9 4.7 3.4 6.8 5.6 4.5 3.7
3.8 2.7 3.8 2.7 1.6 1.6 -99
C 90MIN RAINFALL
C94.1 94.1 94.1 94.1 94.1 -99
C 2HR RAINFALL
C106.0 106.0 106.0 106.0 106.0 -99
C 3HR RAINFALL
C125.4 125.4 125.4 125.4 125.4 -99
C 4.5HR RAINFALL
C149.0 149.0 149.0 149.0 149.0 -99
C REFERENCE PATTERN
2 2 2 2 2 -99


20 ARI 9HR STORM
DESIGN
0.5 36 1 3 1 -99
0 24
6HR PATTERN
4.1 8.0 11.0 23.3 15.3 8.1 7.0 7.0 5.1
6.1 3.1 1.9 0 0 0 0 0 0 0 0 0 0 0 0 -99
9HR PATTERN
```

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2.4 6.3 4.4 4.5 3.4 10.5 2.8 4.7 7.4
17.6 13.1 6.5 5.4 3.5 2.4 2.5 1.3 1.3
0 0 0 0 0 0 -99
12HR PATTERN
1.6 4.5 3.5 1.6 0.6 2.6 2.6 4.7 3.6 2.6 3.6 7.0
9.2 15.8 3.5 0.6 4.8 11.3 6.0 4.9 1.6 2.7 0.6 0.5 -99
C 6HR RAINFALL
C166.8 166.8 166.8 166.8 166.8 -99
C 9HR RAINFALL
C198.9 198.9 198.9 198.9 198.9 -99
C 12HR RAINFALL
C222.0 222.0 222.0 222.0 222.0 -99
C REFERENCE PATTERN
2 2 2 2 2 -99


100 ARI 2HR STORM
DESIGN
0.25 48 1 4 1 -99
0 18
90MIN PATTERM
23.3 37.5 15.4 11.6 7.6 4.6 0 0
0 0 0 0 0 0 0 0 0 0 -99
2HR PATTERN
10.9 19.2 33.9 11.0 9.1 7.0 4.9 4.0
0 0 0 0 0 0 0 0 0 0 -99
3HR PATTERN
5.7 16.8 23.4 8.7 11.8 7.8 5.8 6.7 4.8 3.8 2.8 1.9
0 0 0 0 0 0 -99
4.5HR PATTERN
1.6 5.4 9.8 7.6 17.8 12.9 4.7 3.4 6.8 5.6 4.5 3.7
3.8 2.7 3.8 2.7 1.6 1.6 -99
C 90MIN RAINFALL
C123.8 123.8 123.8 123.8 123.8 -99
C 2HR RAINFALL
C140.3 140.3 140.3 140.3 140.3 -99
C 3HR RAINFALL
C166.8 166.8 166.8 166.8 166.8 -99
C 4.5HR RAINFALL
C199.1 199.1 199.1 199.1 199.1 -99
C 2HR RAINFALL + 10%
C154.3 154.3 154.3 154.3 154.3 -99
C REFERENCE PATTERN
2 2 2 2 2 -99


100 ARI 9HR STORM
DESIGN
0.5 36 1 3 1 -99
0 24
6HR PATTERN
4.1 8.0 11.0 23.3 15.3 8.1 7.0 7.0 5.1
6.1 3.1 1.9 0 0 0 0 0 0 0 0 0 0 0 0 -99
9HR PATTERN
2.4 6.3 4.4 4.5 3.4 10.5 2.8 4.7 7.4
17.6 13.1 6.5 5.4 3.5 2.4 2.5 1.3 1.3
0 0 0 0 0 0 -99
12HR PATTERN
1.6 4.5 3.5 1.6 0.6 2.6 2.6 4.7 3.6 2.6 3.6 7.0
9.2 15.8 3.5 0.6 4.8 11.3 6.0 4.9 1.6 2.7 0.6 0.5 -99
C 6HR RAINFALL
C223.8 223.8 223.8 223.8 223.8 -99
```

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C 9HR RAINFALL
C267.6 267.6 267.6 267.6 267.6 -99
C 12HR RAINFALL
C301.0 301.0 301.0 301.0 301.0 -99
C REFERENCE PATTERN
2 2 2 2 2 -99


500 ARI 2HR STORM
DESIGN
0.25 48 1 4 1 -99
0 18
90MIN PATTERM
23.3 37.5 15.4 11.6 7.6 4.6 0 0
0 0 0 0 0 0 0 0 0 0 -99
2HR PATTERN
10.9 19.2 33.9 11.0 9.1 7.0 4.9 4.0
0 0 0 0 0 0 0 0 0 0 -99
3HR PATTERN
5.7 16.8 23.4 8.7 11.8 7.8 5.8 6.7 4.8 3.8 2.8 1.9
0 0 0 0 0 0 -99
4.5HR PATTERN
1.6 5.4 9.8 7.6 17.8 12.9 4.7 3.4 6.8 5.6 4.5 3.7
3.8 2.7 3.8 2.7 1.6 1.6 -99
C 200ARI 2HR RAINFALL
C155.4 155.4 155.4 155.4 155.4 -99
C 500ARI 2HR RAINFALL
176.2 176.2 176.2 176.2 176.2 -99
C REFERENCE PATTERN
2 2 2 2 2 -99


500 ARI 9HR STORM
DESIGN
0.5 36 1 3 1 -99
0 24
6HR PATTERN
4.1 8.0 11.0 23.3 15.3 8.1 7.0 7.0 5.1
6.1 3.1 1.9 0 0 0 0 0 0 0 0 0 0 0 0 -99
9HR PATTERN
2.4 6.3 4.4 4.5 3.4 10.5 2.8 4.7 7.4
17.6 13.1 6.5 5.4 3.5 2.4 2.5 1.3 1.3
0 0 0 0 0 0 -99
12HR PATTERN
1.6 4.5 3.5 1.6 0.6 2.6 2.6 4.7 3.6 2.6 3.6 7.0
9.2 15.8 3.5 0.6 4.8 11.3 6.0 4.9 1.6 2.7 0.6 0.5 -99
C 200ARI 9HR RAINFALL
C297.0 297.0 297.0 297.0 297.0 -99
C 500ARI 9HR RAINFALL
339.3 339.3 339.3 339.3 339.3 -99
C REFERENCE PATTERN
2 2 2 2 2 -99
```

```
MOONEE CREEK (EXCLUDING SUGARMILL CREEK)
1
1 1.6 -99        M1
3
1 0.8 -99        M2
4
5 0.7 -99
2 1.3 -99        M3
2 0.8 -99        M4
7
Q 1
5 1.6 -99
3
1 0.5 -99       M5
7
Q 2
4
3
1 2.1 -99        M6
2 1.2 -99        M7
7
Q 3
5 0.9 -99
3
1 0.6 -99        M8
7
Q 4
4
4
5 2.5 -99
3
1 0.9 -99       M9
7
Q 5
4
3
1 1.1 -99      M10
7
Q 6
3
1 1.0 -99      M11
7
Q 7
4
5 0.5 -99
3
1 0.5 -99      M12
7
Q 8
4
3
1 0.3 -99      M13
7
Q 9
5 0.5 -99
3
1 0.3 -99      M14
7
Q 10
4
4
5 0.4 -99
```

```
4
5 1.2 -99
3
1 0.6 -99      M15
7
Q 11
4
3
1 1.7 -99      M16
2 0.7 -99      M17
7
Q 12
3
1 1.6 -99      M18
7
Q 13
3
1 0.5 -99      M19
7
Q 14
4
4
5 1.0 -99
3
1 0.6 -99      M20
7
Q 15
4
4
5 0.4 -99
7
UPPER MOONEE CREEK
3
1 1.7 -99      S1
2 0.8 -99      S2
7
Q 16
3
1 1.3 -99      S3
2 0.8 -99      S4
7
Q 17
4
5 1.6 -99
3
1 0.7 -99      S5
7
Q 18
4
7
SKINNERS CREEK
4
5 1.2 -99
3
1 0.7 -99      M21
7
INFLOW19
4
3
1 1.2 -99      C1
3
1 0.6 -99     C2
```

```
4
7
BUCCA CREEK
4
5 0.2 -99
3
1 1.0 -99      C3
3
1 0.3 -99      C4
4
5 1.0 -99
3
1 0.6 -99      C5
4
5 0.1 -99
7
CUNNINGHAMS CREEK
4
5 1.0 -99
3
1 0.5 -99      M22
7
INFLOW25
4
5 0.3 -99
7
MOONEE CREEK AT SUGARMILL CREEK
0
C SUB-AREAS
2.40 1.36 1.12 0.80 0.72 1.98 1.36 0.32 1.19 0.34 1.47
0.55 0.47 0.28 0.74 1.88 0.49 0.61 0.65 0.48
2.48 1.05 1.79 0.67 0.74 1.17 0.41 0.47 1.90 0.63 0.98 1.09 -9
C IMPERVIOUS FRACTIONS
1 0 0 0 0 0 0.06 0 0 0 0 0
0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0.02 -99
5 ARI 2HR STORM
DESIGN
0.25 48 1 4 1 -99
0 18
90MIN PATTERN
23.3 37.5 15.4 11.6 7.6 4.6 0 0
0 0 0 0 0 0 0 0 0 0 -99
2HR PATTERN
10.9 19.2 33.9 11.0 9.1 7.0 4.9 4.0
0 0 0 0 0 0 0 0 0 0 -99
3HR PATTERN
5.7 16.8 23.4 8.7 11.8 7.8 5.8 6.7 4.8 3.8 2.8 1.9
0 0 0 0 0 0 -99
4.5HR PATTERN
1.6 5.4 9.8 7.6 17.8 12.9 4.7 3.4 6.8 5.6 4.5 3.7
3.8 2.7 3.8 2.7 1.6 1.6 -99
C 90MIN RAINFALL
C71.6 71.6 71.6 71.6 71.6 71.6 71.6 71.6
C71.6 71.6 71.6 71.6 71.6 71.6 71.6 71.6
C71.6 71.6 71.6 71.6 71.6 71.6 71.6 71.6
C71.6 71.6 71.6 71.6 71.6 71.6 71.6 71.6 -99
C 2HR RAINFALL
C80.4 80.4 80.4 80.4 80.4 80.4 80.4 80.4
C80.4 80.4 80.4 80.4 80.4 80.4 80.4 80.4
C80.4 80.4 80.4 80.4 80.4 80.4 80.4 80.4
C80.4 80.4 80.4 80.4 80.4 80.4 80.4 80.4 -99
```

```
C 3HR RAINFALL
C94.5 94.5 94.5 94.5 94.5 94.5 94.5 94.5
C94.5 94.5 94.5 94.5 94.5 94.5 94.5 94.5
C94.5 94.5 94.5 94.5 94.5 94.5 94.5 94.5
C94.5 94.5 94.5 94.5 94.5 94.5 94.5 94.5 -99
C 4.5HR RAINFALL
C111.6 111.6 111.6 111.6 111.6 111.6 111.6 111.6
C111.6 111.6 111.6 111.6 111.6 111.6 111.6 111.6
C111.6 111.6 111.6 111.6 111.6 111.6 111.6 111.6
C111.6 111.6 111.6 111.6 111.6 111.6 111.6 111.6 -99
C REFERENCE PATTERN
2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 -99


5 ARI 9HR STORM
DESIGN
0.5 36 1 3 1 -99
0 24
6HR PATTERN
4.1 8.0 11.0 23.3 15.3 8.1 7.0 7.0 5.1
6.1 3.1 1.9 0 0 0 0 0 0 0 0 0 0 0 0 -99
9HR PATTERN
2.4 6.3 4.4 4.5 3.4 10.5 2.8 4.7 7.4
17.6 13.1 6.5 5.4 3.5 2.4 2.5 1.3 1.3
0 0 0 0 0 0 -99
12HR PATTERN
1.6 4.5 3.5 1.6 0.6 2.6 2.6 4.7 3.6 2.6 3.6 7.0
9.2 15.8 3.5 0.6 4.8 11.3 6.0 4.9 1.6 2.7 0.6 0.5 -99
C 6HR RAINFALL
C124.2 124.2 124.2 124.2 124.2 124.2 124.2 124.2
C124.2 124.2 124.2 124.2 124.2 124.2 124.2 124.2
C124.2 124.2 124.2 124.2 124.2 124.2 124.2 124.2
C124.2 124.2 124.2 124.2 124.2 124.2 124.2 124.2 -99
C 9HR RAINFALL
C146.7 146.7 146.7 146.7 146.7 146.7 146.7 146.7
C146.7 146.7 146.7 146.7 146.7 146.7 146.7 146.7
C146.7 146.7 146.7 146.7 146.7 146.7 146.7 146.7
C146.7 146.7 146.7 146.7 146.7 146.7 146.7 146.7 -99
C 12HR RAINFALL
C163.2 163.2 163.2 163.2 163.2 163.2 163.2 163.2
C163.2 163.2 163.2 163.2 163.2 163.2 163.2 163.2
C163.2 163.2 163.2 163.2 163.2 163.2 163.2 163.2
C163.2 163.2 163.2 163.2 163.2 163.2 163.2 163.2 -99
C REFERENCE PATTERN
2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 -99


20 ARI 2HR STORM
DESIGN
0.25 48 1 4 1 -99
0 18
90MIN PATTERN
23.3 37.5 15.4 11.6 7.6 4.6 0 0
0 0 0 0 0 0 0 0 0 0 -99
2HR PATTERN
10.9 19.2 33.9 11.0 9.1 7.0 4.9 4.0
0 0 0 0 0 0 0 0 0 0 -99
3HR PATTERN
5.7 16.8 23.4 8.7 11.8 7.8 5.8 6.7 4.8 3.8 2.8 1.9
0 0 0 0 0 0 -99
```

```
4.5HR PATTERN
1.6 5.4 9.8 7.6 17.8 12.9 4.7 3.4 6.8 5.6 4.5 3.7
3.8 2.7 3.8 2.7 1.6 1.6 -99
C 90MIN RAINFALL
C94.1 94.1 94.1 94.1 94.1 94.1 94.1 94.1
C94.1 94.1 94.1 94.1 94.1 94.1 94.1 94.1
C94.1 94.1 94.1 94.1 94.1 94.1 94.1 94.1
C94.1 94.1 94.1 94.1 94.1 94.1 94.1 94.1 -99
C 2HR RAINFALL
C106.0 106.0 106.0 106.0 106.0 106.0 106.0 106.0
C106.0 106.0 106.0 106.0 106.0 106.0 106.0 106.0
C106.0 106.0 106.0 106.0 106.0 106.0 106.0 106.0
C106.0 106.0 106.0 106.0 106.0 106.0 106.0 106.0 -99
C 3HR RAINFALL
C125.4 125.4 125.4 125.4 125.4 125.4 125.4 125.4
C125.4 125.4 125.4 125.4 125.4 125.4 125.4 125.4
C125.4 125.4 125.4 125.4 125.4 125.4 125.4 125.4
C125.4 125.4 125.4 125.4 125.4 125.4 125.4 125.4 -99
C 4.5HR RAINFALL
C149.0 149.0 149.0 149.0 149.0 149.0 149.0 149.0
C149.0 149.0 149.0 149.0 149.0 149.0 149.0 149.0
C149.0 149.0 149.0 149.0 149.0 149.0 149.0 149.0
C149.0 149.0 149.0 149.0 149.0 149.0 149.0 149.0 -99
C REFERENCE PATTERN
2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 -99


20 ARI 9HR STORM
DESIGN
0.5 36 1 3 1 -99
0 24
6HR PATTERN
4.1 8.0 11.0 23.3 15.3 8.1 7.0 7.0 5.1
6.1 3.1 1.9 0 0 0 0 0 0 0 0 0 0 0 0 -99
9HR PATTERN
2.4 6.3 4.4 4.5 3.4 10.5 2.8 4.7 7.4
17.6 13.1 6.5 5.4 3.5 2.4 2.5 1.3 1.3
0 0 0 0 0 0 -99
12HR PATTERN
1.6 4.5 3.5 1.6 0.6 2.6 2.6 4.7 3.6 2.6 3.6 7.0
9.2 15.8 3.5 0.6 4.8 11.3 6.0 4.9 1.6 2.7 0.6 0.5 -99
C 6HR RAINFALL
C166.8 166.8 166.8 166.8 166.8 166.8 166.8 166.8
C166.8 166.8 166.8 166.8 166.8 166.8 166.8 166.8
C166.8 166.8 166.8 166.8 166.8 166.8 166.8 166.8
C166.8 166.8 166.8 166.8 166.8 166.8 166.8 166.8 -99
C 9HR RAINFALL
C198.9 198.9 198.9 198.9 198.9 198.9 198.9 198.9
C198.9 198.9 198.9 198.9 198.9 198.9 198.9 198.9
C198.9 198.9 198.9 198.9 198.9 198.9 198.9 198.9
C198.9 198.9 198.9 198.9 198.9 198.9 198.9 198.9 -99
C 12HR RAINFALL
C222.0 222.0 222.0 222.0 222.0 222.0 222.0 222.0
C222.0 222.0 222.0 222.0 222.0 222.0 222.0 222.0
C222.0 222.0 222.0 222.0 222.0 222.0 222.0 222.0
C222.0 222.0 222.0 222.0 222.0 222.0 222.0 222.0 -99
C REFERENCE PATTERN
2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 -99
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100 ARI 2HR STORM
DESIGN
0.25 48 1 4 1 -99
0 18
90MIN PATTERN
23.3 37.5 15.4 11.6 7.6 4.6 0 0
0 0 0 0 0 0 0 0 0 0 -99
2HR PATTERN
10.9 19.2 33.9 11.0 9.1 7.0 4.9 4.0
0 0 0 0 0 0 0 0 0 0 -99
3HR PATTERN
5.7 16.8 23.4 8.7 11.8 7.8 5.8 6.7 4.8 3.8 2.8 1.9
0 0 0 0 0 0 -99
4.5HR PATTERN
1.6 5.4 9.8 7.6 17.8 12.9 4.7 3.4 6.8 5.6 4.5 3.7
3.8 2.7 3.8 2.7 1.6 1.6 -99
C 90MIN RAINFALL
C123.8 123.8 123.8 123.8 123.8 123.8 123.8 123.8
C123.8 123.8 123.8 123.8 123.8 123.8 123.8 123.8
C123.8 123.8 123.8 123.8 123.8 123.8 123.8 123.8
C123.8 123.8 123.8 123.8 123.8 123.8 123.8 123.8 -99
C 2HR RAINFALL
C140.3 140.3 140.3 140.3 140.3 140.3 140.3 140.3
C140.3 140.3 140.3 140.3 140.3 140.3 140.3 140.3
C140.3 140.3 140.3 140.3 140.3 140.3 140.3 140.3
C140.3 140.3 140.3 140.3 140.3 140.3 140.3 140.3 -99
C 3HR RAINFALL
C166.8 166.8 166.8 166.8 166.8 166.8 166.8 166.8
C166.8 166.8 166.8 166.8 166.8 166.8 166.8 166.8
C166.8 166.8 166.8 166.8 166.8 166.8 166.8 166.8
C166.8 166.8 166.8 166.8 166.8 166.8 166.8 166.8 -99
C 4.5HR RAINFALL
C199.1 199.1 199.1 199.1 199.1 199.1 199.1 199.1
C199.1 199.1 199.1 199.1 199.1 199.1 199.1 199.1
C199.1 199.1 199.1 199.1 199.1 199.1 199.1 199.1
C199.1 199.1 199.1 199.1 199.1 199.1 199.1 199.1 -99
C 2HR RAINFALL + 10%
C154.3 154.3 154.3 154.3 154.3 154.3 154.3 154.3
C154.3 154.3 154.3 154.3 154.3 154.3 154.3 154.3
C154.3 154.3 154.3 154.3 154.3 154.3 154.3 154.3
C154.3 154.3 154.3 154.3 154.3 154.3 154.3 154.3 -99
C REFERENCE PATTERN
2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 -99


100 ARI 9HR STORM
DESIGN
0.5 36 1 3 1 -99
0 24
6HR PATTERN
4.1 8.0 11.0 23.3 15.3 8.1 7.0 7.0 5.1
6.1 3.1 1.9 0 0 0 0 0 0 0 0 0 0 0 0 -99
9HR PATTERN
2.4 6.3 4.4 4.5 3.4 10.5 2.8 4.7 7.4
17.6 13.1 6.5 5.4 3.5 2.4 2.5 1.3 1.3
0 0 0 0 0 0 -99
12HR PATTERN
1.6 4.5 3.5 1.6 0.6 2.6 2.6 4.7 3.6 2.6 3.6 7.0
9.2 15.8 3.5 0.6 4.8 11.3 6.0 4.9 1.6 2.7 0.6 0.5 -99
C 6HR RAINFALL
C223.8 223.8 223.8 223.8 223.8 223.8 223.8 223.8
```

```
C223.8 223.8 223.8 223.8 223.8 223.8 223.8 223.8
C223.8 223.8 223.8 223.8 223.8 223.8 223.8 223.8
C223.8 223.8 223.8 223.8 223.8 223.8 223.8 223.8 -99
C 9HR RAINFALL
C267.6 267.6 267.6 267.6 267.6 267.6 267.6 267.6
C267.6 267.6 267.6 267.6 267.6 267.6 267.6 267.6
C267.6 267.6 267.6 267.6 267.6 267.6 267.6 267.6
C267.6 267.6 267.6 267.6 267.6 267.6 267.6 267.6 -99
C 12HR RAINFALL
C301.0 301.0 301.0 301.0 301.0 301.0 301.0 301.0
C301.0 301.0 301.0 301.0 301.0 301.0 301.0 301.0
C301.0 301.0 301.0 301.0 301.0 301.0 301.0 301.0
C301.0 301.0 301.0 301.0 301.0 301.0 301.0 301.0 -99
C REFERENCE PATTERN
2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 -99


500 ARI 2HR STORM
DESIGN
0.25 48 1 4 1 -99
0 18
90MIN PATTERN
23.3 37.5 15.4 11.6 7.6 4.6 0 0
0 0 0 0 0 0 0 0 0 0 -99
2HR PATTERN
10.9 19.2 33.9 11.0 9.1 7.0 4.9 4.0
0 0 0 0 0 0 0 0 0 0 -99
3HR PATTERN
5.7 16.8 23.4 8.7 11.8 7.8 5.8 6.7 4.8 3.8 2.8 1.9
0 0 0 0 0 0 -99
4.5HR PATTERN
1.6 5.4 9.8 7.6 17.8 12.9 4.7 3.4 6.8 5.6 4.5 3.7
3.8 2.7 3.8 2.7 1.6 1.6 -99
C 200ARI 2HR RAINFALL
C155.4 155.4 155.4 155.4 155.4 155.4 155.4 155.4
C155.4 155.4 155.4 155.4 155.4 155.4 155.4 155.4
C155.4 155.4 155.4 155.4 155.4 155.4 155.4 155.4
C155.4 155.4 155.4 155.4 155.4 155.4 155.4 155.4 -99
C 500ARI 2HR RAINFALL
176.2 176.2 176.2 176.2 176.2 176.2 176.2 176.2
176.2 176.2 176.2 176.2 176.2 176.2 176.2 176.2
176.2 176.2 176.2 176.2 176.2 176.2 176.2 176.2
176.2 176.2 176.2 176.2 176.2 176.2 176.2 176.2 -99
C REFERENCE PATTERN
2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 -99


500 ARI 9HR STORM
DESIGN
0.5 36 1 3 1 -99
0 24
6HR PATTERN
4.1 8.0 11.0 23.3 15.3 8.1 7.0 7.0 5.1
6.1 3.1 1.9 0 0 0 0 0 0 0 0 0 0 0 0 -99
9HR PATTERN
2.4 6.3 4.4 4.5 3.4 10.5 2.8 4.7 7.4
17.6 13.1 6.5 5.4 3.5 2.4 2.5 1.3 1.3
0 0 0 0 0 0 -99
12HR PATTERN
1.6 4.5 3.5 1.6 0.6 2.6 2.6 4.7 3.6 2.6 3.6 7.0
```

```
9.2 15.8 3.5 0.6 4.8 11.3 6.0 4.9 1.6 2.7 0.6 0.5 -99
C 200ARI 9HR RAINFALL
C297.0 297.0 297.0 297.0 297.0 297.0 297.0 297.0
C297.0 297.0 297.0 297.0 297.0 297.0 297.0 297.0
C297.0 297.0 297.0 297.0 297.0 297.0 297.0 297.0
C297.0 297.0 297.0 297.0 297.0 297.0 297.0 297.0 -99
C 500ARI 9HR RAINFALL
339.3 339.3 339.3 339.3 339.3 339.3 339.3 339.3
339.3 339.3 339.3 339.3 339.3 339.3 339.3 339.3
339.3 339.3 339.3 339.3 339.3 339.3 339.3 339.3
339.3 339.3 339.3 339.3 339.3 339.3 339.3 339.3 -99
C REFERENCE PATTERN
2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 -99
```

```
SUGARMILL CREEK CATCHMENT
1
1 1.1 -99       'SM1'
2 0.6 -99       'SM2'
7
INFLOW26
5 1.2 -99
3
1 0.6 -99       'SM3'
7
INFLOW27
5 0.5 -99
3
1 0.3 -99       'SM4'
7
Q27A
4
3
1 1.0 -99       'SM5'
2 0.6 -99       'SM6'
7
INFLOW28
5 1.1 -99
3
1 0.6 -99       'SM7'
7
Q28A
4
3
1 0.9 -99       'SM8'
2 0.9 -99       'SM9'
2 0.3 -99       'SM10'
7
INFLOW29
3
1 0.5 -99       'SM11'
7
INFLOW30
4
5 0.6 -99
3
1 1.0 -99       'SM12'
7
INFLOW31
4
5 0.5 -99
3
1 0.5 -99       'SM13'
7
INFLOW32
4
5 0.7 -99
4
4
4
5 0.3 -99
3
1 0.3 -99       'SM14'
7
INFLOW33
4
7
```

```
SUGARMILL CREEK AT OUTLET
0
C SUB-AREAS
1.54 0.84 0.58 0.17 1.31 0.82 0.28 0.75
0.71 0.14 0.20 0.65 0.49 0.92 -99
C IMPERVIOUS FRACTIONS
1 0 0 0 0 0 0 0 0 0 0 0 0 0 0.06 -99
5 ARI 2HR STORM
DESIGN
0.25 48 1 4 1 -99
0 18
90MIN PATTERN
23.7 39.6 15.1 10.8 6.7 4.1 0 0
0 0 0 0 0 0 0 0 0 0 -99
2HR PATTERN
10.6 19.7 36.0 10.6 8.6 6.5 4.2 3.8
0 0 0 0 0 0 0 0 0 0 -99
3HR PATTERN
5.3 17.6 25.1 8.7 12.1 7.6 5.5 6.4 4.3 3.5 2.4 1.5
0 0 0 0 0 0 -99
4.5HR PATTERN
1.5 5.3 10.2 7.8 19.1 13.6 4.5 3.1 6.8 5.5 4.3 3.4
3.6 2.5 3.5 2.4 1.5 1.4 -99
C 90MIN RAINFALL
C71.6 71.6 71.6 71.6 71.6 71.6 71.6 71.6
C71.6 71.6 71.6 71.6 71.6 71.6 -99
C 2HR RAINFALL
80.4 80.4 80.4 80.4 80.4 80.4 80.4 80.4
80.4 80.4 80.4 80.4 80.4 80.4 -99
C 3HR RAINFALL
C94.5 94.5 94.5 94.5 94.5 94.5 94.5 94.5
C94.5 94.5 94.5 94.5 94.5 94.5 -99
C 4.5HR RAINFALL
C111.6 111.6 111.6 111.6 111.6 111.6 111.6 111.6
C111.6 111.6 111.6 111.6 111.6 111.6 -99
C REFERENCE PATTERN
1 1 1 1 1 1 1 1 1 1 1 1 1 1 -99


5 ARI 12HR STORM
DESIGN
0.5 36 1 3 1 -99
0 24
6HR PATTERN
3.6 7.8 11.4 25.0 16.0 8.2 6.7 6.7 4.7
5.7 2.7 1.5 0 0 0 0 0 0 0 0 0 0 0 0 -99
9HR PATTERN
2.2 6.2 4.1 4.3 3.1 10.9 2.5 4.5 7.6
18.9 13.8 6.5 5.3 3.2 2.1 2.4 1.1 1.3
0 0 0 0 0 0 -99
12HR PATTERN
1.4 4.4 3.3 1.5 0.5 2.4 2.3 4.6 3.5 2.3 3.4 7.1
9.6 17.0 3.3 0.6 4.8 11.9 6.1 5.0 1.4 2.5 0.6 0.5 -99
C 6HR RAINFALL
C124.2 124.2 124.2 124.2 124.2 124.2 124.2 124.2
C124.2 124.2 124.2 124.2 124.2 124.2 -99
C 9HR RAINFALL
C146.7 146.7 146.7 146.7 146.7 146.7 146.7 146.7
C146.7 146.7 146.7 146.7 146.7 146.7 -99
C 12HR RAINFALL
163.2 163.2 163.2 163.2 163.2 163.2 163.2 163.2
163.2 163.2 163.2 163.2 163.2 163.2 -99
```

```
C REFERENCE PATTERN
3 3 3 3 3 3 3 3 3 3 3 3 3 3 -99


20 ARI 1.5HR STORM
DESIGN
0.25 48 1 4 1 -99
0 18
90MIN PATTERN
23.7 39.6 15.1 10.8 6.7 4.1 0 0
0 0 0 0 0 0 0 0 0 0 -99
2HR PATTERN
10.6 19.7 36.0 10.6 8.6 6.5 4.2 3.8
0 0 0 0 0 0 0 0 0 0 -99
3HR PATTERN
5.3 17.6 25.1 8.7 12.1 7.6 5.5 6.4 4.3 3.5 2.4 1.5
0 0 0 0 0 0 -99
4.5HR PATTERN
1.5 5.3 10.2 7.8 19.1 13.6 4.5 3.1 6.8 5.5 4.3 3.4
3.6 2.5 3.5 2.4 1.5 1.4 -99
C 90MIN RAINFALL
94.1 94.1 94.1 94.1 94.1 94.1 94.1 94.1
94.1 94.1 94.1 94.1 94.1 94.1 -99
C 2HR RAINFALL
C106.0 106.0 106.0 106.0 106.0 106.0 106.0 106.0
C106.0 106.0 106.0 106.0 106.0 106.0 -99
C 3HR RAINFALL
C125.4 125.4 125.4 125.4 125.4 125.4 125.4 125.4
C125.4 125.4 125.4 125.4 125.4 125.4 -99
C 4.5HR RAINFALL
C149.0 149.0 149.0 149.0 149.0 149.0 149.0 149.0
C149.0 149.0 149.0 149.0 149.0 149.0 -99
C REFERENCE PATTERN
1 1 1 1 1 1 1 1 1 1 1 1 1 1 -99


20 ARI 6HR STORM
DESIGN
0.5 36 1 3 1 -99
0 24
6HR PATTERN
3.6 7.8 11.4 25.0 16.0 8.2 6.7 6.7 4.7
5.7 2.7 1.5 0 0 0 0 0 0 0 0 0 0 0 0 -99
9HR PATTERN
2.2 6.2 4.1 4.3 3.1 10.9 2.5 4.5 7.6
18.9 13.8 6.5 5.3 3.2 2.1 2.4 1.1 1.3
0 0 0 0 0 0 -99
12HR PATTERN
1.4 4.4 3.3 1.5 0.5 2.4 2.3 4.6 3.5 2.3 3.4 7.1
9.6 17.0 3.3 0.6 4.8 11.9 6.1 5.0 1.4 2.5 0.6 0.5 -99
C 6HR RAINFALL
166.8 166.8 166.8 166.8 166.8 166.8 166.8 166.8
166.8 166.8 166.8 166.8 166.8 166.8 -99
C 9HR RAINFALL
C198.9 198.9 198.9 198.9 198.9 198.9 198.9 198.9
C198.9 198.9 198.9 198.9 198.9 198.9 -99
C 12HR RAINFALL
C222.0 222.0 222.0 222.0 222.0 222.0 222.0 222.0
C222.0 222.0 222.0 222.0 222.0 222.0 -99
C REFERENCE PATTERN
1 1 1 1 1 1 1 1 1 1 1 1 1 1 -99
```

```
100 ARI 2HR STORM
DESIGN
0.25 48 1 4 1 -99
0 18
90MIN PATTERN
23.3 37.5 15.4 11.6 7.6 4.6 0 0
0 0 0 0 0 0 0 0 0 0 -99
2HR PATTERN
10.9 19.2 33.9 11.0 9.1 7.0 4.9 4.0
0 0 0 0 0 0 0 0 0 0 -99
3HR PATTERN
5.7 16.8 23.4 8.7 11.8 7.8 5.8 6.7 4.8 3.8 2.8 1.9
0 0 0 0 0 0 -99
4.5HR PATTERN
1.6 5.4 9.8 7.6 17.8 12.9 4.7 3.4 6.8 5.6 4.5 3.7
3.8 2.7 3.8 2.7 1.6 1.6 -99
C 90MIN RAINFALL
C123.8 123.8 123.8 123.8 123.8 123.8 123.8 123.8
C123.8 123.8 123.8 123.8 123.8 123.8 -99
C 2HR RAINFALL
C140.3 140.3 140.3 140.3 140.3 140.3 140.3 140.3
C140.3 140.3 140.3 140.3 140.3 140.3 -99
C 3HR RAINFALL
C166.8 166.8 166.8 166.8 166.8 166.8 166.8 166.8
C166.8 166.8 166.8 166.8 166.8 166.8 -99
C 4.5HR RAINFALL
C199.1 199.1 199.1 199.1 199.1 199.1 199.1 199.1
C199.1 199.1 199.1 199.1 199.1 199.1 -99
C 2HR RAINFALL +10%
C154.3 154.3 154.3 154.3 154.3 154.3 154.3 154.3
C154.3 154.3 154.3 154.3 154.3 154.3 -99


100 ARI 9HR STORM
DESIGN
0.5 36 1 3 1 -99
0 24
6HR PATTERN
4.1 8.0 11.0 23.3 15.3 8.1 7.0 7.0 5.1
6.1 3.1 1.9 0 0 0 0 0 0 0 0 0 0 0 0 -99
9HR PATTERN
2.4 6.3 4.4 4.5 3.4 10.5 2.8 4.7 7.4
17.6 13.1 6.5 5.4 3.5 2.4 2.5 1.3 1.3
0 0 0 0 0 0 -99
12HR PATTERN
1.6 4.5 3.5 1.6 0.6 2.6 2.6 4.7 3.6 2.6 3.6 7.0
9.2 15.8 3.5 0.6 4.8 11.3 6.0 4.9 1.6 2.7 0.6 0.5 -99
C 6HR RAINFALL
C223.8 223.8 223.8 223.8 223.8 223.8 223.8 223.8
C223.8 223.8 223.8 223.8 223.8 223.8 -99
C 9HR RAINFALL
C267.6 267.6 267.6 267.6 267.6 267.6 267.6 267.6
C267.6 267.6 267.6 267.6 267.6 267.6 -99
C 12HR RAINFALL
C301.0 301.0 301.0 301.0 301.0 301.0 301.0 301.0
C301.0 301.0 301.0 301.0 301.0 301.0 -99


500 ARI 2HR STORM
DESIGN
0.25 48 1 4 1 -99
```

```
0 18
90MIN PATTERN
23.3 37.5 15.4 11.6 7.6 4.6 0 0
0 0 0 0 0 0 0 0 0 0 -99
2HR PATTERN
10.9 19.2 33.9 11.0 9.1 7.0 4.9 4.0
0 0 0 0 0 0 0 0 0 0 -99
3HR PATTERN
5.7 16.8 23.4 8.7 11.8 7.8 5.8 6.7 4.8 3.8 2.8 1.9
0 0 0 0 0 0 -99
4.5HR PATTERN
1.6 5.4 9.8 7.6 17.8 12.9 4.7 3.4 6.8 5.6 4.5 3.7
3.8 2.7 3.8 2.7 1.6 1.6 -99
C 200ARI 2HR RAINFALL
C155.4 155.4 155.4 155.4 155.4 155.4 155.4 155.4
C155.4 155.4 155.4 155.4 155.4 155.4 -99
C 500ARI 2HR RAINFALL
176.2 176.2 176.2 176.2 176.2 176.2 176.2 176.2
176.2 176.2 176.2 176.2 176.2 176.2 -99
C REFERENCE PATTERN
2 2 2 2 2 2 2 2 2 2 2 2 2 2 -99


500 ARI 9HR STORM
DESIGN
0.5 36 1 3 1 -99
0 24
6HR PATTERN
4.1 8.0 11.0 23.3 15.3 8.1 7.0 7.0 5.1
6.1 3.1 1.9 0 0 0 0 0 0 0 0 0 0 0 0 -99
9HR PATTERN
2.4 6.3 4.4 4.5 3.4 10.5 2.8 4.7 7.4
17.6 13.1 6.5 5.4 3.5 2.4 2.5 1.3 1.3
0 0 0 0 0 0 -99
12HR PATTERN
1.6 4.5 3.5 1.6 0.6 2.6 2.6 4.7 3.6 2.6 3.6 7.0
9.2 15.8 3.5 0.6 4.8 11.3 6.0 4.9 1.6 2.7 0.6 0.5 -99
C 200ARI 9HR RAINFALL
C297.0 297.0 297.0 297.0 297.0 297.0 297.0 297.0
C297.0 297.0 297.0 297.0 297.0 297.0 -99
C 500ARI 9HR RAINFALL
339.3 339.3 339.3 339.3 339.3 339.3 339.3 339.3
339.3 339.3 339.3 339.3 339.3 339.3 -99
C REFERENCE PATTERN
2 2 2 2 2 2 2 2 2 2 2 2 2 2 -99
```

APPENDIX B

MIKE-11 Model File Details

MIKE-11 Model Files

MOON-74.RDF	Pre- "Heritage Park" conditions
MOON-96.RDF	Partial completion of "Heritage Park" - 1996
MOON-99.RDF	Completion of "Heritage Park" as designed
MOON-74.SSF	Pre- "Heritage Park", use with MOON-74.RDF
MOONEE.SSF	Post- "Heritage Park" for use with MOON-96.RDF and MOON-99.RDF

Calibration Floods

NOV96MOD.BSF	Modified rainfall for Nov 1996 storm
MARCH-74.BSF	March 1974 flood

Design Floods

1%AEP2HR.BSF	1% AEP Flood, 2 hour storm 1% ocean
1%AEP3HR.BSF	1% AEP Flood, 3 hour storm 1% ocean
1%AEP45H.BSF	1% AEP Flood, 4.5 hour storm 1% ocean
1%AEP6HR.BSF	1% AEP Flood, 6 hour storm 1% ocean
1%AEP9HR.BSF	1% AEP Flood, 9 hour storm 1% ocean
1%AEP12H.BSF	1% AEP Flood, 12 hour storm 1% ocean
1%2H-5%.BSF	1% AEP Flood, 2 hour storm, 5% AEP ocean
1%2H-GH.BSF	1% AEP Flood, 2 hour storm, Greenhouse ocean
1%2H-110.BSF	1% AEP Flood, 2 hour storm, 10% increase in rainfall
1%9H-ST.BSF	1% AEP Flood, 9 hour storm, spring tide
1%9H-GH.BSF	1% AEP Flood, 9 hour storm, Greenhouse ocean
5%AEP2HR.BSF	5% AEP Flood, 2 hour storm, 5% AEP ocean
5%AEP3HR.BSF	5% AEP Flood, 3 hour storm, 5% AEP ocean
5%AEP45H.BSF	5% AEP Flood, 4.5 hour storm, 5% AEP ocean
5%AEP6HR.BSF	5% AEP Flood, 6 hour storm, 5% AEP ocean
5%AEP9HR.BSF	5% AEP Flood, 9 hour storm, 5% AEP ocean
5%AEP12H.BSF	5% AEP Flood, 12 hour storm, 5% AEP ocean
20%AEP2H.BSF	20% AEP Flood, 2 hour storm, 20% AEP ocean
20%AEP3H.BSF	20% AEP Flood, 3 hour storm, 20% AEP ocean
20%AEP45.BSF	20% AEP Flood, 4.5 hour storm, 20% AEP ocean
20%AEP6H.BSF	20% AEP Flood, 6 hour storm, 20% AEP ocean
20%AEP9H.BSF	20% AEP Flood, 9 hour storm, 20% AEP ocean
20%AEP12.BSF	20% AEP Flood, 12 hour storm, 20% AEP ocean
2HRPMF.BSF	PMF Flood, 2 hour storm, 1% AEP ocean
9HRPMF.BSF	PMF Flood, 9 hour storm, 1% AEP ocean

Cross-section

MOONEE.TXT	Raw cross-section data, offset and level
MOONEE.PST	MIKE-11 cross-section database file
MOONEE.IX0	MIKE-11 cross-section database file
MOONEE.IX1	MIKE-11 cross-section database file

Results Files

NOV96MOD.RRF	November 1996 Calibration
1%AEP2HR.RRF	1% AEP Design Flood, 2 hour storm
1%AEP9HR.RRF	1% AEP Design Flood, 9 hour storm

APPENDIX C

Design Flood Levels

Appendix C

Design Flood Levels (m AHD)

Branch	Distance (km)	1% AEP	5% AEP	20% AEP	PMF	Landmark
DRAIN	0.000	7.83	7.70	7.56	8.41	d/s Beacon Crescent
DRAIN	0.050	7.54	7.43	7.29	8.19	
DRAIN	0.250	6.96	6.56	6.52	8.07	Moonee Creek
MOONEE	0.020	10.41	10.28	10.16	11.33	u/s Pacific Highway
MOONEE	0.070	10.06	10.02	9.98	10.44	d/s Pacific Highway
MOONEE	0.300	8.91	8.89	8.86	9.14	
MOONEE	0.330	8.79	8.76	8.73	9.06	
MOONEE	0.570	7.98	7.93	7.89	8.45	
MOONEE	0.680	7.76	7.70	7.67	8.24	
MOONEE	0.850	7.24	7.15	7.10	8.10	
MOONEE	1.050	6.96	6.56	6.52	8.07	"Drain" Tributary
MOONEE	1.420	5.86	5.54	5.12	7.18	
MOONEE	1.750	5.69	5.33	4.85	7.04	"Gun Club" Tributary
MOONEE	2.480	4.57	4.21	3.77	5.81	
MOONEE	3.025	4.08	3.76	3.39	5.31	
MOONEE	3.570	3.85	3.55	3.19	4.97	
MOONEE	4.050	3.55	3.23	2.88	4.58	
MOONEE	4.250	3.12	2.73	2.33	4.36	"Airfield" Tributary
MOONEE	4.350	3.08	2.70	2.30	4.28	
MOONEE	4.700	3.00	2.64	2.24	4.23	
MOONEE	5.550	2.92	2.57	2.16	4.11	"Sharp" Tributary
MOONEE	5.600	2.91	2.56	2.16	4.11	
MOONEE	5.950	2.88	2.52	2.10	4.05	Skinners Creek
MOONEE	6.050	2.87	2.51	2.10	4.04	
MOONEE	6.580	2.80	2.45	2.05	3.89	

Branch	Distance (km)	1% AEP	5% AEP	20% AEP	PMF	Landmark
MOONEE	7.200	2.71	2.38	1.98	3.68	"Bucca" Tributary
MOONEE	7.280	2.70	2.37	1.97	3.65	
MOONEE	7.400	2.69	2.35	1.95	3.61	Cunninghams Creek
MOONEE	7.800	2.64	2.31	1.91	3.46	
MOONEE	8.150	2.53	2.22	1.82	3.11	
MOONEE	8.420	2.50	2.18	1.78	3.00	
MOONEE	8.760	2.47	2.16	1.75	2.87	
MOONEE	8.960	2.43	2.13	1.73	2.65	
MOONEE	9.200	2.41	2.11	1.71	2.52	Sugarmill Creek
MOONEE	9.400	2.40	2.10	1.70	2.40	Entrance
GUN-CLUB	0.020	8.50	8.32	8.20	10.14	u/s Pacific Highway
GUN-CLUB	0.070	8.30	8.21	8.14	9.04	d/s Pacific Highway
GUN-CLUB	0.200	7.63	7.49	7.33	8.63	
GUN-CLUB	0.400	6.97	6.78	6.52	8.08	
GUN-CLUB	0.750	6.16	5.88	5.45	7.43	
GUN-CLUB	0.900	5.69	5.33	4.85	7.04	Moonee Creek
RUSSELL	0.100	5.35	5.21	5.08	6.83	u/s Pacific Highway
RUSSELL	0.150	4.85	4.81	4.77	5.03	d/s Pacific Highway
RUSSELL	0.650	4.24	4.20	4.16	4.53	
RUSSELL	1.000	3.86	3.84	3.81	4.36	"Smiths" Tributary
SMITHS	0.060	5.96	5.81	5.66	7.06	
SMITHS	0.100	5.93	5.76	5.58	7.04	u/s Pacific Highway
SMITHS	0.150	4.28	4.23	4.18	4.54	d/s Pacific Highway
SMITHS	0.300	4.09	4.06	4.02	4.36	
SMITHS	0.400	3.86	3.84	3.81	4.36	"Russell" Tributary
SMITHS	0.500	3.67	3.61	3.56	4.36	

Branch	Distance (km)	1% AEP	5% AEP	20% AEP	PMF	Landmark
SMITHS	0.700	3.13	2.76	2.38	4.36	"Airfield" Tributary
AIRFIELD	0.030	10.23	10.19	10.14	10.39	
AIRFIELD	0.140	9.11	9.08	9.03	9.25	
AIRFIELD	0.280	7.12	7.09	7.05	7.25	
AIRFIELD	0.400	5.29	5.04	4.72	6.68	u/s Pacific Highway
AIRFIELD	0.450	4.09	3.99	3.89	4.53	d/s Pacific Highway
AIRFIELD	0.550	4.00	3.90	3.79	4.41	
AIRFIELD	0.730	3.60	3.49	3.35	4.36	
AIRFIELD	0.850	3.14	2.76	2.39	4.36	
AIRFIELD	0.900	3.13	2.76	2.38	4.36	"Smiths" Tributary
AIRFIELD	1.200	3.12	2.74	2.33	4.36	
AIRFIELD	1.300	3.12	2.73	2.33	4.36	Moonee Creek
SHARP	0.000	13.87	13.74	13.61	14.61	
SHARP	0.190	10.79	10.67	10.54	11.38	u/s "Heritage Park" Ring Road
SHARP	0.580	7.09	6.87	6.68	8.48	d/s "Heritage Park" Ring Road
SHARP	0.670	6.43	6.07	5.75	8.37	u/s Pacific Highway
SHARP	0.720	5.66	5.50	5.32	6.32	d/s Pacific Highway
SHARP	1.000	3.63	3.45	3.23	4.47	
SHARP	1.600	2.92	2.57	2.16	4.11	Moonee Creek
MAIN CHANNEL	0.060	9.07	8.98	8.90	9.51	
MAIN CHANNEL	0.100	8.75	8.66	8.58	9.20	
MAIN CHANNEL	0.250	8.30	8.23	8.16	8.74	
MAIN CHANNEL	0.290	8.26	8.19	8.14	8.63	
MAIN CHANNEL	0.320	7.75	7.65	7.58	8.28	
MAIN CHANNEL	0.485	7.18	7.09	6.97	7.59	
MAIN CHANNEL	0.675	6.53	6.43	6.32	7.12	

Branch	Distance (km)	1% AEP	5% AEP	20% AEP	PMF	Landmark
MAIN CHANNEL	0.700	6.47	6.37	6.27	7.11	"Line-A", "Line-B" Branches continue
LINE-A	0.000	6.47	6.37	6.27	7.11	
LINE-A	0.070	6.40	6.31	6.21	7.04	
LINE-A	0.100	6.09	5.96	5.83	6.89	
LINE-A	0.180	6.01	5.85	5.69	6.87	u/s "Heritage Park" Ring Road
LINE-A	0.210	5.64	5.58	5.49	6.45	d/s "Heritage Park" Ring Road
LINE-A	0.400	5.23	5.11	4.98	6.43	"Heritage" Branch continues
HERITAGE	0.850	5.23	5.11	4.98	6.43	u/s Pacific Highway
HERITAGE	0.900	5.02	4.97	4.93	5.43	d/s Pacific Highway
HERITAGE	1.050	4.88	4.70	4.61	5.19	
HERITAGE	1.200	3.63	3.45	3.23	4.47	
LINE-B	0.000	6.47	6.37	6.27	7.11	
LINE-B	0.090	6.40	6.31	6.23	7.04	u/s "Heritage Park" Ring Road
LINE-B	0.110	6.24	6.04	5.85	6.97	d/s "Heritage Park" Ring Road
LINE-B	0.170	6.24	6.03	5.84	6.97	
LINE-B	0.200	5.96	5.82	5.70	6.80	
LINE-B	0.380	5.88	5.64	5.37	6.66	"Tiki" Branch continues
TIKI	0.300	5.88	5.64	5.37	6.66	u/s Pacific Highway
TIKI	0.350	5.02	4.97	4.93	5.40	d/s Pacific Highway
TIKI	0.550	4.84	4.76	4.65	5.26	
TIKI	0.650	4.55	4.50	4.44	4.96	u/s Tiki Road
TIKI	0.850	2.95	2.60	2.18	4.37	d/s Tiki Road
TIKI	1.000	2.92	2.57	2.15	4.30	Skinners Creek

Branch	Distance (km)	1% AEP	5% AEP	20% AEP	PMF	Landmark
SKINNERS	0.000	12.83	12.52	12.22	14.36	
SKINNERS	0.180	11.32	11.02	10.76	12.65	
SKINNERS	0.450	8.83	8.67	8.54	9.53	
SKINNERS	0.600	7.74	7.66	7.59	8.19	
SKINNERS	0.950	5.84	5.79	5.72	6.29	
SKINNERS	1.270	3.90	3.52	3.26	5.80	u/s Pacific Highway
SKINNERS	1.300	3.72	3.33	3.07	5.47	d/s Pacific Highway
SKINNERS	1.600	3.32	2.90	2.53	5.12	
SKINNERS	2.200	3.00	2.63	2.21	4.61	
SKINNERS	2.500	2.92	2.57	2.15	4.30	"Tiki" Tributary
SKINNERS	2.650	2.89	2.53	2.12	4.10	
SKINNERS	2.900	2.88	2.52	2.11	4.06	
SKINNERS	3.000	2.88	2.52	2.10	4.05	Moonee Creek
BUCCA	0.300	6.80	6.76	6.73	6.93	
BUCCA	0.500	5.02	4.87	4.70	6.01	
BUCCA	0.680	5.01	4.86	4.70	6.01	u/s Pacific Highway
BUCCA	0.720	4.35	4.32	4.28	4.52	d/s Pacific Highway
BUCCA	0.760	4.08	4.06	4.03	4.11	
BUCCA	0.900	3.33	3.32	3.31	3.70	
BUCCA	1.100	2.83	2.73	2.68	3.69	
BUCCA	1.350	2.78	2.61	2.41	3.68	
BUCCA	1.520	2.77	2.59	2.34	3.68	
BUCCA	1.800	2.71	2.38	1.98	3.68	Moonee Creek
CUNNINGHAM	0.000	11.98	11.88	11.79	12.38	
CUNNINGHAM	0.250	9.04	8.92	8.81	9.20	
CUNNINGHAM	0.500	7.40	7.19	6.98	8.35	
CUNNINGHAM	0.520	7.22	7.03	6.83	8.10	

Branch	Distance (km)	1% AEP	5% AEP	20% AEP	PMF	Landmark
CUNNINGHAM	0.750	5.70	5.40	5.06	6.70	
CUNNINGHAM	0.880	5.23	4.89	4.44	6.10	
CUNNINGHAM	0.980	4.83	4.46	4.08	5.50	u/s Hoys Road
CUNNINGHAM	1.000	4.34	4.02	3.72	5.42	d/s Hoys Road
CUNNINGHAM	1.220	3.09	2.83	2.58	4.21	
CUNNINGHAM	1.360	2.83	2.52	2.31	3.90	u/s Pacific Highway
CUNNINGHAM	1.380	2.78	2.47	2.27	3.79	d/s Pacific Highway
CUNNINGHAM	1.600	2.70	2.37	1.97	3.63	
CUNNINGHAM	1.800	2.69	2.36	1.96	3.61	"Beach-Road" Tributary
CUNNINGHAM	1.850	2.69	2.36	1.96	3.61	
CUNNINGHAM	2.000	2.69	2.35	1.95	3.61	Moonee Creek
BEACH-ROAD	0.800	6.93	6.77	6.44	8.04	
BEACH-ROAD	0.830	4.68	4.60	4.46	5.15	
BEACH-ROAD	1.020	2.96	2.69	2.48	3.90	
BEACH-ROAD	1.300	2.69	2.36	1.96	3.61	Cunninghams Creek
RUSHTON	0.050	6.38	6.24	6.10	7.23	u/s Pacific Highway
RUSHTON	0.090	6.25	6.13	6.00	7.00	d/s Pacific Highway
RUSHTON	0.200	5.04	4.84	4.68	6.00	
RUSHTON	0.400	3.95	3.78	3.63	4.92	
RUSHTON	0.650	2.84	2.57	2.42	4.03	
RUSHTON	1.020	2.76	2.44	2.09	3.93	
RUSHTON	1.100	2.76	2.44	2.09	3.93	Sugarmill Creek
FAIRVIEW	0.080	7.73	7.63	6.75	8.05	
FAIRVIEW	0.100	4.30	4.00	3.94	4.80	u/s Pacific Highway
FAIRVIEW	0.500	2.83	2.62	2.48	3.99	d/s Pacific Highway
FAIRVIEW	0.700	2.79	2.49	2.19	3.97	**Sugarmill Creek**

Branch	Distance (km)	1% AEP	5% AEP	20% AEP	PMF	Landmark
SUGARMILL	0.060	9.48	9.32	8.54	9.87	u/s Pacific Highway
SUGARMILL	0.080	7.36	7.11	6.93	8.26	d/s Pacific Highway
SUGARMILL	0.470	5.17	4.98	4.82	6.07	
SUGARMILL	0.860	2.83	2.63	2.52	3.99	
SUGARMILL	1.100	2.79	2.49	2.19	3.97	"Fairview" Tributary
SUGARMILL	1.320	2.76	2.45	2.10	3.94	
SUGARMILL	1.450	2.75	2.44	2.09	3.93	"Rushton" & "Sapphire" Tribs
SUGARMILL	1.700	2.62	2.30	1.92	3.55	
SUGARMILL	2.000	2.41	2.11	1.71	2.52	Moonee Creek
MILL-ROAD	0.080	7.65	7.05	6.69	9.67	u/s Pacific Highway
MILL-ROAD	0.120	5.89	5.78	5.69	6.50	d/s Pacific Highway
MILL-ROAD	0.190	5.24	5.16	5.09	5.78	
MILL-ROAD	0.340	3.42	3.31	3.21	4.28	
MILL-ROAD	0.600	2.97	2.83	2.65	4.11	"Gaudrons" Tributary
MILL-ROAD	0.670	2.95	2.81	2.64	4.10	
MILL-ROAD	1.000	2.88	2.75	2.59	4.01	"Sapphire" Tributary
GAUDRONS	0.040	13.77	13.61	13.42	14.25	d/s Pacific Highway
GAUDRONS	0.190	10.71	10.64	10.57	11.05	
GAUDRONS	0.460	2.99	2.85	2.69	4.12	
GAUDRONS	0.700	2.97	2.83	2.65	4.11	"Mill-Road" Tributary
SAPPHIRE	0.050	8.55	8.30	8.08	10.41	u/s Pacific Highway
SAPPHIRE	0.100	7.04	7.01	6.94	7.18	d/s Pacific Highway
SAPPHIRE	0.280	7.03	7.00	6.93	7.11	
SAPPHIRE	0.350	3.97	3.86	3.75	4.26	
SAPPHIRE	0.490	3.88	3.78	3.70	4.17	

Branch	Distance (km)	1% AEP	5% AEP	20% AEP	PMF	Landmark
SAPPHIRE	0.580	3.78	3.70	3.64	4.14	u/s Caravan Park Entry Road
SAPPHIRE	0.600	3.44	3.23	3.01	4.12	d/s Caravan Park Entry Road
SAPPHIRE	0.700	3.22	3.03	2.84	4.10	
SAPPHIRE	0.940	2.97	2.84	2.67	4.03	
SAPPHIRE	1.450	2.88	2.75	2.59	4.01	"Mill-Road" Tributary
SAPPHIRE	1.580	2.80	2.51	2.22	3.99	
SAPPHIRE	1.600	2.80	2.51	2.19	3.99	
SAPPHIRE	2.420	2.76	2.45	2.10	3.94	
SAPPHIRE	2.600	2.75	2.44	2.09	3.93	Sugarmill Creek