LAND & WATER CONSERVATION

DEADMAN'S CREEK FLOOD STUDY

for

SUTHERLAND SHIRE COUNCIL

February 1997

NSW Department of Land and Water Conservation

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FOREWORD

The State Government's Flood Policy is directed towards providing solutions to existing flood problems in developed areas and ensuring that new development is compatible with the flood hazard and does not create additional flooding problems in other areas. Under the policy, the management of flood liable land is the responsibility of local government.

This investigation was carried out for Sutherland Shire Council to determine flood behaviour in the lower reaches of Deadman's Creek which is a tributary of the Georges River.

1.0 INTRODUCTION

The Deadman's Creek catchment rises to the north of Woronora Reservoir at a maximum elevation of about 200m above sea level (see Figure 1). The creek flows in a northerly direction to its confluence with the Georges River at Sandy Point, opposite Picnic Point.

The catchment is relatively long and narrow, with a total area of 18.5 km^2 and a mainstream length of 14.2 km. Most of the catchment is contained within the Holsworthy Military Reserve up to the reserve boundary at Heathcote Road. In this upper reach, the creek channel is relatively deeply incised.

The lower reach of about 1.4 km length between Heathcote Road and the Georges River is the subject area for this study. Along parts of this reach, the creek has low banks and floodplain inundation may occur. There is some residential development on the right overbank in the suburb of Sandy Point.

This study was undertaken for Sutherland Shire Council to assist Council in determining a floodplain management plan for the lower floodplain in the light of potential urban development.

2.0 AVAILABLE DATA

2.1 Previous Studies

There have been no previous investigations with the specific objective of defining flood behaviour in Deadman's Creek. However the contribution of runoff from the Deadman's Creek catchment to the Georges River was considered as part of the Georges River Flood Study (Ref. 1). This study included modelling of historical flood events in the Georges River, using rainfall records for the total catchment. The historical events included the two most recent major flood events of August 1986 and April 1988. Rainfall and river level records for these events are available (Refs. 2 and 3).

The results of the Georges River Flood Study included stage hydrographs at various locations as well as flood profiles along the river for the 1%, 2% and 5% AEP events. Hydrographs are available for the river at East Hills which is about 2 km upstream of the Deadman's Creek confluence. The flood profile was also determined for an extreme flood event.

2.2 Survey

Sutherland Shire Council undertook a survey of Deadman's Creek channel and floodplain to provide the cross-section data required for the purposes of the study. The locations of the thirteen (13) surveyed cross-sections are shown in Figure 2. Data was also obtained for the Heathcote Road bridge. Details of the survey are provided in Council File No. S97-034, Drawing No. 13284, Sheets 1 to 10.

At some locations, it was not possible to survey to the full extent of the floodplain that would be affected by an extreme flood event because of difficult terrain. In these cases, topographic maps of the study area at 1:4000 scale with 2m contour intervals were used for the purpose of extending the surveyed cross-sections.

2.3 Historical Flood Levels

As part of the cross-section survey, Council requested information on historical flooding from local residents. A small number of flood levels along Deadman's Creek were obtained for flood events which occurred in August 1986 and April/May 1988. In addition, information on flood levels in 1961, May 1975 and July 1975 was extracted from Council records. The historical flood levels are shown in Figure 2.

3.0 METHODOLOGY

There are no streamflow records and limited flood level records available for Deadman's Creek. Therefore it is not possible to determine flood behaviour by means of frequency analysis of recorded data.

Hydrologic and hydraulic modelling was undertaken to determine flood behaviour. The Watershed Bounded Network Model (WBNM) developed by Boyd et al (Ref. 4) was adopted as the hydrologic model for computation of catchment runoff hydrographs. This model was previously used for runoff hydrograph computation in the Georges River Flood Study. Design rainfall intensities and temporal patterns for input to the model were calculated in accordance with the 1987 edition of Australian Rainfall and Runoff.

The numerical hydraulic modelling system MIKE 11 was adopted for determination of flood levels and velocities (Ref. 5). The model includes an implicit, finite difference computer program for unsteady flow computations, and is suitable for modelling floodplain behaviour.

The runoff hydrographs from the Deadman's Creek catchment provide the upstream boundary condition for the model. The downstream boundary condition is provided by the stage hydrograph in the Georges River.

It is desirable to calibrate the linked hydrologic-hydraulic models, where possible, using recorded flood levels from historical events. Modelling was undertaken for the 1986 and 1988 flood events.

The hydraulic model was used to produce flood profiles for the 1%, 2% and 5% AEP events, as well as for an extreme flood event.

For the purposes of this study, the extreme event was defined as the event with runoff from the Deadman's Creek catchment of three (3) times the magnitude of the 1% AEP runoff, combined with the extreme flood level in the Georges River. The extreme flood level in the Georges River was determined in the Georges River Flood Study based on a preliminary estimate of the probable maximum precipitation over the total catchment area (Ref. 1).

4.0 HYDROLOGIC ANALYSIS

4.1 Watershed Bounded Network Model

The WBNM layout adopted for the Deadman's Creek catchment is shown in Figure 3. The model contains seven subcatchments upstream of the Heathcote Road bridge, an additional subcatchment (no. 8) for the area which drains through culverts under Heathcote Road, and a final subcatchment (no. 9) for the local area downstream of Heathcote Road.

Model parameter values were adopted similar to the values used in the Georges River Flood Study. The adopted values were:

Storage delay coefficient C	1.68
Non-linearity coefficient n	-0.23
Initial loss	25 mm
Continuing loss	2.5 mm/hr

4.2 Modelling of 1986 and 1988 Events

Major storm events in August 1986 and April/May 1988 were modelled using WBNM to derive catchment runoff hydrographs. An estimated total rainfall of 350 mm occurred over the Deadman's Creek catchment in the 72 hours to 9am, 7 August 1986. The estimated total rainfall over the catchment in the 96 hours to 9am, 1 May 1988 was 300 mm. The temporal patterns of rainfall for the two events were established from the pluviograph records at Glenfield WPCP, to the north of the Deadman's Creek catchment.

The estimated peak discharges from the Deadman's Creek catchment were 53 m^3/s for the 1986 event and 68 m^3/s for the 1988 event.

4.3 Design Rainfall Estimation

Rainfall intensities for the Deadman's Creek catchment were calculated in accordance with Australian Rainfall and Runoff (1987). Rainfall intensity-frequency-duration (IFD) values for the catchment are presented in Table 1. The temporal patterns of rainfall were also adopted from Australian Rainfall and Runoff (1987).

4.4 Modelling of Design Events

Storm durations between 1 hour and 48 hours were modelled using WBNM in order to determine the critical duration; ie the duration which produces the maximum discharge from the Deadman's Creek catchment. The effect of storm duration for the 1% AEP event is shown in Table 2.

TABLE 1 Design Rainfall Intensities

Duration (hours)	Design Rainfall Intensity (mm/hr) for Annual Exceedance Probability:					
	50%	20%	10%	5%	2%	1%
1	37.0	46.9	52.6	60.2	70.0	77.4
2	24.3	31.3	35.3	40.6	47.5	52.8
3	18.9	24.5	27.8	32.0	37.7	41.9
6	12.3	16.1	18.4	21.4	25.3	28.3
9	9.6	12.6	14.5	16.9	20.0	22.5
12	8.0	10.6	12.2	14.3	17.0	19.1
18	6.4	8.4	9.7	11.3	13.4	15.0
24	5.4	7.1	8.1	9.5	11.3	12.6
36	4.2	5.6	6.4	7.4	8.8	9.8
48	3.5	4.6	5.3	6.2	7.3	8.1
72	2.7	3.5	4.0	4.7	5.5	6.1

TABLE 2 Effect of Storm Duration on 1% AEP Peak Discharge from Deadman's Creek Catchment

Duration (hours)	Peak Discharge (m^3/s)
1	38
2	65
3	83
6	110
9	132
12	131
24	125
36	135
48	126

The storm durations which cause the highest discharges are 9 hours and 36 hours. Both durations were considered in the hydraulic modelling, in combination with Georges River conditions, as follows:

- The 9 hour storm coincident with normal Georges River levels
- The 36 hour storm coincident with major flooding on the Georges River.

These two event combinations were considered appropriate for determination of the critical event with regard to flood levels in Deadman's Creek.

Runoff hydrographs for the 1%, 2% and 5% AEP events were determined for the 9 hour and 36 hour storm durations. The modelled peak discharges at key locations for input to the MIKE 11 hydraulic model are given in Table 3.

TABLE 3 Peak Discharge Estimates for 9 Hour and 36 Hour Events

Location	Peak Discharge (m^3/s)					
	1% AEP		2% AEP		5% AEP	
	9 hrs	36 hrs	9 hrs	36 hrs	9 hrs	36 hrs
Deadman's Creek upstream of Heathcote Road bridge	121	121	103	105	82	91
Heathcote Road culverts (subcatchment no. 8)	15	12	14	11	12	9.5
Local area downstream of Heathcote Road (subcatchment no. 9)	14	7.3	13	6.5	11	5.8

An extreme event was also considered in the study. The runoff hydrographs for the extreme event were assumed to have three (3) times the magnitude of the hydrographs for the 1% AEP, 36 hour event.

5.0 HYDRAULIC ANALYSIS

5.1 MIKE 11 Hydraulic Model

The layout of the hydraulic model adopted for the study is shown in Figure 4. The study reach of Deadman's Creek was represented as a single branch, with an additional branch at the Heathcote Road bridge to allow for possible flow over the road. The model incorporates cross-sections at the locations of the survey cross-sections, except for the right overbank of survey cross-section no. 5 which was re-oriented to be approximately perpendicular to the floodplain flow path.

Manning's n values to represent channel and floodplain roughness were selected primarily on the basis of field inspection. The adopted n values were:

Deadman's Creek channel	0.03
Overbank areas	0.06

5.2 Modelling of 1986 and 1988 Flood Events

The 1986 and 1988 flood events were modelled using the catchment runoff hydrographs derived by WBNM as the upstream boundary condition. The downstream boundary condition was estimated from the recorded Georges River stage hydrographs at East Hills adjusted to account for the flood gradient between East Hills and the Deadman's Creek confluence. The estimated peak levels at the confluence are:

August 1986	2.83m AHD
April/May 1988	3.17m AHD

The modelled flood profiles along Deadman's Creek for the 1986 and 1988 events are shown in Figure 5.

The modelled flood profiles have negligible flood gradient along the lower reaches of Deadman's Creek for these two events; ie the modelled peak flood levels were controlled by backwater flooding from the Georges River. The limited available flood records along Deadman's Creek, as shown in Figure 5, also suggest that the flooding in the study area resulted from backwater from the Georges River. Overall, the fit of the model levels to the recorded levels is considered to be reasonable, given that the recorded levels were surveyed several years after the historical events.

5.3 Modelling of Design Events

The 1%, 2% and 5% AEP events were modelled for the 9 hour and 36 hour storm durations. The downstream boundary conditions for these events were adopted as follows:

- For the 9 hour duration event, the Georges River level was taken to be 1.0m AHD. This allows for a small river rise above high tide level due to runoff from the Georges River catchment. It reflects localised short duration rainfall over the catchment.

- For the 36 hour duration event, there was assumed to be a coincident flood in the Georges River. River stage hydrographs were obtained by adjusting the hydrographs at East Hills to correspond to the design peak flood levels at the Deadman's Creek confluence as obtained from Ref. 1. These levels are:

1% AEP	3.92m AHD
2% AEP	3.52m AHD
5% AEP	3.12m AHD

The modelled 1% AEP flood levels along Deadman's Creek for the two storm durations are given in Table 4.

TABLE 4 Modelled 1% AEP Flood Levels

Location	Cross-Section No.	MIKE 11 Model Chainage (km)	Flood Level (m AHD)	
			9 Hour Storm	36 Hour Storm
Heathcote Road (downstream side)	2A	0.115	2.36	3.92
	6	0.814	1.74	3.92
Georges River	11	1.494	1.00	3.92

The 36 hour storm produced higher flood levels in the lower reaches of Deadman's Creek and was adopted as the critical event. It is expected that the 9 hour storm, or other short duration event, will be critical with respect to flood levels in the upper reaches of the creek.

The extreme flood event in the Deadman's Creek catchment was also modelled using MIKE 11. This event was assumed to be coincident with the 36 hour extreme event in the Georges River, and a peak flood level of 9.0m AHD was adopted as the downstream boundary condition.

The results of the modelling indicated that there is negligible flood gradient along the lower reach of Deadman's Creek for all the design events. Peak flood levels are determined principally by flood levels in the Georges River. Hence the design flood levels at the Georges River confluence may be adopted as the design flood levels for Deadman's Creek downstream of Heathcote Road, namely:

1% AEP	3.92m AHD
2% AEP	3.52m AHD
5% AEP	3.12m AHD
extreme	9.0m AHD

The velocities in the Deadman's Creek channel and overbank areas at the time of the peak flood level are given in Table 5. These velocities are low, principally because of the influence of high tailwater levels from the Georges River. Higher velocities occur at the time of maximum discharge from the Deadman's Creek catchment, which precedes the peak water level in the Georges River by several hours. The velocities at the time of maximum discharge are given in Table 6.

5.4 Sensitivity Analyses

Sensitivity tests were undertaken to determine the effects on the 1% AEP flood levels of the following changes:

- 1% AEP discharge from Deadman's Creek catchment increased by 50%.
- Manning n values for Deadman's Creek channel increased from 0.03 to 0.04 and n values for overbank areas increased from 0.06 to 0.08.
- Timing of catchment runoff adjusted so that the peak of the discharge hydrograph from the Deadman's Creek catchment coincides with the peak water level in the Georges River.

Increasing the discharges and increasing the Manning n values had no effect on peak flood levels. Coincidence of peaks in Deadman's Creek and the Georges River resulted in a small flood gradient along the creek, with the peak flood level at Heathcote Road calculated as 130 mm higher than the Georges River peak.

5.5 Potential Impacts of Greenhouse Effect

Various scenarios for climate change due to the Greenhouse Effect have been presented by research organisations such as CSIRO. The impacts of the Greenhouse Effect are likely to include:

- Sea level rise
- More frequent heavy rainfall events, as part of a more intense hydrological cycle

Both of these factors have the potential to increase flood levels in Deadman's Creek. However, there is considerable uncertainty regarding the magnitude of the impacts of future climate change.

It is proposed that at this stage, no adjustment be made to the design flood levels for Deadman's Creek for possible impacts of the Greenhouse Effect. Council should monitor the available information from expert bodies to assess whether any adjustments will be warranted in the future.

TABLE 5 Velocities at Peak Flood Level for 1% AEP Event

Location	Cross-Section No.	MIKE 11 Model Chainage (km)	Flood Level (m AHD)	Velocity (m/s)		
				Left Overbank	Creek Channel	Right Overbank
	1	0.000	3.93	0.1	0.4	0.1
Heathcote Road (U/S)	2	0.083	3.93	0	0.2	0
Heathcote Road (D/S)	2A	0.115	3.92	0	0.3	0.1
	2B	0.243	3.92	0.1	0.2	0
	3	0.396	3.92	0.1	0.2	0.1
	4	0.504	3.92	0.1	0.2	0.1
	5	0.641	3.92	0.1	0.2	0.1
	6	0.814	3.92	0.1	0.2	0.1
	7	0.965	3.92	0.1	0.2	0.1
	8	1.165	3.92	0.1	0.2	0
	9	1.285	3.92	0.1	0.2	0
	10	1.412	3.92	0.1	0.1	0
Georges R.	11	1.494	3.92	0	0.1	0

TABLE 6 Velocities at Peak Discharge for 1% AEP Event

Location	Cross-Section No.	MIKE 11 Model Chainage (km)	Flood Level (m AHD)	Velocity (m/s)		
				Left Overbank	Creek Channel	Right Overbank
	1	0.000	2.66	0.8	2.5	0.4
Heathcote Road (U/S)	2	0.083	2.68	0	1.3	0
Heathcote Road (D/S)	2A	0.115	2.55	0	1.9	0.4
	2B	0.243	2.51	0.2	1.4	0.2
	3	0.396	2.46	0.5	1.7	0.3
	4	0.504	2.40	0.7	1.9	0.3
	5	0.641	2.35	0.5	1.9	0.4
	6	0.814	2.31	0.3	1.9	0.4
	7	0.965	2.28	0.4	1.4	0.4
	8	1.165	2.23	0.4	1.3	0.1
	9	1.285	2.21	0.4	1.2	0.2
	10	1.412	2.21	0.3	0.9	0.1
Georges R.	11	1.494	2.21	0.2	0.7	0.2

6.0 REFERENCES

1. "Georges River Flood Study", NSW Public Works, PWD Report No. 91066, December 1991.

2. "Georges River Flood Data August 5th-6th, 1986", Public Works Department NSW, Manly Hydraulics Laboratory Report No 472, July 1987.

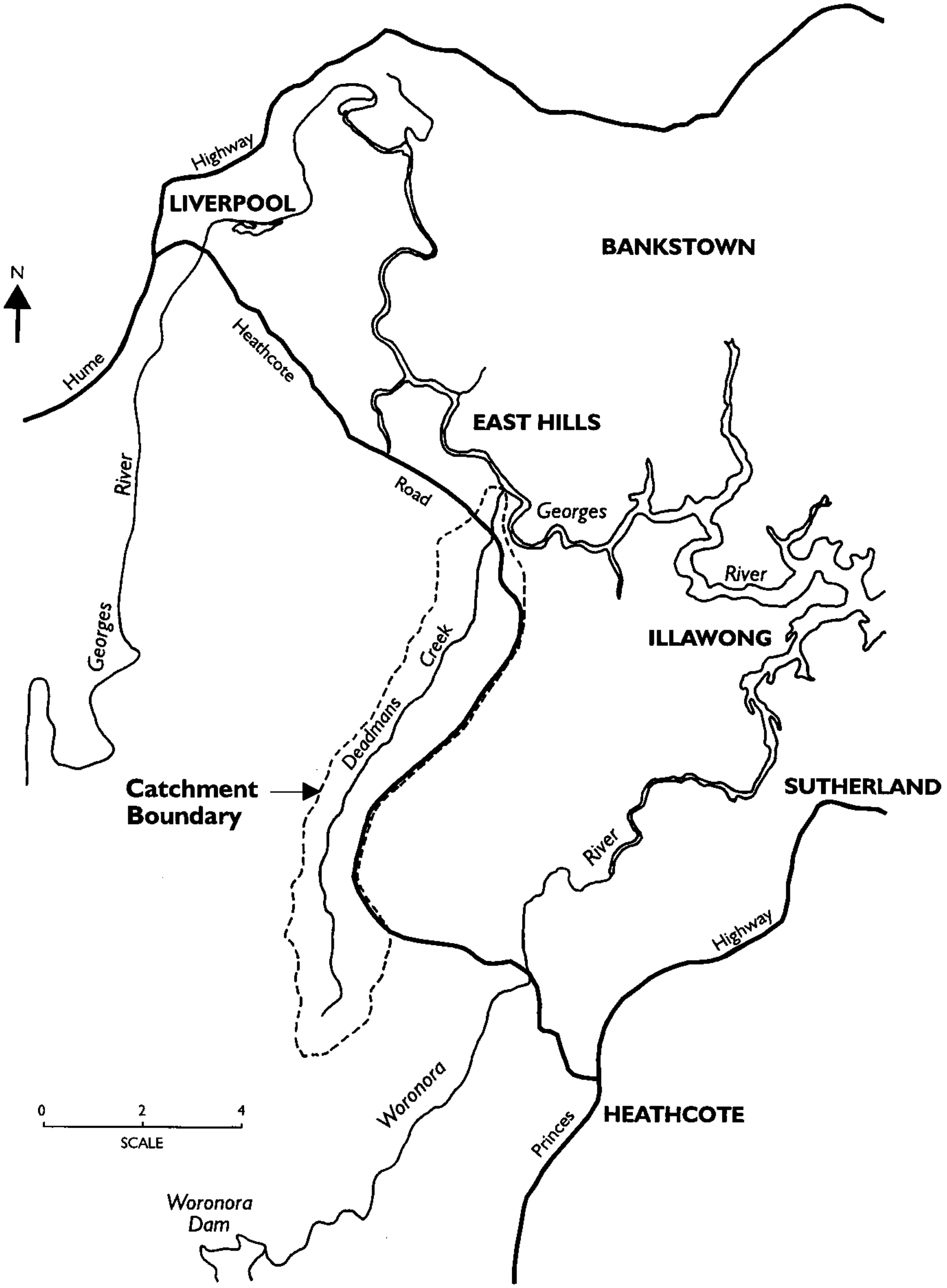
3. "Georges River Flood Data April 28th -May 1st, 1988", Public Works Department NSW Manly Hydraulics Laboratory Report No. 553, February 1989.

4. "WBNM - A General Runoff Routing Model - Computer Program and User Guide", Boyd M.J., Bates B.C., Pilgrim D.H. and Cordery I. (1987), University of New South Wales Water Research Laboratory Report No. 170.

5. "MIKE 11 V3.01 Users Guide", Danish Hydraulics Institute.

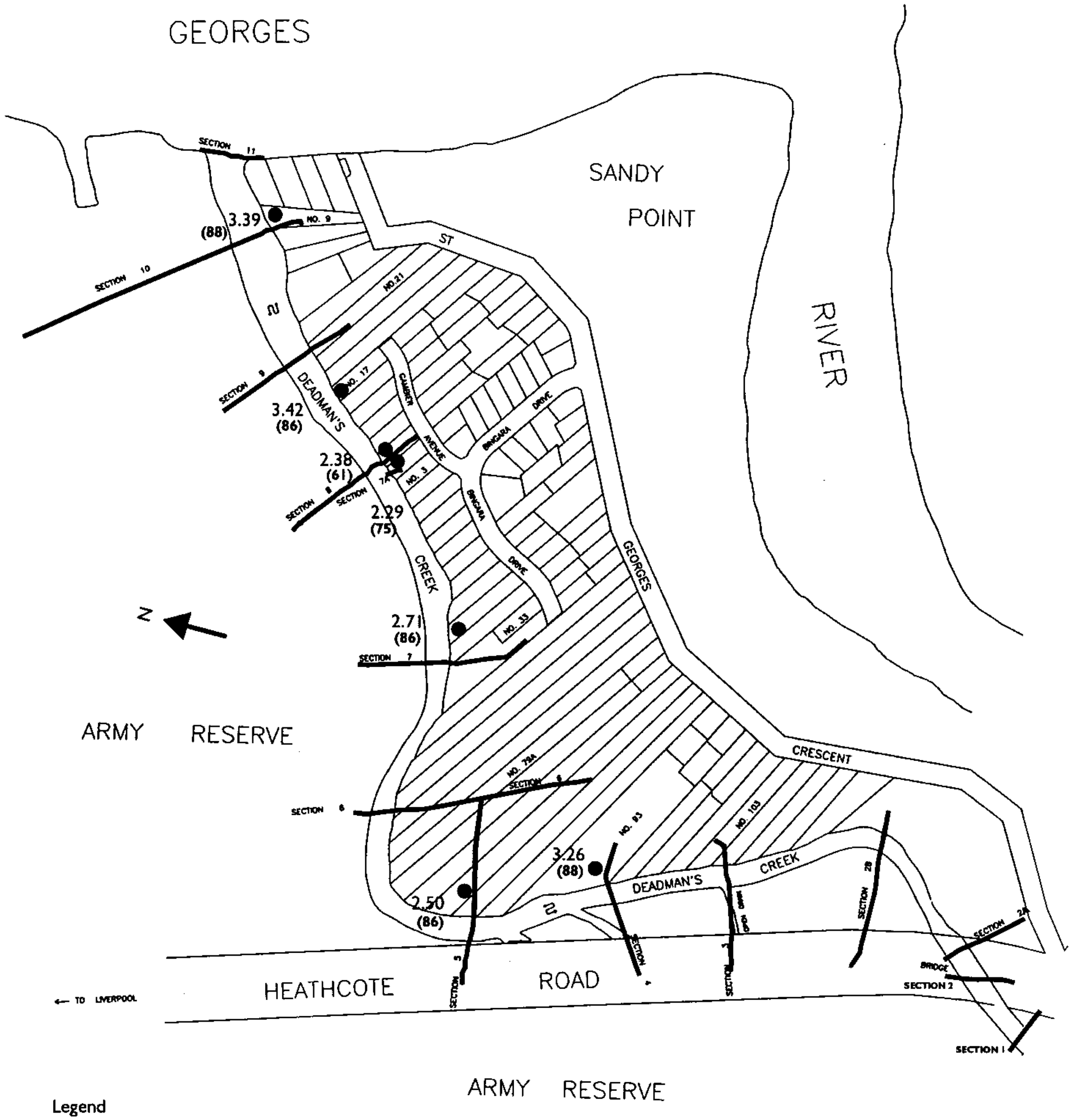
7.0 ACKNOWLEDGMENTS

This study was jointly funded by the New South Wales Government and Sutherland Shire Council. It was undertaken by the Coastal Floodplain and Riverine Resources Directorate of the Department of Land and Water Conservation.



Locality Plan

Figure 1

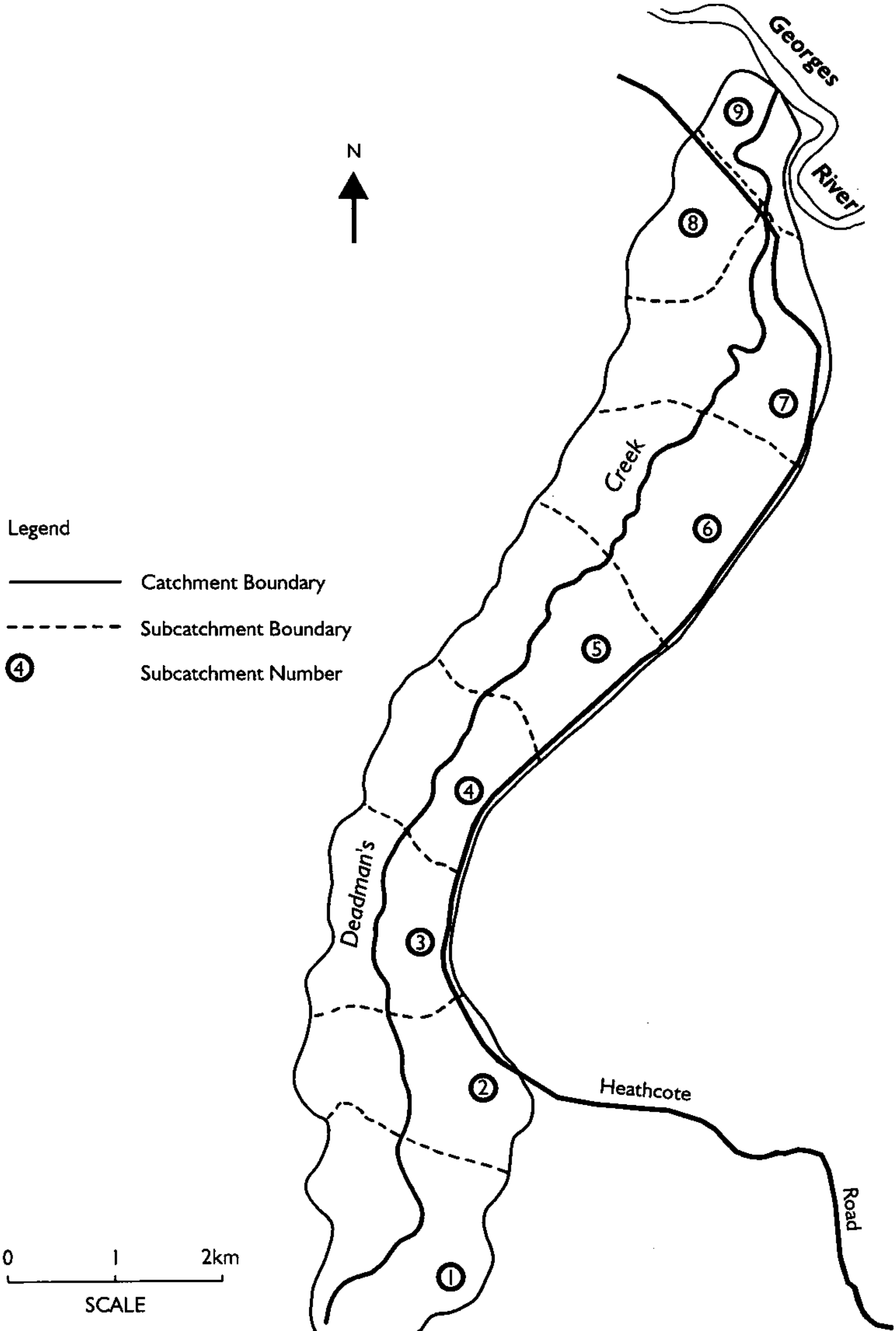


Legend

▬▬▬	Survey Cross-Section
● 2.71	Recorded Flood Level (m AHD)
(88)	Year of Occurance

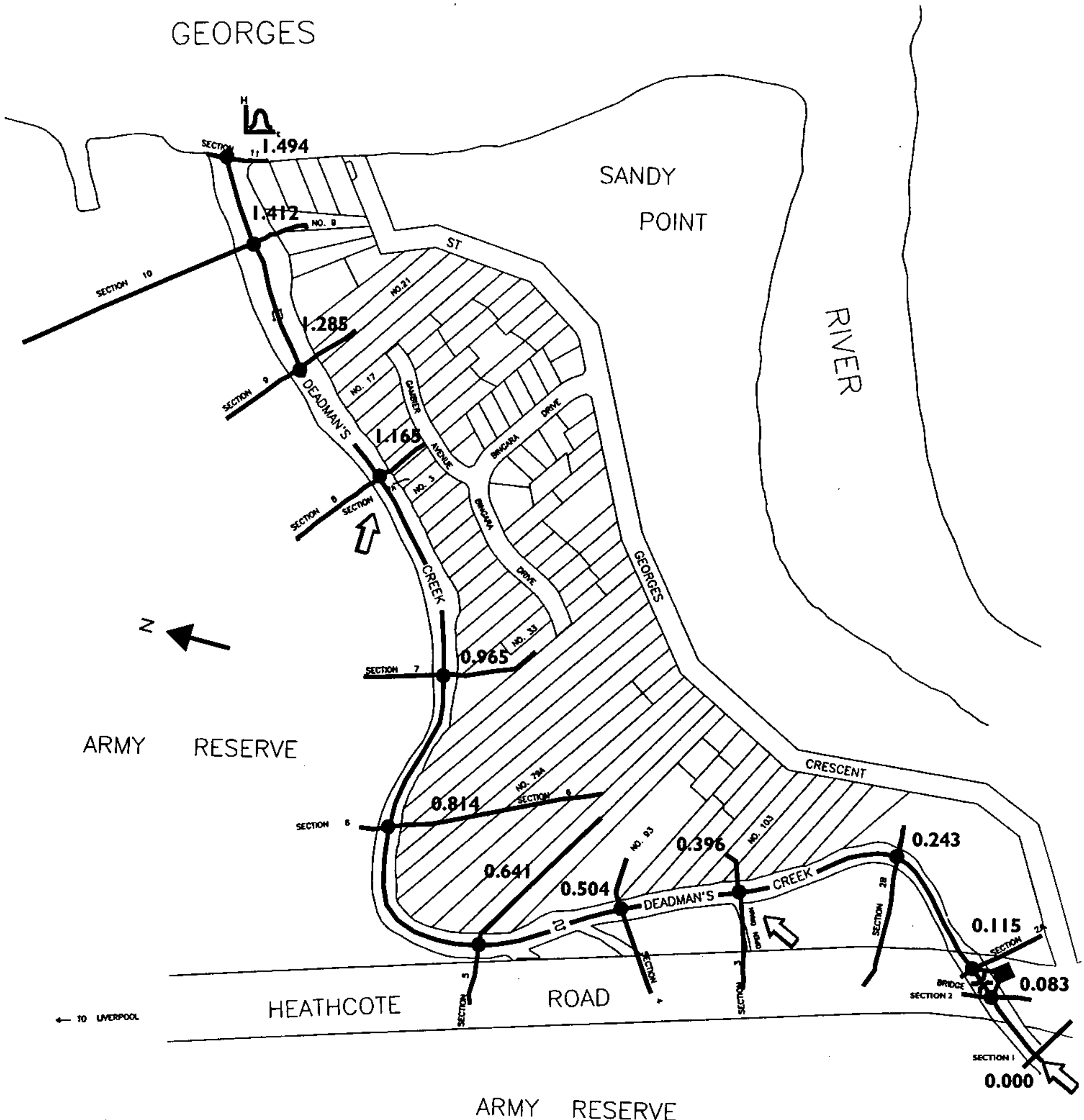
Survey Cross - Sections and Historical Flood Levels

Figure 2



WBNM Model
Layout

Figure 3

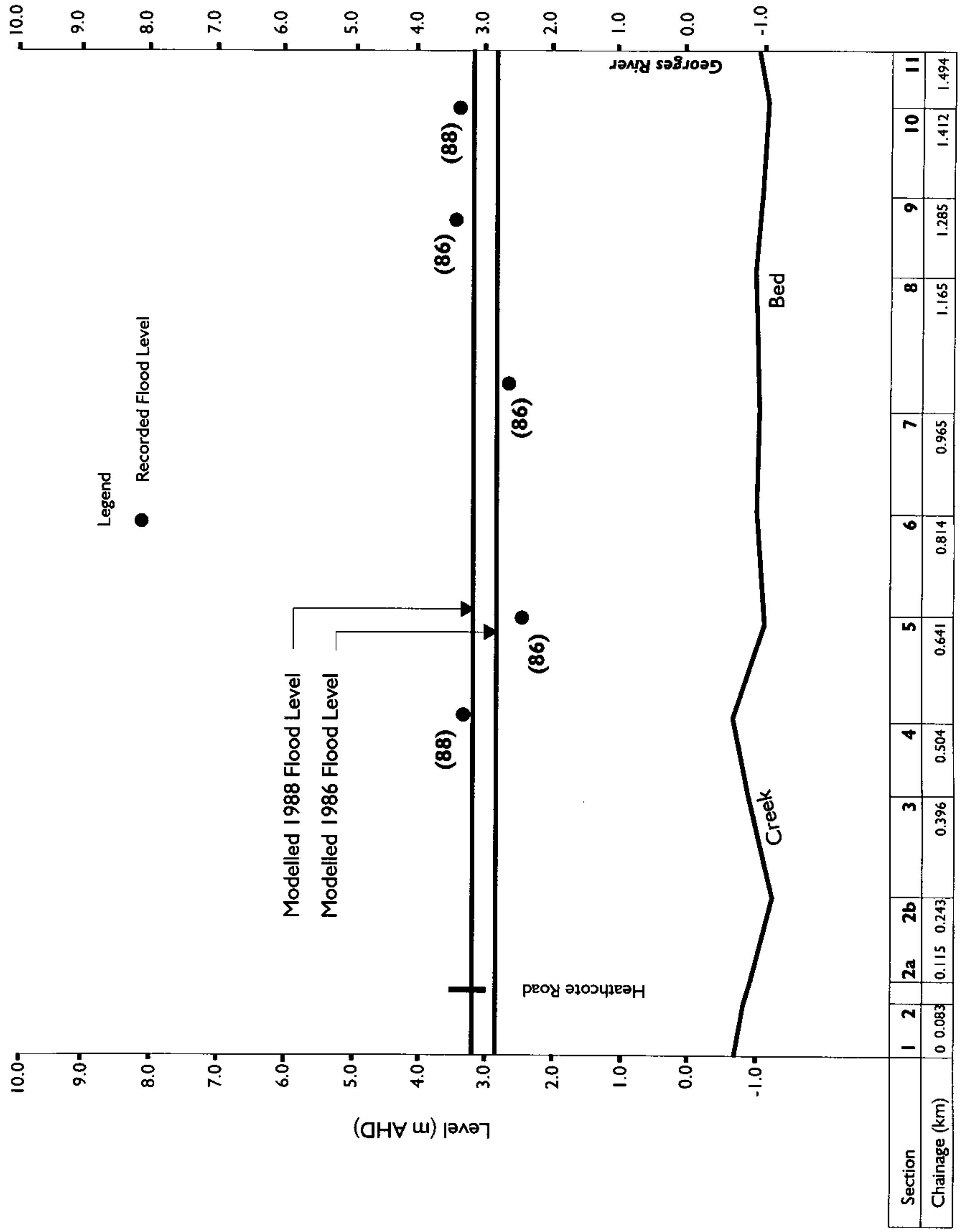


Legend

●	Node (cross-section)
0.504	Chainage (km)
✱	Culvert
■	Weir
⇦	Inflow Hydrograph
H/t	Georges River Stage Hydrograph

MIKE II Model Layout

Figure 4



Historical Flood Profiles

Figure 5