Cardno LawsonTreloar

Shaping the Future

DAVISTOWN CATCHMENT FLOOD STUDY
VOLUME 1 - REPORT

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Gosford City Council

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FOREWORD

The NSW Government's Flood Prone Lands Policy is directed towards providing solutions to existing flood problems in developed areas utilising ecologically positive methods wherever possible 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 prone land is the responsibility of Local Government. To achieve its primary objective, the policy provides for State Government financial assistance to Councils for flood mitigation works to alleviate existing flooding problems. The policy also provides for State Government technical assistance to Councils to ensure that the management of flood prone land is consistent with the flood hazard and that future development does not create or increase flooding problems in flood prone areas.

The Policy provides for technical and financial support by the State Government through the following sequential stages:

1. Flood Study	Determines the nature and extent of the flood problem.
2. Floodplain Risk Management Study	Evaluates management options for the floodplain in respect of both existing and proposed development.
3. Floodplain Risk Management Plan	Involves formal adoption by Council of a plan of management for the floodplain.
4. Implementation of the Plan	Construction of flood mitigation works to protect existing development. Use of Environmental Planning Instruments to ensure new development is compatible with the flood hazard.

The Davistown Catchment Flood Study is the first stage of the management process for the Davistown Catchment. The study, which has been prepared for Gosford City Council by Cardno Lawson Treloar Pty Ltd, defines flood behaviour for existing catchment conditions in the Davistown catchment floodplain.

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EXECUTIVE SUMMARY

This Flood Study has been undertaken to define the nature and extent of flooding due to local rainfall only within the Davistown catchment. It lies wholly within the Gosford City Council (GCC) Local Government Area on the eastern side of Brisbane Waters. The catchment is located to the east of Woy Woy on the peninsula south of the suburb of Saratoga.

The study area extends south from the ridgeline at Saratoga and covers the suburb of Davistown to the foreshore areas on The Broadwater, Cockle Channel and Cockle Bay. This ridgeline, at about RL 50m AHD, falls relatively steeply to the suburb of Davistown which is predominantly low-lying and relatively flat at an elevation of about 1.5m AHD. Land-use within the 190 ha area is primarily residential with significant areas of bushland / vegetated areas. A retirement village, RSL club and some commercial buildings are also located in the catchment.

Davistown has two main drainage channels which divide the suburb into two main areas. As it is a relatively flat area, stormwater runoff drains out to the estuary at multiple locations along the western, southern, and eastern foreshore areas. Pit and piped drainage infrastructure includes many separate branches each draining out to different points on the foreshore.

A questionnaire was delivered to each residence in the Davistown catchment to gauge resident's awareness of flooding in the catchment and to identify specific accounts of flood inundation. Sixty-four percent of respondents were aware of flooding in Davistown with some experiencing inundation within their house. A high percentage of respondents recalled details of inundation during the June 2007 event and less information was noted for flood events prior to this date. The draft report was placed on public exhibition from 18th September to 16th October 2009 inviting submissions for the Study.

Hydrologic and hydraulic modelling was completed to assess flood behaviour within the catchment. The SOBEK 1D/2D model from WL|Delft Hydraulics Laboratory was used to model the catchment and to hydraulically route overland flood flows and street flow. An area of about 260 ha was modelled which includes parts of the estuary. The SOBEK modelling of the Davistown catchment utilises the rainfall-on-grid methodology for developing the hydrology. In the model, rainfall is applied directly to the 2D terrain, and the hydraulic model automatically routes the flow.

Data for the model set-up was collated from various sources including Gosford City Council, Johnson Partners surveyors, Bureau of Meteorology and Manly Hydraulics Laboratory. This data included aerial photos, aerial laser scanning (ALS), field survey of piped drainage systems, historical rainfall from previous storm events and historical water levels in the Brisbane Water estuary.

A terrain grid representing the topography of catchment was generated from the ALS and input to the SOBEK model. Also input to the model was rainfall data, soil loss-rates, drainage pipes and culverts, and parameters for hydraulic roughness to account for the varying land-uses. A 1% probability of exceedance estuary level was adopted from the Brisbane Water Foreshore Flood Study (2009) as the boundary condition at the foreshore areas. This analysis thus determines flood behaviour due to runoff from the local catchment and the Brisbane Water Foreshore Flood Study (2009) assesses flood impacts due to raised storm event levels in the estuary. The model was calibrated to flood levels and responses from the resident questionnaire for the June 2007 event.

Flood behaviour was modelled in SOBEK for a series of Annual Exceedance Probabilities (AEP). The events modelled were 0.5% AEP, 1%, 2%, 5%, 10%, 20%, 50%, and 100% AEP and Probable Maximum Flood (PMF). The sensitivity of the model was tested to demonstrate the range of uncertainty in the model results for changes in key parameters. Variations to the rainfall parameters, hydraulic roughness, downstream boundary, pipe blockage, and land-use were assessed.

The analysis demonstrated that runoff and higher flood depths due to the 1% AEP event occur in the open space and vegetated-marsh areas in the catchment. However, some properties and sections of road experience flood depths up to 0.5m in this event. In the 1% AEP event, the modelling showed that no houses are flooded above the floor level when the storm runoff is combined with a 1% probability of exceedance level in the estuary.

Provisional flood hazard (low and high hazard) and hydraulic categorisation (floodway, flood storage, and flood fringe) were also assessed for the flows within the catchment. No properties or roads are categorised as provisional high hazard in the 1% AEP.

Economic impacts of flooding were evaluated by completing a preliminary flood damage assessment. Costs were estimated for damages resulting to buildings due to local catchment runoff for the various storm events modelled. An average annual damage estimated for the modelled floodplain is about $45,460.

Climate change is expected to result in increased sea levels and increased rainfall intensities. Potential impacts to flood behaviour in the Davistown catchment due to climate change have been analysed for:

- 10%, 20%, and 30% increase to rainfall intensity, and
- Estuary level rises of 0.2m and 0.91m.

Flood inundation in the low elevation areas of the catchment are particularly affected by increases in the sea level which influences the levels in the Brisbane Water estuary. Flooding in the higher elevation areas to the north is more influenced by the increases in rainfall intensities.

1. INTRODUCTION

The Davistown catchment lies within the Gosford City Council (GCC) Local Government Area on the eastern side of Brisbane Waters. It is located to the east of Woy Woy on the peninsula south of Saratoga as shown in Figure 1.1. The catchment is subject to flood inundation and GCC aims to undertake floodplain management in accordance with the Floodplain Management Process as set out in the New South Wales Government *Floodplain Development Manual* (2005).

Cardno Lawson Treloar (CLT) was commissioned by GCC to undertake a flood study as part of the floodplain management process. This flood study has been undertaken to determine the flood behaviour in the catchment due to local storm runoff for the 0.5% Annual Exceedance Probability (AEP), 1% AEP, 2% AEP, 5% AEP, 10% AEP, 20% AEP, 50% AEP and 100% AEP flood events and the Probable Maximum Flood (PMF). In accordance with its objectives, the study has determined the nature and extent of flooding through the estimation of design flood flows, levels and velocities. Flood impacts due to storm events in the Brisbane Water estuary are detailed in the Brisbane Water Foreshore Flood Study (2009).

In undertaking the flood study, a hydrologic-hydraulic computer model of the major channels and floodplain within the catchment was established and verified against historical flood event observations. The hydraulic model was then used with design rainfall conditions to simulate design flood behaviour in the catchment. The study has defined Provisional Flood Hazard and Hydraulic Categories for the flood affected areas.

2. STUDY OBJECTIVES

2.1 Regulatory Context

The NSW Government Floodplain Development Manual (2005) sets out a process for floodplain risk management. A flowchart representation of this process is shown in Figure 2.1, which is adapted from the Floodplain Development Manual (2005).

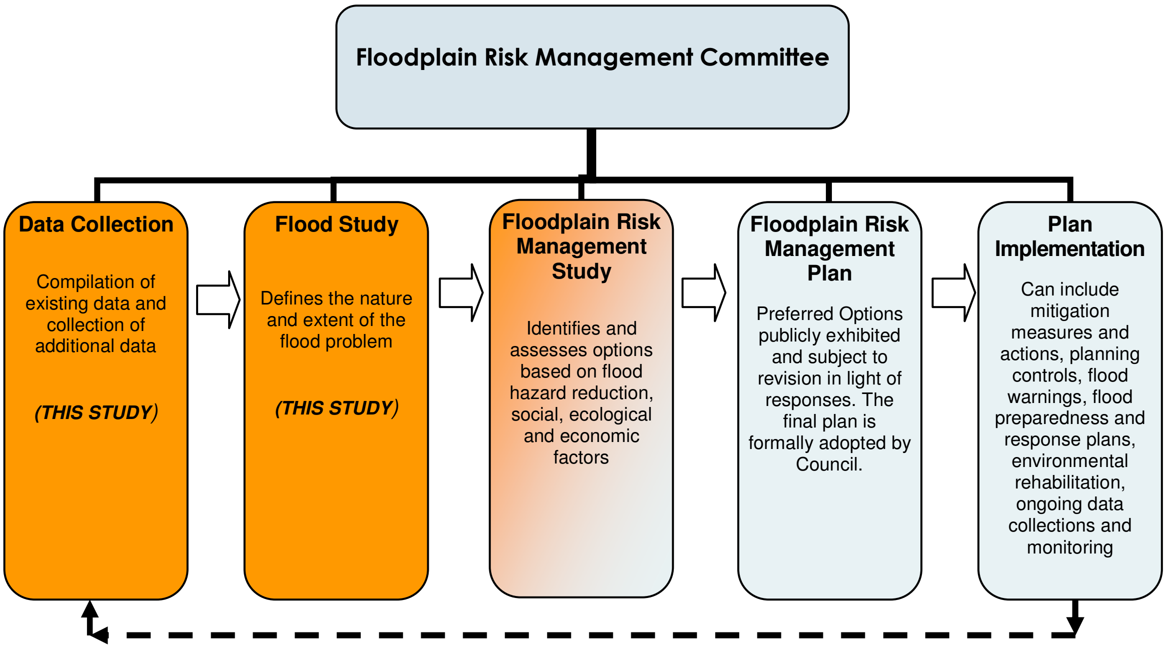

Figure 2.1 Floodplain Management Process

The tasks being undertaken in this Flood Study Report include the compilation of data and definition of the flood behaviour and extent. Assessment of flood management and mitigation options would be undertaken in the next stage of the risk management process as part of the Floodplain Risk Management Study.

2.2 Objectives

The objective of this Study is to define the nature of the existing flood behaviour due to local runoff only in the Davistown catchment.

To achieve the objectives, the following tasks were undertaken:

- Collate available flood-related data,
- Define existing catchment condition flood behaviour for mainstream flooding in the catchment,
- Define design flood levels, velocities and flow distributions for the catchment,
- Define the extent of flooding the nominated AEP events and PMF for the catchment,
- Define the hydraulic categories for the flood-affected areas,
- Define provisional flood hazard for the flood-affected areas,
- Assess flood damages for the flood-affected areas.

2.3 Methodology

This Study was carried out using computer-based hydrologic-hydraulic modelling. The SOBEK 1D/2D program is a purpose-built flood model developed by WL|Delft Hydraulics. In this model, rainfall is applied directly to the elevation grid and flow is routed according to the topography and hydraulic controls of the catchment. Stormwater drainage pits, pipes and channels are represented in the model as one-dimensional elements which are dynamically linked to the water conveyed across the elevation grid.

The study details are grouped together under the following sections of the report:

- Section 3 provides a general description of the catchment,
- Section 4 discusses data which was utilised for the study,
- Section 5 describes the modelling procedure,
- Section 6 details results for the design flood events,
- Section 7 reviews the sensitivity of the model to data used,
- Section 8 identifies the provisional flood hazard,
- Section 9 identifies the hydraulic categorisation,
- Section 10 describes the potential flood damages,
- Section 11 reviews the impacts of climate change.

3. CATCHMENT DESCRIPTION

The Davistown catchment lies within the Gosford City Council (GCC) Local Government Area. The Davistown catchment is a sub-catchment of Brisbane Water, which connects to Broken Bay. It is about 190ha and consists primarily of the suburb of Davistown, situated to the south of Saratoga. The other edges of Davistown are foreshore areas with waterbodies surrounding from the east to the south and to the west, namely The Broadwater, Cockle Bay, Cockle Channel and Lintern Channel.

Land-use in the catchment is primarily residential with significant areas of bushland / vegetated areas. A retirement village, RSL club and some commercial buildings are also located in the catchment.

The Davistown catchment is bounded by the southern parts of the suburb of Saratoga to the north. This ridgeline, at about RL 50m AHD, falls relatively steeply to the suburb of Davistown which is predominantly at an elevation of about 1.5m AHD before extending to the estuary.

Davistown is relatively flat and stormwater runoff drains out to the estuary at multiple locations along the western, southern, and eastern foreshore areas. Pit and piped drainage infrastructure includes many separate branches each draining out to different points on the foreshore. Drainage swales with pipes under driveway crossings are constructed along some streets to convey runoff.

The catchment includes two main drainage channels cutting the suburb adjacent to Murna Ave and behind properties fronting Emora Ave. The major channel is located west of Davistown Road draining towards a large open area west of Malinya Cres, then into Lintern Channel. Both of these channels are tidal. Runoff is also conveyed to depressions that are located within the large vegetated marsh areas.

4. DATA

4.1 Community Consultation

A questionnaire was delivered to each residence in the Davistown catchment in October 2007, totalling about 1400. The aim of the questionnaire was to gauge resident's awareness of flooding in the catchment and to identify specific accounts of flood inundation to be used for the calibration of the computer model. One hundred and forty-four responses were received. Appendix A includes a copy of the questionnaire and a summary of each response. Photos forwarded by residents are included in Appendix A.

Of the responses, 50% indicated that they have lived in the area for more than 10 years. Sixty-four percent of respondents were aware of flooding in Davistown catchment, 28% had some awareness of flooding, and 6% were not aware of flooding in the catchment.

The extent of flooding noted by respondents included 9% indicating flooding inside the house, 56% indicating flooding in the yard, and 38% were inconvenienced by flooding events. Similarly, the following areas were nominated as flooded by respondents – backyard 44%, garage 21%, above-floor 6%, below-floor 16%, and frontyard 52%.

Different occasions of storm events recalled by respondents are listed in Table 4.1.

Table 4.1 Historic Storm Events

Event Date	Responses	Event Date	Responses
June 2007	65(47%)	October 1985	3
January 1996	15(10%)	November 1984	2
February 1992	14(10%)	February 1981	2
February 1990	7	January 1978	3
January 1989	10	March 1977	4
April 1988	7	May 1974	15(10%)

Ten respondents advised they had noticed bridges / culverts as blocked during storm events. Comments were also made noting that the drainage systems were undersized and debris blocked some pipelines. Debris such as dirt, branches, overgrown grass or weeds were identified as materials blocking pipes. The responses also included comments regarding the need for maintenance of drainage systems (including dredging), residual ponding of runoff in areas for several days, and flooding resulting from high / king tides.

From 18th September to 16th October 2009, the draft report was placed on public exhibition at Council's administration centre, local libraries and on its website. Comments and submissions were invited for review for the final report. Three submissions were received and are addressed in Appendix E. Where appropriate, relevant findings and information have been included in the final report. Some comments relate to the effect of flooding from the Brisbane Water estuary which are detailed in the 'Brisbane Water Foreshore Flood Study' by Cardno Lawson Treloar (2009) and other comments related to the assessment of mitigation options which would be assessed in the future Floodplain Risk Management Study and Plan.

4.2 Rainfall

Owing to the small area of the catchment, uniform areal distribution of design storms has been assumed for the hydrologic component of the analysis. Design rainfall depths and temporal patterns for the modelling of 0.5% AEP, 1%, 2%, 5%, 10%, 20%, 50%, and 100% AEP were developed using standard techniques provided in Australian Rainfall and Runoff (1998).

The design Intensity-Frequency-Duration (IFD) parameters are presented in Table 4.2

Table 4.2 Design IFD Parameters

Parameter	Value
2-Years ARI 1-hour Intensity	38.50 mm/hr
2-Years ARI 12-hours Intensity	8.50 mm/hr
2-Years ARI 72-hours Intensity	2.60 mm/hr
50-Years ARI 1-hours Intensity	77.00 mm/hr
50-Years ARI 12-hours Intensity	17.00 mm/hr
50-Years ARI 72-hours Intensity	5.90 mm/hr
Skew	0.0
F2	4.3
F50	15.9
Temporal Pattern Zone	1

The Probable Maximum Precipitation (PMP) was estimated using the publication "*The Estimation of Probable Maximum Precipitation in Australia: Generalised Short-Duration Method*" (Commonwealth Bureau of Meteorology, 2003). The spatial distribution ellipses of the method are not required due to the small size of the catchment. Table 4.3 shows the data for the PMP calculations.

Table 4.3 PMP Calculation Values

Parameter	Value
Moisture Adjustment Factor	0.71
Elevation Adjustment Factor	1.00
Percentage Rough	100%

Estimated average design storm rainfall intensities for the full range of storm events and durations are presented in Table 4.4.

4.3 Pit and Pipe Field Survey

Stormwater drainage pit and pipe details were supplied by Gosford City Council. Johnson Partners completed a detailed field survey of parts of the drainage system to supplement Council's information.

Site inspections and the field survey identified that some of the pipelines were below the standing water level at their outlet due to debris blocking the flow of water or due to the tide level at the time of inspection.

Table 4.4 Design Rainfall Intensities (mm/h)

Duration	1 year ARI	2 year ARI	5 year ARI	10 year ARI	20 year ARI	50 year ARI	100 year ARI	200 year ARI	PMP
15 min	62	79	101	113	130	151	168	191	680
30 min	43.7	56	72	82	94	110	122	138	480
45 min	35.1	45.2	58	66	76	90	100	114	413
1 hour	29.8	38.5	50.0	57	65	77	86	98	350
1.5 hour	23.4	30.3	39.3	44.6	51	61	67	76	307
2 hour	19.7	25.5	33.0	37.5	43.3	51	57	65	265
3 hour	15.4	19.9	25.8	29.2	33.8	39.7	44.3	51	217
4 hour	N/A	N/A	N/A	N/A	N/A	N/A	N/A	43	185
4.5 hour	12.0	15.5	20.1	22.8	26.3	31.0	34.5	N/A	N/A
5 hour	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	164
6 hour	10.0	13.0	16.8	19.1	22.1	26.0	28.9	33	143
9 hour	7.84	10.1	13.1	14.9	17.2	20.3	22.6	N/A	N/A

4.4 Soil Type and Rainfall Loss Rates

The Department of Conservation and Land Management (NSW) soil map of the Gosford-Lake Macquarie area (1993) identifies the soil types within the Davistown catchment. Woy Woy soil type is identified for the majority of Davistown, with Mangrove Creek and Erina soils on the northern side rising up to Saratoga.

Woy Woy soils in the region are noted for their permanently high water table and seasonal waterlogging. High permeability is identified as a feature of the soil. Mangrove Creek soils are a mix of high and low permeability but generally low permeability where not regularly inundated. High run-on of water is also noted as a limitation of the soil. Erina soils have the limitation of high run-on and underlying groups are generally low permeability.

Responses from the resident questionnaire noted that in some cases water can remain on the ground for a couple of hours, days or even up to a week. Water is noted as remaining in gutters for about two days after rainfall. Some roads and houses within the catchment have been built up and may have been constructed with soil materials imported from other areas. The influence of tide levels in the estuary on water ponding in the Davistown area was also noted.

4.5 Boundary Conditions

The 'Brisbane Water Foreshore Flood Study' (2009) completed by Cardno Lawson Treloar established the water levels and flood behaviour for various design events in Brisbane Water. Simulations for design ARI event conditions were undertaken for 5, 10, 20, 50, 100, 200-years ARI and a PMF event. Peak water level results at 119 foreshore locations in Brisbane Water are presented, with eight of these sites located within the Davistown catchment study area.

Peak water levels are shown in Table 4.5 for the Davistown area with the highest level occurring in Lintern Channel in the west and reducing along the Cockle Channel foreshore to Kincumber Broadwater in the east. The joint probability of severe catchment flooding from the Davistown catchment occurring together with severe estuary flooding is low. Hence modelling for the case of a rare storm event, such as 1% AEP, in the catchment with a rare estuary level, such as from a 1% AEP event, as a downstream boundary may not be appropriate.

For the purpose of local creek studies, such as the Davistown Catchment Flood Study, the 1% probability of exceedance (PoE) level is to be used as the downstream boundary level in the estuary (Cardno Lawson Treloar, 2009). The 1% probability of exceedance is the level that one can be 99% confident will not be exceeded during any creek flood event. The 1% PoE level for Davistown is 0.64m AHD (Cardno Lawson Treloar, 2009).

The Davistown Catchment Flood Study assesses flood behaviour due to runoff from the local catchment for the various storm events. Flood behaviour due to elevated water levels in the estuary in storm events is described in the Brisbane Water Foreshore Flood Study (2009).

Table 4.5 Davistown Foreshore Peak Water Level

Average Recurrence Interval (ARI)	Peak Water Level Range (m AHD)
PMF	1.7 – 1.88
200y ARI	1.52 – 1.63
100y ARI	1.47 – 1.56
50y ARI	1.41 – 1.49
20y ARI	1.35 – 1.41
10y ARI	1.29 – 1.35
5y ARI	1.24 – 1.28

5. FLOOD MODELLING

The SOBEK 1D/2D model from WL|Delft Hydraulics Laboratory was used to model the catchment and to hydraulically route overland flood flows and street flow. This modelling system dynamically couples the one-dimensional and two-dimensional flow in the floodplain.

An area of about 260 ha is modelled as shown in Figure 5.1 which includes parts of the estuary.

5.1 Hydrology

The SOBEK modelling of the Davistown catchment utilises the rainfall-on-grid methodology for developing the hydrology. In the model, rainfall is applied directly to the 2D terrain, and the hydraulic model automatically routes the flow. The rainfall patterns are described in Section 4.2 and the loss rates shown in Table 5.1 (described in Section 4.4) are applied to the model.

Table 5.1 Hydrology Loss Rates

Description	Value
Initial Loss	5 mm
Continuing Loss	1 mm/h

5.2 Piped Drainage Systems

Piped drainage systems are incorporated into the SOBEK model as distinct 1D elements connected to the terrain grid. Detailed field survey by Johnson Partners supplemented the pipe information supplied by Gosford City Council.

The different size of inlet pit openings was included in the model as orifice-links of the same size to represent the restriction of flow into the piped system. An orifice-link was included between pipeline reaches to model the energy losses at pits and between conduits. Large channel sections, such as between Malinya Road and Morton Cres, are represented in the terrain grid, but smaller open channel sections, such as adjacent to Murna Road, are included as distinct 1D elements.

Figure 5.2 shows the pipe and channel systems incorporated in the model. About 4.9 km of pipeline and 1.8 km of channel systems are modelled. The roughness values adopted for the piped drainage systems are listed in Table 5.2.

Table 5.2 1D Element Roughness Values

Component	Roughness Value
Pipe	0.018
Culvert	0.025
Open Channel	0.03

5.3 Topography

A terrain grid was developed to represent ground elevations based on aerial laser scanning data from Gosford City Council supplemented by detailed field survey completed by Johnson Partners. Figure 5.3 shows the elevations of the Davistown catchment in the model. The southern parts of Saratoga in the model are at about RL 50 m AHD and there is a relatively steep transition down to Davistown which is generally at RL 1.0 to 1.5 m AHD. House footprints were retained at ground elevation to account for some potential storage of floodwaters at these locations (eg under-floor voids, verandah areas, and above-floor inundation).

The elevation grid for the model was developed at 3m x 3m cells comprising about 590,000 grid points.

5.4 Hydraulic Roughness

Each cell of the elevation grid also has a roughness value to model the influence to flow behaviour of the particular land-use. The adopted roughness layout, shown in Figure 5.4, was based on aerial photographs, site inspections, and Council's land-use zonings. The roughness value applied for each land-use is listed in Table 5.3.

Table 5.3 Roughness Values

Land-use	Roughness Value	Land-use	Roughness Value
Channel	0.03	Waterbody	0.02
Bushland	0.06	Vegetated Marsh	0.07
Open Space	0.035	Road	0.02
Residential	0.09	Estuary	0.02

5.5 Model Calibration

The resident questionnaire detailed in Section 4.1 indicated most respondents recalled the June 2007 event. Recollection of storm events prior to June 2007 was less but a significant proportion of respondents recalled the May 1974 flood event.

The data required to calibrate the SOBEK model to particular events includes water levels, event rainfall data, and event water level data. Residents recalled particular water levels for the June 2007 event and the May 1974 event, but insufficient water levels were available for potential calibration to other events. Rainfall and water level data was available for the June 2007 event, however insufficient data was available for the May 1974 event. Calibration of the model was therefore undertaken to the June 2007 storm event when a significant storm event occurred between 7 and 12 June 2007 in the Central Coast area.

A pluviograph at Kincumber operated by Manly Hydraulics Laboratory is the nearest rainfall record to the Davistown site. It is about 2.8 km from Davistown Oval at an elevation of about 20m AHD and records data in 2 minute timesteps. Manly Hydraulics Laboratory also operates a pluviograph at Koolewong, about 4.4 km from Davistown Oval. The location of these sites is shown in Figure 5.5. Rainfall within Davistown itself is recorded by Mr. B. Evans on a daily basis.

Table 5.4 lists the daily rainfall depths over the period of Wednesday 6 June 2007 to Tuesday 12 June 2007. Kincumber rainfall data was obtained from Manly Hydraulics Laboratory and is equivalent to a storm event of about 20% AEP. Koolewong data was sourced from the report "New South Wales Central Coast June 2007 Flood Summary" by NSW Department of Commerce and Manly Hydraulics Laboratory (2007).

Table 5.4 Rainfall Depths (mm/d)

Date	Davistown (from Mr. B. Evans)	Koolewong	Kincumber (depth to 9am)	Ratio of Davistown to Kincumber
6/6/07	0	n/a	0 (in 9 hours from 6/6/07 00:00)	
7/6/07	54	60.5	129	0.4
8/6/07	38	71	45	0.8
9/6/07	63	92.5	82.5	0.8
10/6/07	49	4.5	63.5	0.8
11/6/07	2	0.0	1	2.0
12/6/07	0	n/a	0.5	0.0
TOTAL	*206*	*228.5*	*321.5*	*0.6*

The Kincumber daily rainfall is significantly higher than the Davistown and Koolewong depths. For the calibration model, the Kincumber pluviograph rainfall will be used as the rainfall per day reflects the pattern of the Davistown data better and is located closer to the catchment. The Kincumber rainfall is multiplied by 0.8 to reflect the rainfall recorded in the catchment and a continuing loss of 1 mm/hr is applied to the data. Figure 5.6 shows the adjusted rainfall depths at two minute intervals from the Kincumber pluviograph data.

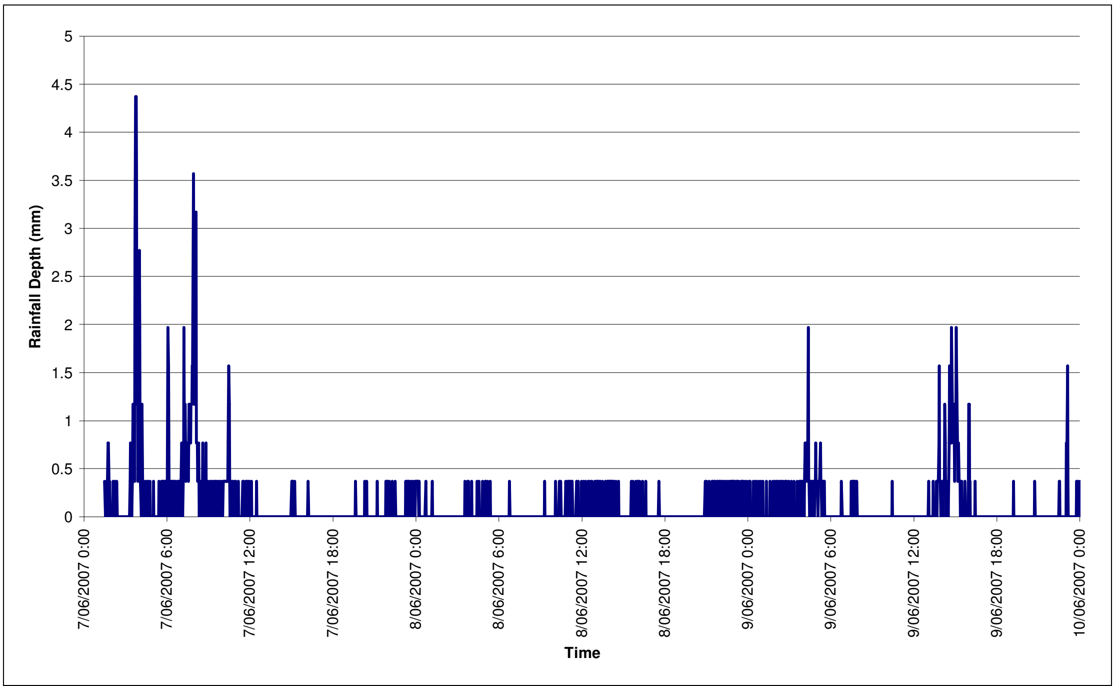

Figure 5.6 Kincumber Rainfall Depth per two-minutes (adjusted by 0.8)

Manly Hydraulics Laboratory operates a water level recorder at Koolewong (shown in Figure 5.5) which is the closest to the Davistown catchment. Figure 5.7 shows the water level time series for the June 2007 storm event. The peak water level of 1.12m AHD occurs at around 06:00 on Saturday 9th June, compared to the peak rainfall burst on Thursday 7th June though rainfall continued for periods up to and beyond the peak tide time.

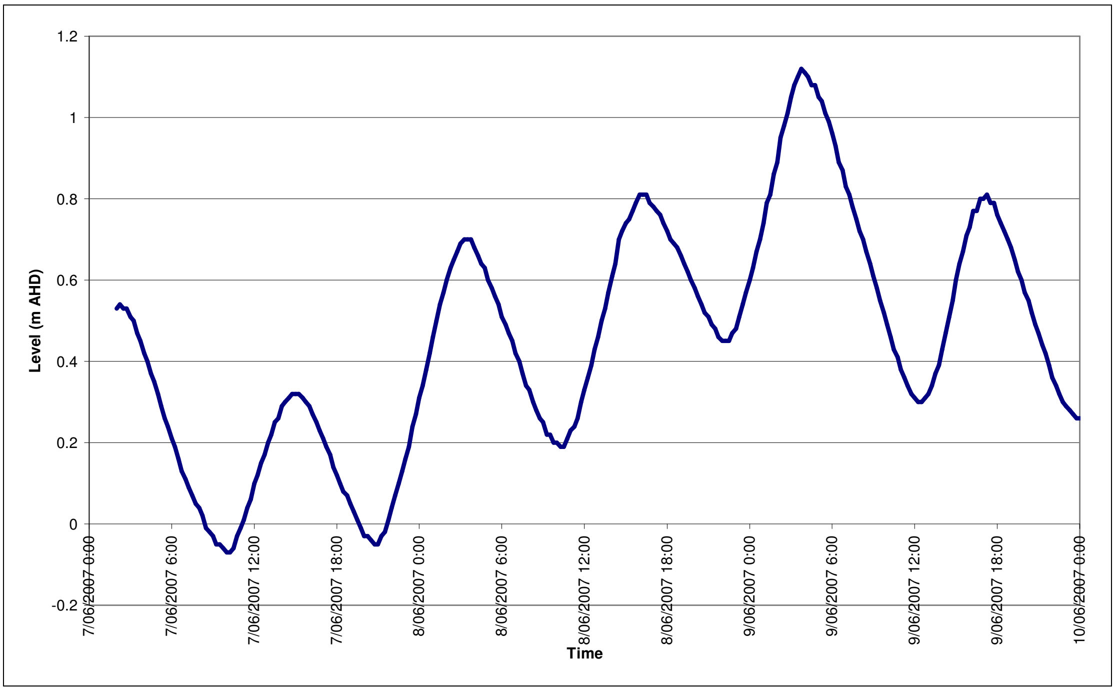

Figure 5.7 Koolewong Water Level Time Series

The SOBEK model incorporating the adjusted Kincumber rainfall pattern and the Koolewong water level pattern was run for the time period of 02:00 on Thursday 7/6/07 to 00:00 on Sunday 10/6/07. Figure 5.8 shows the peak depths modelled for this event. Table 5.5 shows the results from SOBEK for flood levels satisfactorily model the flood descriptions noted in the questionnaire responses. The surveyed levels were obtained by Johnson Partners.

Table 5.5 Model Results for June 2007 event

Location	Description	Surveyed Level (m AHD)	SOBEK Water Level (m AHD)	Comment
85 Kincumber Cres	June 2007 not above floor	Dwelling floor level = 1.475	Peak WL = 1.45 @ 0.02m depth	Satisfactory
37 Magnolia Ave	June 2007 not above floor.	Dwelling floor level = 2.20	Peak WL = 2.04 @ 0.02m depth	Satisfactory
42 Malinya Road	June 2007 had 6" through garage	Garage floor level = 1.22	Peak WL = 1.21 @ 0.01m depth	Low
26 Mirreen Avenue	June 2007 above floor	Dwelling floor = 1.38	Peak WL = 1.11 @ depth 0.16m	Low – note neighbour indicated yard flooding only, thus surveyed level / report may be high
3 Paringa Avenue	2007 – almost entered garage. Peak level occurs with tide about 4am	Garage floor = 1.125	Peak WL = 1.24 @ 0.05m depth. Peak tide at 3:45am	Model ground level of 1.19 is above floor level thus ground level detail not sufficient for compare
27 Paringa Avenue	2007 water in studio/garage	Watermark in studio = 1.335	WL next to house = 1.35 @ 0.18m depth	Satisfactory
15 Paringa Avenue	2007 below floor	Dwelling floor = 1.65	Peak WL = 1.34 @ 0.03m depth	Satisfactory
14 Paringa Avenue	2007 below floor level	Dwelling floor level = 1.245	Peak WL = 1.45 @ 0.02m depth	Model ground level is above floor level thus ground level detail not sufficient for compare
37 Paringa Avenue	2007 to 1" above new shed floor	New shed floor 1.765, old house floor = 1.14	Peak WL = 1.12 @ 0.18m depth	Note tide peak is 1.12, thus survey level may be switched

6. DESIGN FLOOD ESTIMATION

Flood behaviour was modelled in SOBEK for a series of Annual Exceedance Probabilities (AEP). The 0.5% AEP, 1%, 2%, 5%, 10%, 20%, 50%, and 100% AEP and Probable Maximum Flood (PMF) events were modelled for local catchment runoff with a 1% Probability of Exceedance estuary level.

6.1 Critical Duration

The critical duration for the Davistown catchment was evaluated by reviewing the peak water level results for a range of durations for the 20% AEP, 1% AEP and PMF events. Durations of 15 minutes, 30, 60, 90, 120, and 180 minutes were modelled for the 1% AEP event. PMF durations of 15 minutes, 30, 45, 60 and 90 minutes were modelled. Reference locations across the catchment, shown in Figure 6.1, are listed in Table 6.1 for evaluating the results.

Table 6.1 Sensitivity Analysis Reference Locations

Number	Location
1	Malinya Rd (opp. #143)
2	Creek near Malinya Ave
3	Intersection Malinya Rd & Emora Ave
4	Intersection Malinya Rd & Lintern St
5	Intersection Emora Ave & Restella Ave
6	Davistown Oval (centre wicket)
7	Davistown Rd (opp. #55)
8	Intersection Davistown Rd & Paringa Ave
9	Intersection Lilli Pilli St & Grevillea
10	Magnolia Ave (opp. #9)
11	Kincumber Cres (near #37)

The critical durations for the PMF, 1% AEP, and 20% AEP are shown in Figure 6.2, Figure 6.3 and Figure 6.4 respectively.

For the 1% AEP and 20% AEP, the higher elevations in the catchment show a shorter critical duration (about 15 minutes) compared to the lower elevations on the relatively flat area (between 90 and 180 minutes). Table 6.2 shows peak water levels at the reference locations for the 1% AEP durations modelled. Comparison of the separate durations for the 1% AEP and 20% AEP shows that the 2 hour duration storm is the critical event for the catchment as:

- there is no difference to peak water levels (in excess of +/- 0.01m) between the 2 hour and 15 minute storm,
- peak water levels for the 90 minute storm are lower than the 2 hour storm in some locations, but is only slightly higher (<0.01m) in other locations,
- the 3 hour storm peak water levels are only up to 0.02m higher than the 2 hour storm in some locations.

Table 6.2 1% AEP Critical Duration

Point	Peak Flood Level (m AHD) for Duration						
	15 min	30 min	60 min	90 min	120 min	180 min	Critical Duration
1	1.54	1.57	1.59	1.59	1.59	1.57	120 min
2	0.67	0.70	0.75	0.76	0.77	0.77	120 min
3	1.03	1.05	1.07	1.07	1.07	1.07	120 min
4	1.19	1.19	1.19	1.19	1.19	1.19	120 min
5	0.94	0.95	1.01	1.03	1.05	1.06	180 min
6	1.03	1.03	1.03	1.04	1.06	1.08	180 min
7	1.09	1.13	1.14	1.14	1.14	1.13	120 min
8	1.14	1.14	1.15	1.15	1.15	1.14	120 min
9	1.19	1.20	1.21	1.21	1.21	1.21	120 min
10	0.90	0.93	0.95	0.95	0.96	0.93	120 min
11	1.06	1.08	1.09	1.09	1.09	1.09	120 min

6.2 Model Scenarios

Catchment models were therefore run in SOBEK for the durations shown in Table 6.3.

Table 6.3 Model Scenarios

AEP	Rainfall Durations [min]	Estuary Level [m AHD)]
PMF	15, 30, 45, 60, 90	0.64 (1% PoE)
0.5%	120	0.64 (1% PoE)
1%	15, 30, 60, 90, 120, 180	0.64 (1% PoE)
2%	120	0.64 (1% PoE)
5%	120	0.64 (1% PoE)
10%	120	0.64 (1% PoE)
20%	15, 30, 60, 90, 120, 180	0.64 (1% PoE)
50%	120	0.64 (1% PoE)
100%	120	0.64 (1% PoE)

6.3 Results

Model results of the flood extent, peak depth, peak level, and peak flow speed due to local catchment runoff are shown in the figures as included in Volume 2 of this Study Report. As the rainfall-on-grid modelling methodology in SOBEK models rainfall on every cell within the extent, the results figures are filtered and show flood parameters at locations where the depth is greater than or equal to 0.10 m.

Model results from the foreshore within the estuary are not shown for clarity of presentation. This filtering process improves interpretation of results for evaluating areas with significant runoff. The extent figures presented therefore show locations where the flow depth is greater than or equal to 0.10m.

Table 6.4 Model Results Figures

AEP	Flood Extent	Peak Water Levels	Peak Flood Depth	Peak Flow Speed
PMF	Figure 6.5	Figure 6.14	Figure 6.23	Figure 6.32
0.5%	Figure 6.6	Figure 6.15	Figure 6.24	Figure 6.33
1%	Figure 6.7	Figure 6.16	Figure 6.25	Figure 6.34
2%	Figure 6.8	Figure 6.17	Figure 6.26	Figure 6.35
5%	Figure 6.9	Figure 6.18	Figure 6.27	Figure 6.36
10%	Figure 6.10	Figure 6.19	Figure 6.28	Figure 6.37
20%	Figure 6.11	Figure 6.20	Figure 6.29	Figure 6.38
50%	Figure 6.12	Figure 6.21	Figure 6.30	Figure 6.39
100%	Figure 6.13	Figure 6.22	Figure 6.31	Figure 6.40

7. SENSITIVITY ANALYSIS

The sensitivity of the model was tested to demonstrate the range of uncertainty in the model results for changes in key parameters. The following variables were tested for sensitivity:

- Catchment rainfall – increased and decreased by 20%
- Catchment roughness – increased and decreased by 20%
- Downstream boundary condition – increased and decreased by 20%
- Culvert and pipe blockage – for all systems and for particular systems
- Future conditions

The impact of potential climate change scenarios, such as increased sea levels and increased rainfall intensity was also modelled as described in Section 11.

The sensitivity modelling was undertaken for the 2 hour duration event which is the critical duration for the Davistown catchment. The variables were assessed for the 1% AEP event except for the pipe blockage scenario which was modelled for the 20% AEP event. Results for the varied parameters for the selected reference locations are included in Appendix B. These reference locations are listed in Table 6.1 and included on Figure 6.1.

7.1 Catchment Rainfall

The average rainfall intensity for the 1% AEP 2 hour duration was increased and decreased by 20% for the sensitivity analysis. The resultant average intensities for the events were: 57 mm/h for the standard storm, 68.4 mm/h for the 20% increased scenario, and 45.6 mm/h for the 20% decreased scenario. Initial loss and continuing loss rates were applied to the resultant five minute timestep rainfall patterns.

The peak water levels shown in Table B.1 (in Appendix B) show that the 20% adjustment to the rainfall results in changes to the base case levels of several centimetres. Runoff on the Davistown catchment spreads over a wide area rather than concentrating in a single flow location thus the adjusted rainfall results in the small variation. The model shows consistent results as the reduced rainfall results in lower peak water levels and higher peak water levels for the increased rainfall scenario.

7.2 Catchment Roughness

Values of the hydraulic roughness parameter applied to the model, described in Section 5.4, were increased and decreased by 20% for the sensitivity analysis. Resultant peak water levels are listed in Table B.2 (Appendix B). The results show that the roughness parameter does not have a significant influence on water levels at the Davistown reference points. This is due to Davistown being relatively flat with runoff distributed over a wide area rather than being concentrated into a primary flow path.

7.3 Downstream Boundary Condition

The downstream boundary condition applied to the model is the dominant parameter for water levels in the majority of the Davistown catchment. Table B.3 (Appendix B) shows the variation in water levels for the 1% AEP 2h event with for three scenarios of water level in the Brisbane Waters estuary –

- Base scenario – 1% PoE level of 0.64m AHD,
- 20% decrease to base scenario at 0.51m AHD,
- 20% increase to base scenario at 0.77m AHD.

The results for most reference points show no variation in peak water levels for the scenarios as they have elevations above the modelled levels for the estuary and runoff is distributed over the majority of the catchment rather than concentrated into a main flowpath. Peak water level at Location 2 however is influenced by the modelled boundary condition as it is in the channel which is lower than these levels.

7.4 Culvert and Pipe Blockage

Two scenarios for pipe blockage were analysed for the 20% AEP 2 hour storm event. The case of all pipes and culverts blocked was evaluated and a case for particular pipes and culverts blocked was also modelled. The drainage lines selected for the second case were based on determining flood behaviour that may result in a higher peak water level for certain areas. Specifically those selected were the downstream reaches of pipeline branches and pipelines located in properties that conveyed runoff from upstream roads or areas. Figure 7.1 shows the piped drainage infrastructure in the model, and the lines blocked for the second scenario.

Table B.4 in Appendix B shows that the peak water levels are generally increased by blockages to pipelines and culverts. Some of the reference locations are increased only slightly (up to 0.01m) but other areas show a higher increase, such as Locations 1,2, and 5 where flow is conveyed to and is not able to drain away. The peak levels resulting from pipe blockage in the creek line adjacent to Location 2 are lower than the road elevation. Parts of Emora Avenue, Davis Avenue, Alkoomie Close and Romford Close experience increases up to 0.10-0.18m for the pipe blockage scenario.

7.5 Future Conditions

The Davistown catchment is effectively fully developed as most properties are zoned 2(a) for low density residential and are already occupied. Some of the open space / vegetated-marsh areas are zoned 7(a) Conservation but some are in areas zoned 2(a) Residential, such as near Pyang Avenue, Kincumber Crescent and Ilumba Avenue. Council advised these vegetated areas are not to be developed thus the catchment layout as modelled represents the future conditions.

8. PROVISIONAL FLOOD HAZARD

8.1 General

Flood hazard can be defined as the risk to life and limb and damage caused by a flood. The hazard caused by a flood varies both in time and place across the floodplain. The Floodplain Development Manual (NSW Government, 2005) describes various factors to be considered in determining the degree of hazard. These factors are:

- Size of the flood,
- Depth and velocity of floodwaters,
- Effective warning time,
- Flood awareness,
- Rate of rise of floodwaters,
- Duration of flooding,
- Evacuation problems,
- Access.

Hazard categorisation based on all the above factors is part of establishing a Floodplain Risk Management Plan. The scope of the present study calls for determination of provisional flood hazards only, which when considered in conjunction with the above listed factors provides comprehensive analysis of the flood hazard.

8.2 Provisional Flood Hazard

Provisional flood hazard is determined through a relationship developed between the depth and velocity of floodwaters as detailed in the Floodplain Development Manual (NSW Government, 2005). The provisional hazard is defined as either High or Low as shown in Figure 8.1. The transition zone between high and low is assumed as high hazard.

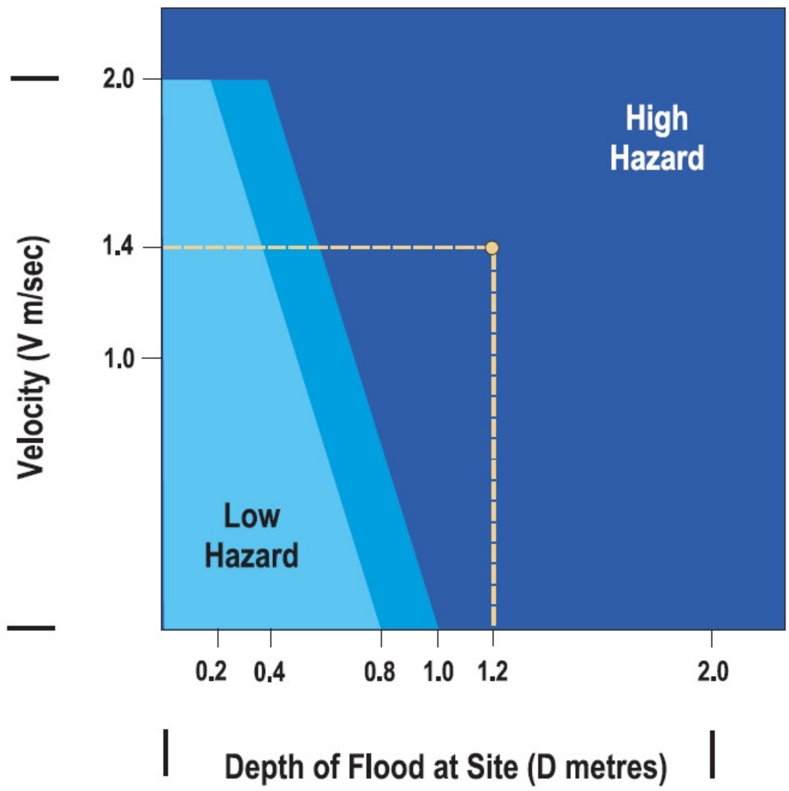

Figure 8.1 Provisional Hazard Classification (NSW Government)

The provisional flood hazard is determined using equations based on the graphs of Figure 8.1 relating the velocity and depth. Provisional hazard due to local catchment runoff determined in the flood model for the PMF, 1% AEP, 5% AEP, and 20% AEP events are shown in Figures 8.2 to 8.5 respectively.

In the 1% AEP event high hazard is confined to the channel west of Malinya Road and part of Malinya Road is shown as low hazard across the roadway. Low hazard areas are shown in isolated points on most roads and large areas within the open space and vegetated / marsh areas.

In the PMF event, high hazard areas are shown in the channel area on both sides of Malinya Road and on part of Davistown Oval. Most roadways are inundated and classified as low hazard areas.

9. HYDRAULIC CATEGORISATION

9.1 General

Hydraulic categorisation of the floodplain is used in the development of the Floodplain Risk Management Plan. The Floodplain Development Manual (2005) defines flood prone land to fall into one of the following three hydraulic categories:

- **Floodway** - Areas that convey a significant portion of the flow. These are areas that, even if partially blocked, would cause a significant increase in flood levels or a significant redistribution of flood flows, which may adversely affect other areas.

- **Flood Storage** - Areas that are important in the temporary storage of the floodwater during the passage of the flood. If the area is substantially removed by levees or fill it will result in elevated water levels and/or elevated discharges. Flood Storage areas, if completely blocked would cause peak flood levels to increase by 0.1m and/or would cause the peak discharge to increase by more than 10%.

- **Flood Fringe** - Remaining area of flood prone land, after Floodway and Flood Storage areas have been defined. Blockage or filling of this area will not have any significant affect on the flood pattern or flood levels.

9.2 Hydraulic Category Identification

Floodways were determined for the 1% AEP, 5% AEP, 20% AEP and PMF by considering those model branches that conveyed a significant portion of the total flow. These branches, if blocked or removed, would cause a significant redistribution of the flow. The criteria used to define the floodways are described below.

As a minimum, the floodway was assumed to follow the creekline from bank to bank. In addition, the following depth and velocity criteria were used to define a floodway:

- Velocity x Depth product must be greater than 0.25 m^2/s **and** velocity must be greater than 0.25 m/s; **OR**
- Velocity is greater than 1 m/s.

Flood storage was defined as those areas outside the floodway, which if completely filled would cause peak flood levels to increase by 0.1 m and/or would cause peak discharge anywhere to increase by more than 10%. The criteria were applied to the model results as described below.

Previous analysis of flood storage in 1D cross sections assumed that if the cross-sectional area is reduced such that 10% of the conveyance is lost, the criteria for flood storage would be satisfied To determine the limits of 10% conveyance in a cross-section, the depth was determined at which 10% of the flow was conveyed. This depth, averaged over several cross-sections, was found to be 0.2 m (Howells et al, 2003). Thus the criteria used to determine the flood storage is:

- Depth greater than 0.2m
- Not classified as floodway.

All areas that were not categorised as Flood Way or Flood Storage, but still fell within the flood extent, where the depth is greater than 0.05 m, are represented as Flood Fringe.

The hydraulic categories for the PMF, 1% AEP, 5% AEP, and 20% AEP based on the peak depth and velocity from local catchment runoff determined in the flood model, are shown in Figures 9.1 to 9.4 respectively.

In the 1% AEP event, floodway areas are shown in isolated locations in the higher elevations in the north of the catchment. Parts of the channel adjacent to the culvert on Morton Crescent are also categorised as floodway. The open space and marsh areas are shown as flood storage areas as well as parts of some private property. These areas include the lowlands / open-space vegetated areas such as adjacent to Kincumber Crescent and Pine Avenue; north of Davistown RSL; Davistown Oval; and the channel between Davistown Road – Malinya Road – Morton Crescent.

In the PMF event, parts of Henderson Road, Broadwater Drive and Davistown Road are shown as floodway. A significant proportion of the catchment is categorised as flood storage in the PMF event.

10. ANNUAL AVERAGE DAMAGE

10.1 Background

The economic impact of flooding can be defined by what is commonly referred to as 'flood damages'. Table 10.1 lists classifications of various types of flood damages incurred in a catchment. Direct damage costs are just one component of the entire cost of a flood event. There are also indirect costs. Both direct and indirect costs are referred to as 'tangible' costs. In addition to this there are also 'intangible' costs. The values discussed in this report are the 'total' damages and include an assumed intangible cost of 25% of the tangible cost.

Table 10.1 Types of Flood Damages

Type	Description
Direct	Building contents (internal) Structural (building repair and clean) External items (vehicles, contents of sheds etc)
Indirect	Clean-up (immediate removal of debris) Financial (loss of revenue, extra expenditure) Opportunity (non-provision of public services)
Intangible	Social – increased levels of insecurity, depression, stress General inconvenience in post-flood stage

Flood damages can be assessed by a number of means including the use of programs such as FLDAMAGE or ANUFLOOD or via more generic methods using spreadsheets. For the purposes of this project, generic spreadsheets have been developed based on damage curves adapted from the Department of Environment and Climate Change (DECC) [formerly Department of Infrastructure Planning and Natural Resources (DIPNR)].

10.2 Stage – Damage Curves

The Stage-Damage curves are based on the category of property identified within the floodplain, being:

- Residential
- Commercial
- Industrial

The Davistown catchment is predominantly residential dwellings with several small commercial properties at the intersection of Davistown Road and Paringa Ave. Also, Davistown RSL and retirement villas are located on Murna Road. No properties within the Davistown catchment are categorised as industrial.

10.2.1 Residential

The draft DECC (DIPNR) Floodplain Management Guideline No.4 *Residential Flood Damage Calculation* (2004) was used for this study. This guideline includes a template spreadsheet program that determines damage curves for three types of residential buildings:

- Single Storey, slab on ground
- Two Storey, slab on ground

- Single Storey, 'high-set' eg piered structures (floor level assumed to be 1.5m above the ground).

All buildings were assumed to be single storey slab on ground with floor levels 0.30m above a ground level obtained by ALS at the dwelling.

The DECC (DIPNR) curves are derived for late 2001 (base curves). It is recommended to adjust values in the base residential damage curves by Average Weekly Earnings (AWE), rather than by the inflation rate as measured by the Consumer Price Index (CPI). While not specified, we have assumed that the base curves were derived in November 2001, which allows the use of November 2001 AWE statistics (issued quarterly). November 2001 AWE is shown in Table 10.2. The most recent data for AWE from the Australian Bureau of Statistics at the time of assessment was for August 2008. AWE values were sourced from the Australian Bureau of Statistics (ABS, 2008).

Table 10.2 AWE Statistics from 2001 and 2008

Month	Year	AWE
November	2001	$676.40
August	2008	$897.90
Change	32.7%	

All ordinates in the base residential flood damage curves were therefore converted into August 2008 dollars. The residential damage curve is shown in Figure 10.1.

Damages are generally incurred on a property prior to any over floor flooding. The curves allow for a damage of $8,891 (August 2008 dollars) to be incurred when the water level reaches the base of the house (determined as 0.1m below the floor level). Damage was assumed to occur for depths of water over the ground of 0.2m or more (that is, 0.1m below the floor level.

10.2.2 Commercial

Commercial damage curves were determined based on those included in the FLDamage Manual (Water Studies Pty Ltd, 1992). FLDamage allows for three types of commercial properties:

- Low Value Commercial
- Medium Value Commercial
- High Value Commercial.

The FLDamage curves have a base date of 1990. The Consumer Price Index (CPI) was used to adjust the 1990 data to December 2008 dollars (this data was obtained from the Australian Bureau of Statistics website (ABS, 2009). It was assumed that the FLDamage data was in June 1990 dollars. The CPI data is shown in Table 10.3.

Table 10.3 CPI Statistics from 1990 and 2008

Month	Year	CPI
June	1990	102.50
December	2008	166.00
Change	61.95%	

Consequently, ordinates on the 1990 damage curves have been increased by 61.95% and GST has been included.

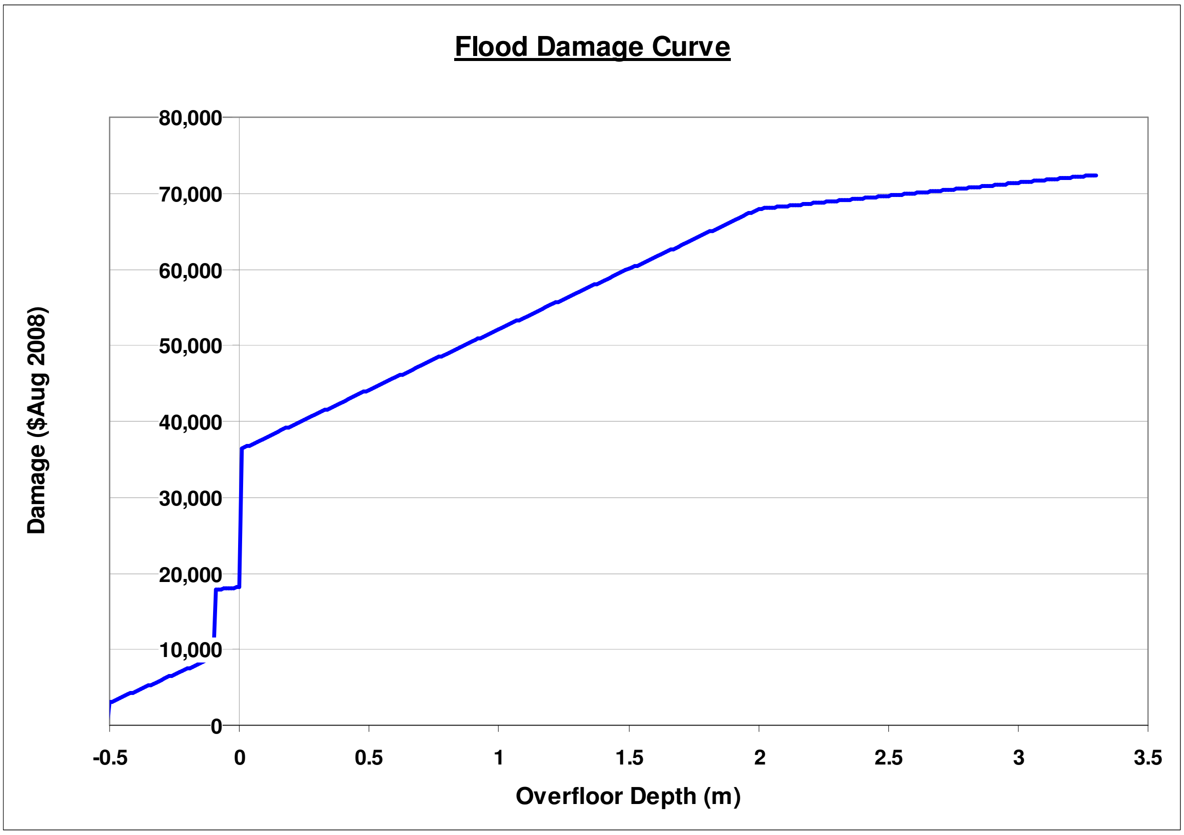

Figure 10.1 Residential Flood Damage Curve

In determining the ordinates on the damage curves, it has been assumed that the effective warning time is approximately zero, and the loss of trading days as a result of the flooding has been taken as 10.

The commercial properties on Davistown Rd and Paringa Ave (four properties) are assumed as low-value commercial with a floor area of 100 m^2. The Davistown RSL on Murna Road is assumed as high-value commercial.

10.3 Results

Table 10.4 outlines the flood impacts due to local catchment runoff. Based on the analysis, the average annual damage for the catchment as modelled is approximately $45,460. A total of about 1250 dwellings are included in the assessment.

Table 10.4 Flood Damage Summary

Event/Property Type	Number of Properties with overfloor flooding	Maximum Overfloor Flooding Depth (m)	Number of Properties with overground flooding (within 0.10m of floor level)	Total Damage ($Dec 2008)
PMF				
Residential	107	0.33	244	$6,301,264
Commercial	0	N/A	1	$0
PMF Total	107		245	$6,301,264
0.5% AEP				
Residential	0	N/A	13	$224,916
Commercial	0	N/A	0	$0
0.5% AEP Total	0		13	$224,916
1% AEP				
Residential	0	N/A	9	$161,993
Commercial	0	N/A	0	$0
1% AEP Total	0		9	$161,993
2% AEP				
Residential	0	N/A	8	$134,714
Commercial	0	N/A	0	$0
2% AEP Total	0		8	$134,714
5% AEP				
Residential	0	N/A	6	$107,618
Commercial	0	N/A	0	$0
5% AEP Total	0		6	$107,618
10% AEP				
Residential	0	N/A	5	$80,613
Commercial	0	N/A	0	$0
10% AEP Total	0		5	$80,613
20% AEP				
Residential	0	N/A	4	$71,619
Commercial	0	N/A	0	$0
20% AEP Total	0		4	$71,619
50% AEP				
Residential	0	N/A	0	$0
Commercial	0	N/A	0	$0
50% AEP Total	0		0	$0
100% AEP				
Residential	0	N/A	0	$0
Commercial	0	N/A	0	$0
100% AEP Total	0		0	$0

11. CLIMATE CHANGE

Increased sea levels and increased rainfall intensities are expected to result from climate change effects. Potential impacts to flood behaviour in the Davistown catchment due to climate change have been analysed.

The Department of Environment and Climate Change in the guideline 'Practical Consideration of Climate Change' (2007) recommended that climate change assessments review three scenarios of increases to rainfall intensities: 10%, 20%, and 30%. A sea-level rise of up to 0.91m was identified as potentially occurring by the year 2100 due to climate change impacts. Council also nominated 0.2m sea level rise for assessment.

The 'Brisbane Water Foreshore Flood Study' (Cardno Lawson Treloar, 2009) assessed impacts to the Brisbane Water area resulting from sea level rise. Modelling showed that a rise in the mean sea level will result in an equivalent rise of the design levels within the estuary.

A combination of scenarios was modelled for the critical storm event of 1% AEP 2 hour duration with a base estuary level of the 1% probability of exceedance (PoE) level (0.64m AHD):

1. 10% increase to rainfall intensities,
2. 20% increase to rainfall intensities,
3. 30% increase to rainfall intensities,
4. 0.2m rise in estuary level,
5. 0.2m rise in estuary level and 30% increase to rainfall intensities,
6. 0.91m rise in estuary level,
7. 0.91m rise in estuary level and 30% increase to rainfall intensities.

Table C.1 (in Appendix C) lists results for the increased peak water levels at the reference locations of Figure 6.1 resulting from Scenarios 1, 2, and 3. The increased rainfall intensities show that some of the locations are generally unaffected compared to up to 0.06m increase in other locations.

Table C.2 lists the peak water level results for Scenarios 4 and 5 with a 0.2m rise in estuary level and Table C.3 lists peak water levels for Scenarios 6 and 7. Figures 11.1 and 11.2 show the peak depths (>0.10m) for Scenario 5 and Scenario 7 respectively.

A 0.2m rise in estuary level above the 1% PoE level (namely 0.84m AHD) is below the general elevation of roads and properties in Davistown thus most areas are unaffected. The 30% increase to rainfall intensities results in slightly higher peak water levels than those shown in Table C.1 without the raised estuary level.

A 0.91m rise in estuary level above the 1% PoE level (namely 1.55m AHD) is higher than a large proportion of the properties in the Davistown catchment. Thus properties are inundated by water flooding from the estuary rather than specifically from catchment runoff.

12. REPORT QUALIFICATIONS

This report has been prepared for Gosford City Council to define the nature and extent of flooding for the study area of the Davistown catchment. Hydrologic and hydraulic modelling was completed to assess flood behaviour within the catchment. Flood modelling is based on local catchment flooding only, the impact of flood levels from the Brisbane Water estuary has not been accounted for in the modelling. Estuary flooding is described in the Brisbane Water Foreshore Flood Study (2009). Flow characteristics including depth, velocity and provisional hazard were evaluated based on the computer modelling.

The investigation and modelling procedures adopted for this study follow current best practice and considerable care has been applied to the preparation of the results. However, model set-up and calibration depends on the quality of data available and there will always be some uncertainties. The flow regime and the flow control structures are very complicated and can only be represented by schematised model layouts.

Hence there will be an unknown level of uncertainty in the results and this should be borne in mind in their application.

Study results should not be used for purposes other than those for which they were prepared.

13. CONCLUSION

Davistown catchment is a predominantly flat area rising relatively sharply to the southern areas of Saratoga. Flood modelling of local catchment runoff was completed for a range of annual exceedance probabilities of storms from 100% AEP to 0.5% AEP and up to a PMF event.

The analysis demonstrated that runoff and higher flood depths due to the 1% AEP event occur in the open space and vegetated-marsh areas in the catchment. However, some properties and sections of road experience flood depths up to 0.5m in this event. In the 1% AEP event, the modelling showed that no houses are flooded above the floor level when the storm runoff is combined with a 1% probability of exceedance level in the estuary.

Mapping of the provisional hazard showed that for the 1% AEP event, high hazard is limited to the open channel west of Malinya Road. Hydraulic category mapping showed that scattered occurrences of floodway for the 1% AEP event occur on the steeper slopes in the north of the catchment and at the Morton Crescent culvert. The open space areas and vegetated-marsh areas and some properties are identified as flood storage locations. Increases to sea levels due to climate change have the potential to significantly affect flood impacts, particularly in the low elevation areas of the Davistown catchment.

The Floodplain Management Authority's Prioritisation Ranking table for the Davistown catchment is included as Appendix D.

14. REFERENCES

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FIGURES

Figure 1.1 Site Locality

Figure 5.5 Rainfall Stations Locations

APPENDIX A

Resident Questionnaire

Our Ref W4715

Contact Andrew Reid

4 October 2007

To The Resident

Dear Sir/Madam,

DAVISTOWN CATCHMENT FLOOD STUDY

Cardno Lawson Treloar have been commissioned by Gosford City Council to undertake a Flood Study for the Davistown catchment. A catchment layout and the study area are shown on the attached figure.

This Flood Study will form part of the overall Flood Plain Risk Management process (Figure 1) for the catchment, and can be used to optimise development potential, and to obtain social and economic benefits from the reduction in flood damages.

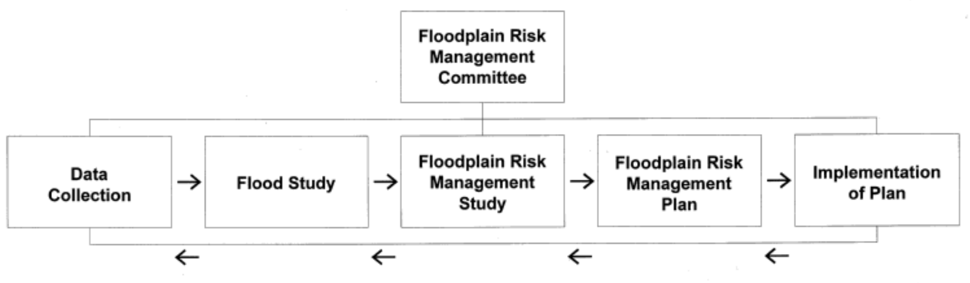

Figure 1: The Floodplain Risk Management Process

The Flood Study comprises a comprehensive technical investigation of flood behaviour in the catchment. The study defines the nature and extent of the flood risk by providing information on the level and velocity of floodwaters and on the distribution of flood flows at various locations in the floodplain.

The Flood Study provides a technical basis from which the Floodplain Risk Management Study (FRMS) and Floodplain Risk Management Plan (FRMP) are developed. They are usually completed in one project and would be completed immediately after the completion of the Flood Study, subject to grant funding.

The FRMS identifies, assesses and compares various risk management options and considers opportunities for environmental enhancement as part of floodplain management measures.

The FRMP provides input into the strategic and statutory planning roles of council. It also documents the adopted management strategy formally approved by Council after assessment of submissions following public exhibition.

The final stage of the process is the implementation of the Plan (which would need to compete for funding from various government sources where works are an option).

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Gold Coast
Gosford
Baulkham Hills
Wollongong
Busselton

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United Arab Emirates
United Kingdom
United States

Community involvement is important at all stages of the Floodplain Management Process. Resident's local knowledge of the catchment and personal experiences of flooding provide an invaluable source of data to define the nature and extent of flooding at the Flood Study stage of the process. In this regard, Council seeks your assistance in undertaking this Flood Study.

You can participate in the study process through your local community associations who can represent your views at Council's Floodplain Risk Management Committee (FRMC) meetings. The FRMC is responsible for overseeing the study and to ensure it follows the Floodplain Risk Management Process. Your community representative on the FRMC is:

Mr. Bill Evans
Davistown Progress Association Incorporated
5 McCauley Street
Davistown NSW 2251
Phone: (02) 4363 2105

Enclosed please find a questionnaire, which focuses on whether your property or any nearby property has been flooded in the past. This questionnaire is similar to one completed by some residents in August 2006. However, this questionnaire covers the entire Davistown Catchment and allows for responses based on the June 2007 storm event to be incorporated into the Flood Study assessment process.

Please take the time to read the questions and answer them as best as you can. Any information you provide may prove vital to the success and accuracy of the study results.

Would you **please return** the questionnaire in the enclosed reply paid envelope **within three weeks** of receipt of this letter.

Please contact Andrew Reid from Cardno Lawson Treloar or Jim Gowing from Gosford City Council if you want to discuss or clarify items regarding the catchment study.

- Andrew Reid
  - Cardno Lawson Treloar
  - Telephone: 02 9499 3000
  - Facsimile: 02 9499 3033
  - Email: andrew.reid@cardno.com.au

- Jim Gowing
  - Gosford City Council
  - Telephone: 02 4235 8818
  - Facsimile: 02 4323 2528
  - Email: jim.gowing@gosford.nsw.gov.au

Yours faithfully

Andrew Reid
Project Engineer
for **Cardno Lawson Treloar**

Encl. Davistown Questionnaire

Davistown Catchment Flood Assessment Study

QUESTIONNAIRE

Please answer the following questions as best as you can. When you have finished answering the questions, please return these pages in the enclosed "reply paid" envelope.

If you have any queries, please contact:

Andrew Reid – CARDNO LAWSON TRELOAR Ph: 02 9499 3000
Fax: 02 9499 3033
andrew.reid@cardno.com.au

Jim Gowing – GOSFORD CITY COUNCIL Ph: 02 4325 8818
Fax: 02 4323 2528

Question 1

Could you please provide us with the following details? We may need to contact you to check some of the information with you.

(The information will remain completely CONFIDENTIAL)

Name: ______________________________

Day time phone Number: ______________________________

Email Address: ______________________________

Address: ______________________________

____

____

Question 2

How long have you lived in this locality?

______ Years ______ Months

Have you previously lived at another address within the catchment (shown on the attached map)?

Details: ______________________________

____

____

Question 3

Are you aware of flooding in the catchment?

Please Tick One:

Aware _____

Some knowledge _____

Not Aware _____

Question 4

Have you ever been inconvenienced, or has your property been flooded because of uncontrolled floodwater in this locality?

(Your property may have been flooded inside the house or in your backyard, or you might have been stopped from getting to work)

Please Tick:

INSIDE HOUSE FLOODED -	YES	______	NO	______
PROPERTY/YARD FLOODED -	YES	______	NO	______
INCONVENIENCED -	YES	______	NO	______

Question 5

Can you remember when that was?

Please Tick:

YES ______

NO ______

If you answered YES, please give us as much detail as possible.
To assist, flooding may have occurred on the following dates:

1. June 2007 ☐
2. January 1996 ☐
3. February 1992 ☐
4. February 1990 ☐
5. January 1989 ☐
6. April 1988 ☐
7. October 1985 ☐
8. November 1984 ☐
9. February 1981 ☐

10. January 1978 ☐
11. March 1977 ☐
12. May 1974 ☐
13. ___________
14. ___________

Details of flooding and when it occurred:
(How long after the rain started? How high was the water level? How long did it stay at this level? When did the water level reach its peak?)

____
____
____
____
____
____
____
____

Question 6

If you have experienced flooding in the area, do you have any evidence of the extents of the floods (such as flood levels or depths at certain locations)?

Please Tick:

YES ______

NO ______

If you answered YES, please give as much detail as possible.

You may have an old photograph, or may have taken a video. Some people remember marks on walls and posts, and this information could prove quite important. Alternatively, you may know someone who has lived in the locality for a long time who might have that type of information.

Details of information:

____
____
____
____
____
____
____
____

Question 7

If you answered Yes to Question 6, what type of property did you see flooded?

You may tick more than one:

RESIDENTIAL	______	COMMERCIAL	______
PARKS	______	ROADS & PATHS	______
OTHER	______		

Please Specify: ____

Can you describe the area of the property that was flooded?

You may tick more than one.

BACKYARD	______
GARAGE	______
BUILDING (ABOVE FLOOR LEVEL)	______
BUILDING (BELOW FLOOR LEVEL)	______
FRONTYARD	______
OTHER	______

Please Specify: ____

Question 8

Did you notice any bridges and/or culverts to be blocked during the event?

__________ YES __________ NO

If YES, please provide details (please mark the location on the map if possible), and how blocked would you say it was? (eg. 50% blocked, 80% blocked)

____

____

If YES, what was causing the blockage? (eg. woody debris, shopping trolley, vehicle)

____

____

Question 9

If possible, can you show the location of the flooding on the enclosed map?

Please Tick:

YES ______

NO ______

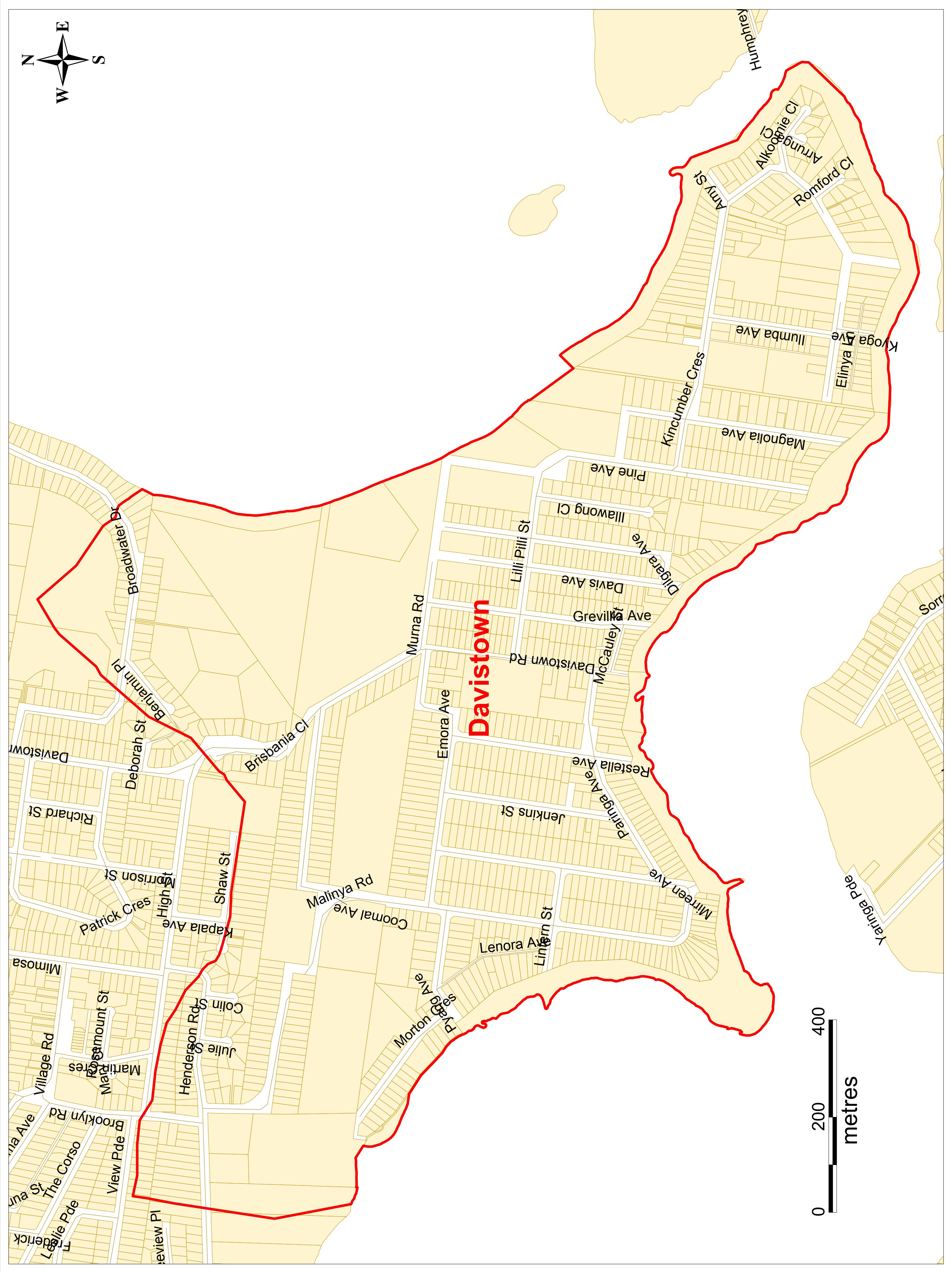
If you have indicated yes, please remember to enclose the map in the envelope, clearly marked.

Question 10

Is there anything else you can tell us about the flooding in this locality?

If so, please provide the information below.

Thank you for providing the above information. Please remember to put it back in the reply paid envelope. A representative from Cardno Lawson Treloar may contact you in the near future to discuss your response.



Cardno Lawson Treloar

W4715
September 2007

Davistown Catchment Flood Study

FIGURE 1
CATCHMENT MAP

W4715\MapInfo\Davistown ResidentMap.Wor

DAVISTOWN	Q1		Q2	Q3			Q4			Q5															Q6			Q7											Q8			Q9		Q10
Survey Ref. No	Street	Suburb	How long - years	Aware	Some knowledge	Not Aware	Inside	Yard	Inconv.	Yes	No	Jun-07	Jan-96	Feb-92	Feb-90	Jan-89	Apr-98	Oct-85	Nov-84	Feb-81	Jan-78	Mar-77	May-74	Comments	Yes	No	Comments	Res	Parks	Comm.	Rds & Paths	Other	Backyard	Garage	Bldg-Above	Bldg-Below	Front yard	Other	Yes	No	Comment	Yes	No	Comments
1	Broadwater Dr	Saratoga	7	1			N	Y	Y	Y		1												Flooded garage,against front wall of house, backyard & paddock from 40mm to 150mm. Occurred within 10 minutes of heavy rain, stayed high whilst raining, slowly subsided. Paddock - ponds for 2 weeks.	Y		Water levels against garage door & front brickwall "high tide" marks.	1				paddock	1	1		1	1	Council drains in easements thru block as well as water draining from neighbouring filled blocks onto paddock		N		Y		Concerned about neighboring block to paddock which has been filled (40 x 10 tonne truck loads) to a height 300mm+ which is adjacent to wetland reserve to S. No silt traps to prevent silt entering paddock or wetlands - could have detrimental effect to both. Council drains not maintained - silted up/often blocked with debris.
2	Paringa Ave	Saratoga	7		1		N	N	N																	N			1											N				
3	Davistown Rd	Saratoga	1																																									
4	Alloura Waters	Davistown	7	1			N	N	N																Y		**SEE PHOTOS**					wetlands								N		Y		
5	Henderson Rd	Saratoga	29	1			N	N	N																	N																		
6	Murna Rd	Davistown	5	1			N	N	N		N															N														N				
7	Paringa Ave	Davistown	24	1			N	N	N																Y		Parks, Roads, Property	1	1		1						1	Parkland, Davistown Oval		N		Y		
8	Paringa Ave	Davistown	20	1				Y	Y	Y		1					1							When? - not sure , after June, August, September. How high? - 100mm over yard and in Studio (garage). Peak? - at night.	Y		Wall marks.	1			1		1	1				All of property due to adjacent properties filled and no street gutters or drainage.		N		Y		Very little drainage in Davistown.
9	Murna Rd	Davistown	11		1		N	N	N																Y		Tidal flooding with King Tides across the other side of Davistown Rd - early Oct. 2007. Approx. 15-30 cms.					Presumably Council property.						Undeveloped but with drainage works installed before our time.		N		Y		Have heard that before 5/1996 flooding caused by a combination of tide and rain entered some older lower houses below the intersection of LillyPilli St & Grevillea Ave as marked.
10	Morton Cres	Davistown	17	1			N	N	N		N															N																Y		Open drains backfill from hightide events only. Rainwater in catchment area has little effect on water levels. Local low pressure in atmosphere and king tide events + high pressure event down the coast will create a wave that will travel up the coast. If this passes Broken Bay on a king tide event then flooding will occur in the low lying areas of Davistown (1-100 years). In 1993 approx. this block did flood around 150mm deep (lowest block in street then) Now level raised by 500mm & house raised 2.1metres above AHD. Have not seen road completely flood in 17 years.
11	Davistown Rd	Davistown	16	1			N	N	Y	Y				1										Davistown Rd flooded at Yattalunga	Y			1	1		1		1	1	1	1	1		Y		80% blocked - don't know cause			
12	Emora Ave	Davistown	36	1			Y	Y	Y	Y													1	Flash flooding plus wind holding tide in.		N		1			1		1	1	1		1	1974 floods plus other times.	Y		Cnr. Restella & Emona Ave.	Y		Cnr. & Restella Ave banks up and can't get away.
13	Broadwater Dr	Saratoga	26	1			N	Y	Y	Y		1												June 07 heavy rain & flooding (house on poles so not flooded) but topsoil washed to paddock at rear which was 70% under water after a day of rain - water ramained for 1 week.		N		1	1		1		1			1			Y					
14	Paringa Ave	Davistown	25	1			Y	Y	Y			1		1											Y		Davistown Shop (Take away)	1	1	1	1		1	1		1	1		Y		Top of Davistown Rd	Y		
15	Broadwater Dr	Saratoga	6	1			N	N	N																																			
16	Jenkins St	Davistown	5		1		N	Y	N		N	1														N														N		Y		
17	Mirreen Ave	Davistown	50	1			N	Y	Y	Y		1				1	1						1	May 74 - 3 days - 8" - 12 hrs- middle night. Apr 88 - 2 days - 12" - 6 hrs - 3pm. Jan 89 - 3 days - 12" - 6 hrs - midarvo. June 07 - 18 hrs - 18" - 4 hrs - 5am.	Y		May 74 - historically well documented. 1988, 1989, 2007 - high tides, high tides, torrential rain + southerly winds + big S/E swells.	1	1	1	1	1	1	1		1	1	Current address lifted 600mm above flood level of 1974 as it lapped floor boards in 1974.		N				
18	Mirreen Ave	Davistown	2	1				Y	Y	Y		1												Heavy rain for just a couple of hrs floods whole yard as wel as garage & laundry. Level approx 5-10cm deep. Pools in yards with no escape unless pumped away.		N							1	1			1	Laundry		N				
19	Jenkins St	Davistown	52	1				Y																1972 or 1973. Extra high tides & storms 18" - Tide Change, peak?		N														N			N	
20	Milinya Rd	Davistown	9	1			N	Y	Y	Y		1												When? - within 8 hrs.How high? Combination of high tide & heavy rain around 4" deep all over block & garage, garden shet, etc. How long? Approx 3 days then took a week to drop & soak into ground. Peak? At high tide each day.	Y		Old photo's possibly 60's. Marks on walls of house & foundations.	1	1			My home & local parks.	1	1			1	Garden shed.	Y		Culverts 80% blocked. Too much water & possibly garden debris	Y		
21	Jenkins St	Davistown	3	1				Y	Y	Y		1												Rain all day Thurs, night/Fri, night. Sat morning aware of property flooding. Up all night minitoring, with no power to assist. Sat. unable to leave via Jenkins St N. due to flooding.	Y		Water over grass & concrete. Unable to exit bia Emora/Jenkins St.	1	1		1		1	1		1	1	Roads		N		Y		
22	Morton Cres	Davistown	1			1	N	N	N			1												Sewer in street needed council attention.		N														N			N	In heavy rain & especially in June 07 footpath in culdesac end of st.underwater & sewerline blocked.
23	Paringa Ave	Davistown	14	1			N	Y	N	Y		1													Y		Build up of slidge.	1	1		1		1				1			N		Y		
24	Davistown Rd	Saratoga	10		1		N	N	N																																			
25	Malinya Rd	Davistown	21	1			N	Y	N				1	1	1	1								2 days after heavy rain & westerly blowing.	Y		100mm - 120mm on reserve	1	1		1		1				1			N		Y		Most flooding when King Tides occur & heavy rain with strong south to westerly winds.
26	Davistown Rd	Davistown	35	1				Y		Y		!												Started light steady rain, around 4pm wind came then tide - bad all night.	Y		Cars written off. Were building at the time - timber was washed down. Have photo's.	1	1		1		1		1		1	People in boats going up & down Emora & Restella Ave.	Y					Flooding in 1974 over my head in Resella Ave. Pipe put in under road. No bad flooding until 2007 caused by blocked pipe - only cleaned out about three times since.
27	Emona Ave	Davistown	25	1			N	N	N		N														Y		Gutters & road sometimes flood after rain around Christmas (King Tides) mainly tidal.	1			1	Properties not filled.					1	Original properties not filled.		N				Any flooding occurs when King Tides and heavy rain which is tital.
28	Broadwater Dr	Saratoga	7	1			N	N	N																	N																		
29	Mirreen Ave	Davistown	1	1			Y	Y	Y	Y		1												Periods of flooding from 7th to 20th June, 2007. Because of toilet, power problems we stayed with friends in Gosford for worst part of flooding.	Y		Some photo's but not of worst flooding.	1					1		1	1	1			N				
30	Allowra Waters,Murr	Davistown	6		1			Y		Y		1												Yard flooded by water in natural course from uphill adjacent villas. Not inconvenienced.		N		1					1						Y		Murna Rd easement overflowed towards lower areas of Davistown, S direction. Blocked by debris & overgrowth.	Y		Has extensive weather records if you wish access them.
31	High St	Saratoga	7		1		N	N	N																				1			Oval at Davistown												Worst seen is full culvert in 7 years.
32	Broadwater Dr	Saratoga	10		1		N	Y	Y	Y		1												Heavy rains cause flooding across driveway - can happen within 1 hr of heavy rain. Stays couple of hours.		N														N	Need kerb & guters.			
33	Morton Cres	Davistown	32		1			Y	Y	Y													1	Thru night & day water in front yard most time when rain is heavy.		N		1			1			1		1	1		Y					
34	Emora Ave	Davistown	5		1		N	N	N																	N														N				No run-off & tidal influence occurs in catchment.
35	Paringa Ave	Davistown	35	1			N	Y	Y	Y		1	1	1	1	1	1	1	1	1	1	1	1	Several hrs. depending on tide, stays sometimes days.		N		1	1		1		1			1	1		Y		Woody debris	Y		
36	Malinya Rd	Davistown	16	1			N	Y	Y	Y		1	1											2007 - Started in morning - 100mm over driveway. 1996 Started in mornning by evenig when tide came in water rose to cover driveway approx. 150mm and most local roads closed.		N														N		Y		Both times flooding occurred there was heavy rain, strong winds & high tides. Approx. 100mm over driveway.
37	Mirreen Ave	Davistown	6	1				Y	Y	Y		1	1	1	1	1								When rains yards flood in short period of time - mainly from run-off & lack of drainage. Water backs up from front & can lay under home for lengthy periods of time.		N																		
38	Colin St	Saratoga	20	1			N	N	N		N															N														N				

DAVISTOWN Survey Ref. No	Q1 Street	Q1 Suburb	Q2 How long - years	Q3 Aware	Q3 Some knowledge	Q3 Not Aware	Q4 Inside	Q4 Yard	Q4 Inconv.	Q5 Yes	Q5 No	Jun-07	Jan-96	Feb-92	Feb-90	Jan-89	Apr-98	Oct-85	Nov-84	Feb-81	Jan-78	Mar-77	May-74	Q5 Comments
39	Emora Ave	Davistown	8	1				Y		Y		1												A few hours. Ground level - 1-1.5 bricks high - 12 hours approx. during early hours of the morning.
40	Alloura Waters	Davistown	8	1			N	N	N															
41	Alloura Waters	Davistown	4																					
42	Julie St	Saratoga	4			1	N	N	N															
43	Paringa Ave	Davistown	8	1			Y	Y	Y	Y													1	1974 flood due to hightide, heavy rain + extreme SW wind. Water came up quickly-receded by morning. Our laundry & garage flooded (ground level) no great damage.
44	Morton Cres	Davistown	40	1			N	Y	N	Y			1	1	1	1					1	1	1	Flooding in Dilgara Av was within 1 day but no damage. Never flooding in Morton Cr. But gutters can get deep & remain for days.
45	Emora Ave	Davistown	15	1				Y		Y		1												Twice at other times (backyard) dates unknown. Water entering backyard is tide related (high tide). Rainfal drains away but is held back by incoming tide. Water was 5-6" deep and receded with ebb tide.
46	Emora Ave	Davistown	34	1				Y		Y													1	Water to backstep below floor level - high tide + wind kept level up. Since drains dug water only comes over back portion of property after heavy rain + high tide.
47	Benjamin Place	Saratoga	24		1		N	Y		Y		1												Pine Ave always flooded in heavy rain. Water on low lying acres behind res. In Benjamin Pl after heavy rain.
48	Murna Rd	Davistown	8		1		N	N	N		N													
49	Colin St	Saratoga	14	1			N	N	N															
50	Paringa Ave	Davistown	1	1			Y	Y	Y	Y		1												On the evening of the day that rain started (after approx 10 hrs of rain). Water rose quickly over 3-4 hr period and stayed while rain continued. Subsided after approx 2-3 hrs of rain stopping.
51	Broadwater Dr	Saratoga	3		1		Y	Y		Y		1												Within 2 hrs water was coursing through garage and either side of house. Water continued running this course for up to 3 days after the rains stopped.
52	Broadwater Dr	Saratoga	5	1			N	Y	N	Y		1												Nuisance flooding - puddles to 6cm deep in undulating paddock and yard areas. Very slow dissipation of water probably due to low land level and influence of tidal water from Kincumber Broadwater. Also, Kincumber Broadwater entrance is silting up, thus not allowing sufficient tidal flow to alleviate problems.
53	Mirreen Ave	Davistown	36	1			Y	Y	Y	Y		1												May 1974 - Vague memories - I was only 7. Flooding of Maccaualey Lane and Grevillea Ave into the house just above floor level - about 20 inches in depth. Rained heavily all day with a king tide and southerly water receded by next day. June 1998 - Yard flooded about 3-4 inches, Emora Ave and Mirren Ave road compltely covered except for the crest of the top of the road. It was a southerly heavy rain storm all evening/night and a high tide at midnight.
54	Davistown Rd	Davistown	1																					
55	Broadwater Dr	Saratoga	4	1			N	Y	Y	Y		1												Lower access dangerous - yard & house & granny flat damaged. Many other times difficult to use lower access.
56	Restella Rd	Davistown	16	1			N	N	Y	Y		1	1	1										2007 didn't notice flooding in our area. 1996 there was water over road but only at very ends of Restella Ave. 1992 there was water over the edges of Restella Ave at each end. Water was also over the road 100metres from Avoca Dr. down Davistown Road.
57	Paringa Ave	Davistown	1	1			Y	Y	Y	Y		1											1	
58	Morton Cres	Davistown	24		1			Y			N	1												Property lower than road - flooded to a couple of inches - couple days after rain started. Also behind garage at lowest point on block and inside gate on waterfront side which receded when tide went down.
59	Paringa Ave	Davistown	4	1			N	N	N		N													
60	Morton Cres	Davistown	6	1					N															
61	Jenkins St	Davistown	1		1		N	Y	N	Y		1												Not sure - woke up due to noise of rain - stayed at level about 1 hr - reached peak at about 5am.
62	Paringa Ave	Davistown	10	1			N	N	N															
63	Paringa Ave	Davistown	7	1			N	N	N															

Survey Ref. No	Q6 Yes	Q6 No	Q6 Comments	Q7 Res	Q7 Parks	Q7 Comm.	Q7 Rds & Paths	Q7 Other	Q7 Backyard	Q7 Garage	Q7 Bldg-Above	Q7 Bldg-Below	Q7 Front yard	Other
39	Y		Salt water marks left on brickwork of house.	1	1		1						1	
40	Y		Property in Davistown Rd water level 8'10" approx in front yrd. Flooding on Davistown Oval.	1	1								1	Much of the oval
41														
42														
43	Y		Have movie showing damage but not flooding (because overnight). Film shows boats washed ashore, fences, sections of jetties washed away etc. some water lying.	1	1		1	Waterfront reserve park & private jetty.	1	1		1	1	
44	Y		In Malinya Ave - high tides + rain left water up to house foodings - floor board but had been fully underwater in caravan at Empire Bay the week before.	1					1	1		1	1	
45	Y		5-6" deep in yard	1	1				1				1	
46		N												
47		N		1	1		1		1				1	Front & backyard under water at Pine Ave.
48		N												
49		N												
50	Y		I have photos of my property and the street. Neighbours on waterfront properties say that water has completely covered Paringa Ave.	1			1		1	1			1	
51		N												
52		N		1	1			Neighbour, Adjacent	1				1	
53		N	June - 2007 - Power outage, sewer failure, roads blocked, unable to get to work in Sydney because of high winds and heavy rain. Sewerage outage needed to not use sewer.		1		1	Front yard of neighbours house under 10-15cm water.						
54														
55		N												
56		N												
57	Y		May 1974 floodwater entered old house (which used to be on property) to about 6" above floor level. June 2007 floodwater entered new shed on property to about 1" above floor level.	1	1		1	Park, Davistown Road	1		1		1	
58		N							1				1	
59	Y		June/July2007 some road flooding - no srormwater gutters.	1	1	1	1							
60	Y		Flotsam left at highest level of recent flood reached camber on road outside house.	1			1		1	1				Neighbours yard & garage & sewerage inspection manhole covered approx 2 bricks high.
61		N		1	1		1	Carport & local oval	1	1				Carport & part of garage
62														
63			All swamp areas are flooded. All 40 yr & houses get flooded up to floor levels.	1	1			Low lying areas	1	1		1	1	

Survey Ref. No	Q8 Yes	Q8 No	Comment	Q9 Yes	Q9 No	Q10 Comments
39		N		Y		
40		N		Y		Property close to Central Wharf had water coming up toilet as a result of flooding in June 2007.
41						No flooding in our area.
42						
43		N		Y		Consider 1974 flood to have been caused by wind and tide rather than rain itself. House now raised in height apart from laundry & garage but not to new law height. Think channels should be dredged to their depths of 1950's or even 1940's.
44	Y		Lack of stormwater drains in Morton Cres.	Y		We desperately need proper curb & guttering to all houses in Morton Cres.
45		N		Y		Water entering properties occurs on incoming tide peak - lasts until tide turns. Water level reduction quite rapid in some storms. Main problems occur with heavy rain, strong winds, big swell in Brown Bay + Run-in tide forcing water into drains & backyards.
46						Problem partly due to drains not cleaned out (silted up) & water can't get away.
47		N				
48						
49		N			N	
50		N				Drains can't cope with water deluge. Many broken/cracked drains.
51		N		Y		
52		N		Y		Dredging of silted Kincumber Broadwater channel would alleviate many of the problems of rainwater dissipation.
53		N		Y		In the 80's there were a couple of occasions that Davistown Road at Yattalunga would cover over near Avoca Dr and the field that is there would fill up. The times that Emora & Mirreen Ave have flooded had been at night, heavy consitent rain for several hours and high or king tides are present with a southerly wind, that seems to have restricted the outflow of the tide at Ettalong.
54						
55	Y		20% cnr Davistown & Broadwater. 40% access Rd below Broadwater Dr & easement to Broadwater itself. Debris, drains blocked not efficient enough.	Y		Water run off from Broadwater Dr to easement out to Broadwater - drains not large enough. Easement on our block - water runs across yard down steps after any heavy rain. Drain in access road & main driveway do not direct water as drain constantly overflowing in rain. No gutters Broadwater Dr. results in all water run off finding its way thru properties rather than down drainage. Aglines, ditches, etc. in place by residents not enough whilst insufficient street drainage exists.
56				Y		Flooding occurs in area when it rains heavy for a week or two at same time as king tides. The king tide flows up canals in Davistown raising the water table so rain can't soak away or run off. When tides go so does flood water. There is a flood marker pole at Davistown Hall - very controversial - houses with floor levels lower than the marks on the pole didn't flood at the same time and that the pole was replaced in the wrong position when it fell off and that some levels were marked through hear-say.
57		N				
58		N				
59	Y		Fully blocked. Lack of service from Council			
60		N	Culvert under bridge working at 100% capacity. No blockage just too small an outlet.	Y		Davistown being built on a sheoak/mangrove wet land will always be subject to flooding. Lazer levelling all drains to a uniform depth & maintaining them clean will reduce flooding times to the minimum.
61		N		Y		
62						Telephone lines damaged by water - Paringa Ave.
63		N				

DAVISTOWN	Q1		Q2	Q3			Q4			Q5															Q6			Q7											Q8			Q9		Q10
Survey Ref. No	Street	Suburb	How long - years	Aware	Some knowledge	Not Aware	Inside	Yard	Inconv.	Yes	No	Jun-07	Jan-96	Feb-92	Feb-90	Jan-89	Apr-88	Oct-85	Nov-84	Feb-81	Jan-78	Mar-77	May-74	Comments	Yes	No	Comments	Res	Parks	Comm.	Rds & Paths	Other	Backyard	Garage	Bldg-Above	Bldg-Below	Front yard	Other	Yes	No	Comment	Yes	No	Comments
64	Alloura Waters	Davistown	7	1			N	N	N																Y		June 2007 saw Emora Ave (near Davistown Rd) flooded right across from wetlands to other side of road. Was about hightide and water spilled out of wetlands. Also saw Davistown Oval flooded - once again!																	
65	Mirreen Ave	Davistown	15	1			N	Y	N		N	1	1											When heavy rain occurs, due to topography of area and increased water table height once saturation is achieved, flooding occurs in lower area.		N		1			1		1							N				
66	Malinya Rd	Davistown	6	1			N	Y	N	Y		1												How long after? Several hours. Water level? 3". How long stay? Several hours. Peak? Unsure.	Y		We know water level achieved by markings in yard.						1							N		Y		At time backyard flooded, only about a 5 foot gap on Malinya Rd between flood waters on each side of road. The water encroached upon street surface such that there was only 5 foot road surface in middle of roat between water.
67	Colin St	Saratoga	3	1			N	N	N		N													Was raised water level in Brisbane Water after heavy rains & king tide - no drama though - expected it as I decided to live in floodprone area.		N														N			N	Was flooded in N end of Malinya Rd but as we have grassed & open gutter system this allows floodwaters to rapidly drain away when tides drop, etc.
68	Jenkins St	Davistown	7		1			Y		Y														October 2005 rained for approx 5 days very heavily. By 3rd day bottom or property was a flood plain. Water level was above ankle height. Once rain stopped water receded within 24 hrs. Still have video.	Y		During storms June 2007 significant flooding at intersection of Emora & Restella Ave. First time have seen road entirely covered by water (Emora) approx 5cm above road level. Dangerous for pedestrians. Also Davistown Oval is regularly swampy after heavy rain.	1	1		1		1							N		Y		
69	Alloura Waters	Davistown	8	1				Y	N	Y														Jan 2002. Heavy downpour - water nearly entered dining room/bedroom - about 25 minutes after start of rain. Stayed at that height for approx 1/2 hr.		N																Y		
70	Paringa Ave	Davistown	13	1			N	N	N																																			
71	Paringa Ave	Davistown	10	1			N	Y	N	Y		1												June 2007- Water (shalow) covered part of driveway, car port & backyard. Peaked at high tide around 4.00 am in morning. Almost entered garage. May 1998 Similar to above - peaked at high tide approx 10.00 pm.	Y		**See photos of aftermath of May 74 flood. Photos obtained from ex-resident at the time.**					Reserve on waterfront in Paringa Ave	1				1	Most of the backyards & frontyards of Paringa Ave.		N		Y		
72	Mirreen Ave	Davistown	36	1				Y	Y			1											1																			Y		**REFER TO ATTACHED MEETING NOTES OF 5/11/07**
73	Davis Ave	Davistown	10	1				Y		Y		1												Overseas at time, but told it was 6" high in yard Did not get into house but filled sewer.		N							1											
74	Emora Ave	Davistown	44	1			N	Y	N	Y		1	1	1	1	1	1	1	1	1	1	1	1	Big flood - king tides & heavy rains went on for 3 weeks or so. Fierce winds etc. The water did drain away in time - under a week.	Y		Wetlands already here should remain and never be built on. We have natural system that works. Water flows in, is clean & not smelly & washes out to sea. Not like some areas around Long Jetty. Plenty of wildlife exists in area - will remain if not built on or altered.	1	1		1		1			1	1		Y		Maybe the oval needs to be dug - one side. It use to be. Blockage? - woody debris.	Y		
75	Malinya Rd	Davistown	9	1			N	Y	Y	Y		1												Also 2006, 2005, 2004, 2003, 2002, 2001, 2000, 1999, 1998. Flooding occurs when winds are S/Sw and tides are high, if it rains as well then the flooding is worse. Water levels reach their peak at the peak of tide.	Y		2007 - 8 inches of water right thru to the Road - Malinya Rd. Other years it varies depending on winds & tides.	1	1		1		1	1			1	Sewerage system	Y		50% blocked. Drain which runs thru Council lot 39 Malinya has pipe at waters edge that appears too small - large mangrove blocking one end of pipe. Drain was filled withmud when watermain @ burst & has never been dredged. Part of drain crossing reserve has been flattened out over time causing flood waters to move onto reserve.	Y		Because flood waters build up in drain they flow back to Malinya Rd and floods properties from the roadside as well. We therefore get flooding right thru property. Have asked Council to make drain deeper particularly across reserve but nothing has ever been done. **SEE ATTACHED PHOTOS**
76	Mirreen Ave	Davistown				1	N	N	N		N	1														N														N			N	
77	Malinya Rd	Davistown	8	1			N	Y	Y			1												Over a number of years the foreshore has erroded allowing flooding from water at high tide combined with rain making a worsening problem. Front of foreshore is mostly water logged and during June flooding water came from this direction - 6" thru garage.		N	All times. The channel for boats is close so foreshore & reserve levels are the big problem especially when tides are high. Ferry and boats create a surfe effect over the reserve. House 6-8 steps from ground level so am always "home" dry. Sewer & shower blocked up. Awful inconvenience and mess.	1			1		1			1	1			N				
78	Morton Cres	Davistown	4	1			N	N	N																																			High tide + southerly - water get close to coming over bitumen in Morton Cres. In June 2007 waterborne debris wat blown to top of bitumen opposite our place.
79	Brisbania Public School		11	1			N	N	N		N															N						Paddocks, houses - Yattalunga								N				Culvert on Davistown Rd at Yattalunga has improved problem of access.
80	Kincumber Crs.	Davistown	16		1		N	N	N																	N	Davistown oval floods regularly - only flooding I have seen.		1			Davistown Oval								N		Y		When I lived in Jenkins St - very tidal and quite low - backyards flooded with heavy rain - some were filled and other not.
81	Magnolia Ave	Davistown			1		N	N	N	Y		1												Southern end of Magnolia Ave covered by a couple of centimetres only. This occurred during 1) Heavy rain 2) Strong southerly winds and 3) High tides. Minor flooding subsided as tide dropped		N			1		1							Roadway and drains in Magnolia Ave, Park and Davistown Road	Y		Magnolia Ave as indicatead on map, and other local swamps - completely blocked. Debris such as branches and culverts being overgrown with grass and weeds, plus assorted rubbish	Y		The minor local flooding in Magnolia Ave is caused during 1) Heavy prolonged rain 2) Strong southerly winds and 3) High tides and in my opinion could be alleviated by the cleaning by Council regularly of culverts and the provision of a drainage system of some type.
82	Kincumber Crs.	Davistown	31		1		N	N	N																	N														N			N	

DAVISTOWN	Q1		Q2	Q3			Q4			Q5															Q6			Q7											Q8			Q9		Q10
Survey Ref. No	Street	Suburb	How long - years	Aware	Some knowledge	Not Aware	Inside	Yard	Inconv.	Yes	No	Jun-07	Jan-96	Feb-92	Feb-90	Jan-89	Apr-98	Oct-85	Nov-84	Feb-81	Jan-78	Mar-77	May-74	Comments	Yes	No	Comments	Res	Parks	Comm.	Rds & Paths	Other	Backyard	Garage	Bldg-Above	Bldg-Below	Front yard	Other	Yes	No	Comment	Yes	No	Comments
83	Alkoomie Close	Davistown	16			1	N	N	N		N															N														N				After heavy rain in June this year problems were experienced with the sewerage system in many areas of Davistown. This was the only time I have experienced any inconvenience.
84	Davis Ave	Davistown	10		1		N	N	N																																			
85	Magnolia Ave	Davistown	7	1				Y	Y	Y		1												After approximately 6 hours, the water level was approximately 1200mm deep and stayed for 2 days after the rain stopped.	Y		Levels in yard and some photos	1					1						Y		In our street some driveways don't have drainage pipes under their driveways, also some are too small and block when it rains.	Y		The flooding in our yard is mainly due to the street drains running back through our stormwater pipes, due to the level in the street drains getting too high, because of small pipes or no pipes under driveways.
86	Grevillia Ave	Davistown	3		1				Y	Y		1												Backyard flooded mainly due to poor drainage. Was flooded for probably 1-2 weeks during continuous rain. However have done new drainage and appears to have solved the problem.	Y		Mostly street drains in this area. Water does not get away. If there is a high tide coinciding with heavy rain the water has nowhere to go and builds up in the drains and then on to properties.				1								Y		50% Generally build up of grass and dirt that blocks culverts and drains and never seems to be cleared.	Y		
87	Magnolia Ave	Davistown	3	1				Y	Y	Y		1												The reserve amd walkway at Pine Ave, street floods every time it rains, you can't walk through to Illawong Close and vice versa, it becomes a pond for ducks.	Y				1		1							Pathway and reserve		N		Y		It is a real pain, especially for residents in Illawong Close, they have to take the long route up their street and along Lilli Pilli Street to get to the shop and waterfront.
88	Kincumber Crs.	Davistown	11		1		N	N	N		N															N																		Have not seen any flooding
89	Magnolia Ave	Davistown	17	1			Y	Y	Y	Y					1	1	1							a) Don't remember b) From ground to my waist - my heigth 5' 2", c) 3 to 4 hours, d) 5am approximately.	Y		Phots of yard and house inside after water had dropped 2 to 3 feet.	1			1	Grevilla Ave	1	1	1	1	1	The whole property plus the road in front of the property only - not next doors either side. We were the only house in the street flooded.		N		Y		When we have heavy rain, strong southerly winds and high tides. The wind holds back the water and the water has no where to go but up the gutters etc. No escape until wind dies down, and tides drop.
90	Amy Street	Davistown	8	1			N	Y	Y	Y		1												The house was surrounded by flood water on the June 07 date, with no electricity and a back-up of the sewer line. Previous minor flooding has occurred on many occasions after a couple of days of consistant rain - result, house surrounded by water up to the doors with a small amount of water in the garage. Water takes about 2 days to receed after rain stops.		N	The neighbours on Amy Street have told us flood waters were inside their house about 10 years ago.						1	1			1		Y		Culverts - 80%. Culverts/gutters no kerbed and sealed, so overflow with dirt, gravel and weeds, due to Council neglect.	Y		In my opinion flooding in my area is highlighted by lack of street drainage and maintenance also many houses in the area have their driveways built up to prevent street water from entering their property, thus preventing water flow along the street gutters, which are in a poor state.
91	Dilgara Ave	Davistown	9		1		N	N	N																																			
92	Pine Avenue	Davistown	17	1			N	Y	Y	Y		1	1	1										Flooding is almost entirely contingent on tide levels. The gutters adjacent to the house are already full when tides of approx 1m are experienced hence not much rain is required to result in the road being covered. Water level usually subsides as tide 'goes out'. The 1996 event resulted in higher water levels but it must have been saltwater as it resulted in plants and trees dying.		N	I think there are flood levels marked on the Progress Association Hall.	1	1		1	Waterfront reserve	1					The house was virtually surrounded with water up to 125-150mm deep.		N		Y		As stated earlier I believe that flooding is tide influenced. I was told that in the 96 event the tides were particularly high and that because of high winds the 'run out' was practically impossible and the next incoming tide ran over the top. The fact that a lot of trees in the reserve died and one in our neighbours yard and all our plants along the side of the house also had to be replaced, indicates that it was salt water flooding. As a matter of interest if rain falls during a big high tide water from our downpipes cannot get away because the gutter outlets are under water.
93	Lilli Pilli St	Davistown	11	1				Y		Y													1	May 1997 & May 1974. Unsure of details. Across Lilli Pilli St.		N	In May 1974 flood, water was knee deep along Davistown Rd near oval.	1	1	1	1	Open drains								N				In 1974 it was the whole of Davistown.
94	Illawong Cl	Davistown	14		1		N	N	N																				1			Local Oval												
95	Illoura Reserve	Davistown	15	1				Y	Y	Y		1	1	1										Rear of house block flooded 200mm deep stayed about 1 week. Same water is their after any long rain period especially if a high tide is present.		N													Y		Davis St & Kilbara Ave have no positive flow to waters above so water just site in gutter/ditch on road edge. No pipes, no flow	Y		We have very little fall to waters edge and no gutters - just trench on sides of road. Flooding could be eased and in some cases avoided in some areas if pipes were run from road sides to water front or area was kerb & guttered.
96	Pine Avenue	Davistown	16		1		N	Y	N															Heavy rain on several occasions front yard flooded - no water in house - backyard had a lot of water but not "flooded". Waterfront had a lot of water especially at high/king tides. Road flooded (Davistown Rd)		N					1		1				1		Y					
97	Magnolia Ave	Davistown	22	1				Y		Y			1	1	1	1	1	1						During heavy rain drain under road gets blocked flooding yards near intersection Magnolia & Kincumber. When drain clear - no problems. Water has not entered our home but yard flooded to a height of 10" in 1974 - other years 2" to 4" in front driveway.	Y		1974 flooding caused by heavy rain, high SW winds, tides. Other years we didn't have strong winds before the rain so no flood just blocked drains everywhere.	1	1		1		1	1	1	1	1							Localised flooding often caused by blocked drains - drain outlet below high tide mark - extra high tides. All drains in flat lying areas shouldn't be below high tide mark.
98	Illawong Cl	Davistown	28			1	N	N	N		N															N														N			N	
99	Illawong Cl	Davistown	29	1			N	N	N	Y												1				N			1		1			1			1	In Pine Avenue		N		Y		
100	Illoura Reserve	Davistown	27		1		N	N	N		N																																	
101	Grevillia Ave	Davistown	2	1			N	N	N																																			
102	Davis Ave	Davistown	3		1		N	Y	Y	Y		1												Almost immediately, we couldn't walk to garage, water was over ankle deep. I run a business from home, my clients couldn't walk down drive - had to enter via Dilgara Ave thru garage. Flooding affected sewer in our steet for over a week.		N														N				
103	Illoura Reserve	Davistown	45	1			N	Y	Y	Y													1	Non stop rain for 1 week. King Tides. Howling wind holding the water in. Reached its peak at top tide and slowly subsided.	Y		Flooding stopped 1" under our verandah. The home on our right was completely flooded.	1	1		1		1	1		1	1			N		Y		All of Davistown flooded that night. If any one of the three causes had not occurred, Davistown would not have flooded. To my memory none of dates named in inquiry affected our property. Possible reason - Albert Davis a descendant of the Davis family told me that when they had cattle on this land years ago, in heavy rain cattle would move toward where our house is now because it was a bit higher. Albert Davis also claimed channel used to be **18' deep** - not 8' max as at present.
104	Grevillia Ave	Davistown	25		1		N	Y	Y		N													Yard not completely flooded, just soggy but never up to house.		N														N			N	More flooding on other side of Davistown - near Lintern St than at our place.
105	Davis Ave	Davistown	18		1			Y	N	Y		1												Heavy storm weekend was worse than other heavy rain periods. Took quite a while to dry out - gutters overflowing for days.		N	Davistown is usually water logged after heavy downpours.	1	1		1	Oval	1	1	1		1		Y		Water couldn't flow away in dug out gutters - soaked into ground	Y		
107	Davis Ave	Davistown	9	1			N	N	N																	N		1			1								Y		50% blocked by debris. Most culverts in D'town Rd & Lilli Pilli St.	Y		
108	Pine Avenue	Davistown		1			N	Y	Y	Y		1												Backyard had 10cm of water all over. It stayed flooded for approx 4-5 days. Sewer system no longer functioned. Water was at it's peak on day 2 of the storm event.		N		1	1				1							N				Not much rain needed for "ponding" to occur. Davistown Park floods in no time at all. Roads don't normally flood which is good. Water takes long time to drain from front of property (drainage culvert at front of property).
109	Davis Ave	Davistown	31	1				Y		Y			1			1								(i) 2-3 hours (ii) 100mm above ground level (iii) subsided in approx 2 hrs after rain stop.		N		1					1							N		Y		It is all subject to rain,tides and winds or even a cloud burst. Davistown is a low lying area & one must expect these problems. We do!
110	Grevillia Ave	Davistown	6			1		Y	N	Y														April 2001 Backyard flooded for approx. 2 weeks. House not flooded.		N														N				
111	Davis Ave	Davistown	4	1			N	N	N		N															N														N				

DAVIST OWN	Q1		Q2	Q3			Q4			Q5															Q6			Q7											Q8			Q9		Q10
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112	Pine Avenue	Davistown	23	1			Y	Y	Y	Y		1		1		1	1							With 2m high tides and rain - water runs to rear of property. When rain water meets hightide property floods - garage goes underwater also granny flat damaged & cars in garage.	Y		**Photo's attched**															Y		
113	Davis Ave	Davistown	33		1		N	N	N														1	Combination of hightide & rain, water t my knees in midle of streets. It was a Sat.night by Sunday it had gone down. Some people in Davistown got it thru homes.		N		1	1			Reserve	1	1		1			Y		80% blocked in Grevillia Ave. Wood debris & leaves.	Y		A lot of boats were washed off their moorings and a lot of rubbish floated in Brisbane Water.
114	Pine Avenue	Davistown	2		1		N	Y	Y	Y		1														N			1				1				1	Street drains can't cope with stormwater & run off from block in heavy & prolonged rain.		N				
115	Kincumber Crs.	Davistown	21	1				Y		Y		1		1										Basically 100mm to 150mm of water across block only - didn't enter house. 4 hours after rain it reached levels above noted. Receded within hours.	Y		As previous	1	1		1		1				1			N				
116	Illawong Cl	Davistown	12		1		N	N	Y	Y		1	1											Not sure of details, too long ago.		N		1	1		1		1				1					Y		
117	Davis Ave	Davistown	20	1			N	N	Y	Y		1												No flooding just loss of power and sewer.		N														N			N	
118	Ilumba Ave	Davistown	12		1				Y		N																																	
119	Grevillia Ave	Davistown	4	1				Y				1													Y		Water level mark on fence in bachyard.	1	1				1					Half b'yard under water maybe 100mm of water above grass.		N		Y		Davistown has major problems - no kerb & gutter - open drains hold water for days. Larger rebates for rain water tanks needed.
120	Kincumber Crs.	Davistown		1			N	Y	Y	Y		1												Area flooded repeatedly due to volume of water in short space of time. This time couple of days into storms before flooding and very slow to recede. Level ankle deep in garage/bungalow. Receded after a day or two of less heavy rain.	Y		Road beyond our house - corner of Kincumber Cres & Alkoomie Pl. was flooded - approx. ankle deep - a little deeper in parts.		1		1		1	1						N		Y		Currently trying to upgrade & improve drainage on our block. Not sure how this impacts on overall flooding that goes on around us - getting advice from a plumber on this. We believe problem was caused by inadequate/blocked drains - although there is no public drain at the front of our house - not sure where ours runs off to.
121	Malinya Rd	Davistown	11		1		N	N	N																	N																		
122	Paringa Ave	Davistown	1			1	N	N	N																	N			1		1							Parks in Davistown Rd. Parts of Davistown Rd especially edges.		N			N	
123	Kincumber Crs.	Davistown	4	1			N	Y	N	Y		1												Flooding in verandah area in heavy rain.		N																	N	Flood watr disperses quickly in summer.
124	Davis Ave	Davistown	14	1					N																	N														N				Houses near water channels do get flooded up to various depths when heavy rain coincides with high tides. Some streets become underwater.
125	Davis Ave	Davistown	9		1		N	N	Y	Y		1												2-3 days flooding began around our local area.		N														N				
126	Kincumber Crs.	Davistown		1			Y	Y	Y		N													**Answer to Q4 relates to Magnolia Ave.** During heavy rain yards are consistantly flooded in this area.		N		1	1		1		1				1			N		Y		
126	Davistown Rd	Davistown	10	1			N	Y	Y	Y		1	1											Flooding in yard exacerbated by adjoining development.	Y			1	1		1		1							N		Y		
127	Grevillia Ave	Davistown	7	1				Y	Y	Y		1												Extremely heavy rainfall starting about midday Fri.8th June - by late afternoon front & rear yards under sheet of water - then lost power so hard to see in dark. Sat. morning water was covering half of street as wall.		N							1				1	Up side of house of boundary line.		N				Only a couple of streets in Davistown have kerb & guttering/stormwater drainage, flooding is regular occurrence just in different degrees. Only takes half day of consistent heavy rain for front and back yards to be under thin sheet of water. Lucky not affected house but makes us anxious. Hope someting can be done about drainage.
128	Arrunga Cl	Davistown	26	1			N	N	N														1	In May 1974 the whole of Davistown was flooded up to a height of 1.2m		N	Mainly inundation of roadway during heavy rain with high tides. Tides of 1.9m-2.2m are the worst.																	High tides combined with torrential rain cause the roadway to flood in Alkoomie Crs. and the cnr of Kincumber Rd & Alkoomie Crs. Like wise waterfront reserve behind Romford Cls floods, ditto at end of Magnolia Ave.
129	Alkoomie Close	Davistown	28	1			N	Y	Y	Y		1												May 1977. Flooding only surface water from rain & strong winds & tide. Subsided quickly with tide going down (Lot 11). Have not experienced flooding on Lot 12 except for overland flow from adjacent property.	Y		See flood level indicator marker on corner of Davistown Progress Hall. Davistown Memorial Oval floods routinely in major rainevents but understand it is detention basin.	1	1		1	Central & eastern Davistown	1	1			1	Especially along Davistown Rd opposite oval.		N		Y		Davistown area tends to flood due to poor maintenance of inadequate infrastructure and inappropriate enviro policy constraints.
130	Davis Ave	Davistown	1		1		N	N	Y	Y		1												Sewer flooded - toilets backed up.	Y		Water across Davis Ave. approx 150mm at east end during storms 8th, 9th, 10th June, 2007.		1		1	Park Davistown Rd.								N		Y		Freak storm caused flooding, trees & powerlines down across roads in Davistown area.
131	Pine Avenue	Davistown	8			1	N	Y	N	Y														House not threatened. New development - built to Council height spec.		N														N			N	
132	Paringa Ave	Davistown	28	1			N	N	N		N															N																		
133	Kincumber Crs.	Davistown	20		1			Y	Y	Y		1	1											Land is so flat & low, flood in yard from rain & runoff from neighbours property due to raised land but properties like ours are 30 yrs old on concrete slabs - we look like being "welled in" in the future.	Y		A friend experienced 1974 floods - Greg Denning 0438 690 992	1	1	1	1		1	1	1	1	1		Y		Drain under roadway out front of our house drains to Wetlands but "no flow" due to flat area. Debris & rocks from kids & road grading.	Y		Public reserve is constantly flooding thru the year.
134	Davis Ave	Davistown	33	1			N	Y	Y	Y		1											1	1974 water reached crown of rd due to consistent rain and high tides & wind - water levels dropped when tide receded. 2007 Consistent rain & severe storms caused local flooding.		N		1	1		1		1			1	1		Y		75% Woody debris & grass cuttings once I removed blockage water drained freely.	Y		Flooding has significantly decreased since drains placed around Davistown but poor maintenance has caused blockages. Rear of property drains quickly - deep gutter drain - front stays wet due to poor gutter drain.
135	Mirreen Ave	Davistown	32	1	1		Y	Y	Y	Y														Easter 1975. Knee high until rain stopped & tide went out. Hightide & strong winds.		N	No exact levels, but too highto go in backyard.	1	1	1	1		1	1		1	1		Y		Easement at back does become blocked by rubbish & flood.	Y		Had 10" rain - two feet in garage.
136	Kincumber Crs.	Davistown	9		1		N	Y	Y	Y		1												Flooding occurs generally almost immediately after heavy rain but gets away very quickly.		N					1		1				1		Y		Davistown Rd Yattalunga. Bridge too low.	Y		Isolated - local - gets away very quickly.
137	Paringa Ave	Davistown	20	1				Y	Y															Dec. 4th 2007. About 100mm - 2 days - about 2 hours	Y		Marks on walls of studio.	1	1		1		1	1			1	Studio		N		Y		All we need is good drainage - reported to Council many times.
138	Pine Avenue	Davistown	40		1		N	Y	Y	Y		1		1										Flooding 2007 receded with tide. Caused by strong wind, king tide. The 1974 flood water entered houses built on ground or very low foundations.			Flood waters that come into our property - 6" - 8".Need deeper gutters.																	
139	McCauley St	Davistown	73		1		N	Y	N		N													Had small cyclone - whole place was flooded - homes wverywhere water had gone in - came to side steps.							1		1				1						N	I came here seventy three years to live, we had no flooding. Heavy rain got away quickly. Every household had tanks and no water escaped. Filling of blocks of land has had a lot to do with water backing up - no where to go. Where RSL is built that used to be low lying ground. As soon as tide goes out water leave my property.
140	Elinya	Davistown	15		1				N																	N			1		1	Laneways						Reserves	Y		Natural debris.	Y		Strong winds combined with high tides contribute to excess water on roadways in our area although there has been some improvement since drainage has been carried out.
141	Dilgara Ave	Davistown	11	1			N	Y		Y		1												Southerly winds & high tides + excessive rain water rises & cuts off road.	Y		Have photos (I think)	1	1		1		1				1		Y		80% blocked by woody debris	Y		

DAVISTOWN	Q1		Q2	Q3			Q4			Q5															Q6			Q7											Q8			Q9		Q10
Survey Ref. No	Street	Suburb	How long - years	Aware	Some knowledge	Not Aware	Inside	Yard	Inconv.	Yes	No	Jun-07	Jan-96	Feb-92	Feb-90	Jan-89	Apr-98	Oct-85	Nov-84	Feb-81	Jan-78	Mar-77	May-74	Comments	Yes	No	Comments	Res	Parks	Comm.	Rds & Paths	Other	Backyard	Garage	Bldg-Above	Bldg-Below	Front yard	Other	Yes	No	Comment	Yes	No	Comments
142	Lilli Pilli St	Davistown	10	1				Y	Y	Y		1					1							Footpath in LilliPilli St floods easily, then flows into my rear yard. Resulting "flooding" is not a risk to the house, more an inconvenience. Footpath and yard remain covered with several inches while rain continues and remai swampy for at least a week afterwards. Situation would be improved if shallow gutter alongside LilliPilli was deepened.		N			1		1		1			1		Footpath alongside LilliPilli St.	Y					
143	Kincumber Crs.	Davistown	1	1			Y			Y		1												Torrential rain. Waterfront reserve flooded - came into border of front yard. Right side of block outside house flooded. Water came into right side of garage and beneath deckig which faces waterfront. Road side pedestrian strip over driveway & outside front fence floods. Apparently our property was the watercourse for a pre-existing river - per neighbour.	Y		Approx 30-50 cm Rightside of house, roadside of house - pedestiran strip.	1	1		1		1	1		1	1		Y		Kincumber Cres. - sewer pipe/stormwater opposite approx Kincumber Crs in bush 80% blocked. Debris.	Y		Water collects in kerb & guttering/or pedestrian strips throughout Davistown. Reserve (waterfront) off Kincumber Crs. Floods during heavy rain/storms/king tides - can take a couple of weeks for flooding to subside.
144	Kincumber Dr.		5			1																																						

Photos forwarded by residents

May 1974 – Boatshed at end of Mirreen Avenue

May 1974 – Boatshed at end of Mirreen Avenue

1999 Malinya Road Residence

1999 Malinya Road Residence – face north

Malinya Road Residence

Malinya Road Residence

Location not specified – vicinity of Malinya Road

Location not specified – vicinity of Malinya Road

APPENDIX B

Sensitivity Analysis

Table B.1 Catchment Rainfall Sensitivity

Point	Location	Base Case	20% Decrease		20% Increase	
		Peak Water Level (m AHD)	Peak Water Level (m AHD)	Difference to Base Case (m)	Peak Water Level (m AHD)	Difference to Base Case (m)
1	Malinya Rd (opp. #143)	1.59	1.57	-0.02	1.61	0.02
2	Creek near Malinya Ave	0.77	0.73	-0.04	0.81	0.04
3	Intersection Malinya Rd & Emora Ave	1.07	1.06	-0.01	1.10	0.03
4	Intersection Malinya Rd & Lintern St	1.19	1.19	0.00	1.20	0.00
5	Intersection Emora Ave & Restella Ave	1.05	1.00	-0.05	1.09	0.03
6	Davistown Oval (centre wicket)	1.06	1.03	-0.04	1.09	0.03
7	Davistown Rd (opp. #55)	1.14	1.12	-0.01	1.15	0.01
8	Intersection Davistown Rd & Paringa Ave	1.15	1.14	-0.01	1.17	0.01
9	Intersection Lilli Pilli St & Grevillea Ave	1.21	1.20	0.00	1.22	0.01
10	Magnolia Ave (opp. #9)	0.96	0.93	-0.03	0.98	0.03
11	Kincumber Cres (near #37)	1.09	1.09	-0.01	1.10	0.01

* Location of reference points shown on Figure 6.1.

Table B.2 Catchment Roughness Sensitivity

Point	Location	Base Case	20% Decrease		20% Increase	
		Peak Water Level (m AHD)	Peak Water Level (m AHD)	Difference to Base Case (m)	Peak Water Level (m AHD)	Difference to Base Case (m)
1	Malinya Rd (opp. #143)	1.59	1.59	0.00	1.59	0.00
2	Creek near Malinya Ave	0.77	0.77	0.00	0.77	0.00
3	Intersection Malinya Rd & Emora Ave	1.07	1.07	0.00	1.07	0.00
4	Intersection Malinya Rd & Lintern St	1.19	1.19	0.00	1.19	0.00
5	Intersection Emora Ave & Restella Ave	1.05	1.05	0.00	1.05	0.00
6	Davistown Oval (centre wicket)	1.06	1.06	0.00	1.06	0.00
7	Davistown Rd (opp. #55)	1.14	1.14	0.00	1.14	0.00
8	Intersection Davistown Rd & Paringa Ave	1.15	1.15	0.00	1.15	0.00
9	Intersection Lilli Pilli St & Grevillea Ave	1.21	1.21	0.00	1.21	0.00
10	Magnolia Ave (opp. #9)	0.96	0.95	-0.01	0.96	0.01
11	Kincumber Cres (near #37)	1.09	1.09	0.00	1.10	0.00

* Location of reference points shown on Figure 6.1.

Table B.3 Downstream Boundary Sensitivity

Point	Location		Base Case	20% Decrease		20% Increase	
		Ground Elevation (m AHD)	Peak Water Level (m AHD)	Peak Water Level (m AHD)	Difference to Base Case (m)	Peak Water Level (m AHD)	Difference to Base Case (m)
1	Malinya Rd (opp. #143)	1.33	1.59	1.59	0.00	1.59	0.00
2	Creek near Malinya Ave	-0.88	0.77	0.70	-0.07	0.85	0.08
3	Intersection Malinya Rd & Emora Ave	0.96	1.07	1.07	0.00	1.07	0.00
4	Intersection Malinya Rd & Lintern St	1.19	1.19	1.19	0.00	1.19	0.00
5	Intersection Emora Ave & Restella Ave	0.93	1.05	1.05	0.00	1.06	0.01
6	Davistown Oval (centre wicket)	1.02	1.06	1.06	0.00	1.07	0.01
7	Davistown Rd (opp. #55)	1.08	1.14	1.14	0.00	1.14	0.00
8	Intersection Davistown Rd & Paringa Ave	1.13	1.15	1.15	0.00	1.15	0.00
9	Intersection Lilli Pilli St & Grevillea Ave	1.19	1.21	1.21	0.00	1.21	0.00
10	Magnolia Ave (opp. #9)	0.81	0.96	0.96	0.00	0.96	0.00
11	Kincumber Cres (near #37)	1.05	1.09	1.09	0.00	1.09	0.00

* Location of reference points shown on Figure 6.1.

Table B.4 Pipe Blockage Sensitivity (20% AEP)

Point	Location	Base Case	All Pipes Blocked		Selected Pipes Blocked	
		Peak Water Level (m AHD)	Peak Water Level (m AHD)	Difference to Base Case (m)	Peak Water Level (m AHD)	Difference to Base Case (m)
1	Malinya Rd (opp. #143)	1.53	1.58	0.04	1.54	0.01
2	Creek near Malinya Ave	0.68	0.76	0.07	0.76	0.08
3	Intersection Malinya Rd & Emora Ave	1.04	1.06	0.02	1.06	0.01
4	Intersection Malinya Rd & Lintern St	1.19	1.20	0.01	1.20	0.01
5	Intersection Emora Ave & Restella Ave	0.94	1.02	0.07	0.94	0.00
6	Davistown Oval (centre wicket)	1.03	1.03	0.00	1.03	0.00
7	Davistown Rd (opp. #55)	1.09	1.12	0.03	1.09	0.00
8	Intersection Davistown Rd & Paringa Ave	1.14	1.14	0.01	1.15	0.01
9	Intersection Lilli Pilli St & Grevillea Ave	1.19	1.20	0.01	1.20	0.01
10	Magnolia Ave (opp. #9)	0.90	0.90	0.00	0.90	0.00
11	Kincumber Cres (near #37)	1.07	1.07	0.00	1.07	0.00

* Location of reference points shown on Figure 6.1.

APPENDIX C

Climate Change

Table C.1 Climate Change Assessment – Increased Rainfall (1% AEP 2h)

Point	Location	Base Case	10% Increased Rainfall		20% Increased Rainfall		30% Increased Rainfall	
		Peak Water Level (mAHD)	Peak Water Level (mAHD)	Diff. to Base Case (m)	Peak Water Level (mAHD)	Diff. to Base Case (m)	Peak Water Level (mAHD)	Diff. to Base Case (m)
1	Malinya Rd (opp. #143)	1.59	1.60	0.01	1.61	0.02	1.61	0.02
2	Creek near Malinya Ave	0.77	0.79	0.02	0.81	0.04	0.83	0.06
3	Intersection Malinya Rd & Emora Ave	1.07	1.08	0.01	1.10	0.03	1.12	0.05
4	Intersection Malinya Rd & Lintern St	1.19	1.19	0.00	1.20	0.00	1.20	0.00
5	Intersection Emora Ave & Restella Ave	1.05	1.07	0.02	1.09	0.03	1.10	0.05
6	Davistown Oval (centre wicket)	1.06	1.08	0.02	1.09	0.03	1.11	0.05
7	Davistown Rd (opp. #55)	1.14	1.14	0.00	1.15	0.01	1.15	0.01
8	Intersection Davistown Rd & Paringa Ave	1.15	1.16	0.01	1.17	0.01	1.17	0.02
9	Intersection Lilli Pilli St & Grevillea Ave	1.21	1.21	0.00	1.22	0.01	1.23	0.02
10	Magnolia Ave (opp. #9)	0.96	0.97	0.01	0.98	0.03	1.00	0.04
11	Kincumber Cres (near #37)	1.09	1.10	0.01	1.10	0.01	1.11	0.01

* Location of reference points shown on Figure 6.1.

Table C.2 Climate Change Assessment – 0.2m Raised Estuary Level

Point	Location	1% AEP 2h (Base Case)	1% AEP 2h Storm and 0.2m Raised Estuary Level		1% AEP 2h Storm with additional 30% rainfall & 0.2m Raised Estuary Level	
		Peak Water Level (mAHD)	Peak Water Level (mAHD)	Difference to Base (m)	Peak Water Level (mAHD)	Difference to Base (m)
1	Malinya Rd (opp. #143)	1.59	1.59	0.00	1.61	0.02
2	Creek near Malinya Ave	0.77	0.89	0.12	0.93	0.16
3	Intersection Malinya Rd & Emora Ave	1.07	1.08	0.01	1.13	0.06
4	Intersection Malinya Rd & Lintern St	1.19	1.20	0.00	1.20	0.00
5	Intersection Emora Ave & Restella Ave	1.05	1.07	0.01	1.11	0.05
6	Davistown Oval (centre wicket)	1.06	1.07	0.01	1.12	0.05
7	Davistown Rd (opp. #55)	1.14	1.14	0.00	1.15	0.01
8	Intersection Davistown Rd & Paringa Ave	1.15	1.15	0.00	1.18	0.03
9	Intersection Lilli Pilli St & Grevillea Ave	1.21	1.21	0.00	1.24	0.03
10	Magnolia Ave (opp. #9)	0.96	0.96	0.00	1.00	0.04
11	Kincumber Cres (near #37)	1.09	1.09	0.00	1.11	0.02

* Location of reference points shown on Figure 6.1.

Table C.3 Climate Change Assessment – 0.91m Raised Estuary Level

Point	Location	1% AEP 2h (Base Case)	1% AEP 2h Storm and 0.91m Raised Estuary Level		1% AEP 2h Storm with additional 30% rainfall & 0.91m Raised Estuary Level	
		Peak Water Level (mAHD)	Peak Water Level (mAHD)	Difference to Base (m)	Peak Water Level (mAHD)	Difference to Base (m)
1	Malinya Rd (opp. #143)	1.59	1.62	0.03	1.64	0.05
2	Creek near Malinya Ave	0.77	1.56	0.79	1.57	0.79
3	Intersection Malinya Rd & Emora Ave	1.07	1.56	0.49	1.57	0.50
4	Intersection Malinya Rd & Lintern St	1.19	1.56	0.36	1.56	0.37
5	Intersection Emora Ave & Restella Ave	1.05	1.57	0.51	1.57	0.52
6	Davistown Oval (centre wicket)	1.06	1.56	0.50	1.57	0.51
7	Davistown Rd (opp. #55)	1.14	1.57	0.43	1.57	0.44
8	Intersection Davistown Rd & Paringa Ave	1.15	1.56	0.40	1.56	0.41
9	Intersection Lilli Pilli St & Grevillea	1.21	1.56	0.35	1.57	0.36
10	Magnolia Ave (opp. #9)	0.96	1.55	0.60	1.55	0.60
11	Kincumber Cres (near #37)	1.09	1.55	0.46	1.55	0.46

* Location of reference points shown on Figure 6.1.

APPENDIX D

FMA Prioritisation Ranking

Prioritisation of catchment areas regarding the undertaking of Flooding and Drainage Works
Flood Mitigation Works

Davistown Catchment

Categories		Attributes		
1. Hazard level in area Place tick in appropriate boxes (applies to worst recorded event)	a	Area is a high hazard floodway, (defined by the Floodplain Management Manual)	1	-
	b	Little warning time, (less than 2 days)	1	1
	c	Rapid water level rise, (more than 0.1m per hour)	1	1
	d	Typical depth above floor greater than 0.1m	1	1
	e	Typical depth above floor greater than 0.5m	1	-
2. Social Impact Place tick in appropriate boxes (Existing or anticipated problems)	a	Business area closes down affecting long term viability	1	-
	b	Community infrastructure affected (Hospitals, Schools etc.)	1	-
	c	Community isolated in major floods	1	1
	d	Essential infrastructure at risk of failure (electricity, water, sewerage etc.)	1	-
	e	Long term isolation / long duration flooding in the town area (greater than 1 day)	1	-
3. Scale of problem - No. of dwellings affected Place tick in one box for highest no. dwellings affected by above floor flooding (applies to worst recorded event)	a	1 - 4 dwellings affected	1	-
	b	5 - 9 dwellings affected	2	-
	c	10 - 14 dwellings affected	3	-
	d	15 - 19 dwellings affected	4	-
	e	Greater than 20 dwellings affected	5	5
4. Scale of problem - % of dwellings flooded Place tick in one box for highest % dwellings affected by overfloor flooding. (applies to worst recorded event)	a	Reports/records show 9% or more dwellings affected	5	5
	b	Reports/records show 6 - 9% or more dwellings affected	4	-
	c	Reports/records show 4 -6% or more dwellings affected	3	-
	d	Reports/records show 2 - 4% or more dwellings affected	2	-
	e	Reports/records show 0 -2% or more dwellings affected	1	-
5. Scale of Problem - Frequency of over floor flooding Place tick in one box for highest no. incidences of over floor flooding (all recorded events)	a	Reports/records show at least 1 incidence of flooding	1	-
	b	Reports/records show at least 2 incidences of flooding	2	-
	c	Reports/records show at least 3 incidences of flooding	3	-
	d	Reports/records show at least 4 incidences of flooding	4	-
	e	Reports/records show 5 or more incidences of flooding	5	5
6. Evacuation Placed tick in appropriate boxes (applies to worst recorded event)	a	Evacuation to centres outside the community required (adajcent suburbs etc.)	1	-
	b	Urgent evacuation due to quickly rising water levels and associated danger to personal safety	1	1
	c	Evacuation leaving no time for damage reduction	1	1
	d	Evacuation from entire area required (localised group of suburbs)	1	-
	e	External evacuation assistance required due to lack of overlanf evacuation route (SES etc.)	1	-
		DECC / DIPNR Sub-Total		21
7. Damage Place tick in appropriate boxes (applies to worst recorded event)	a	Structural damage mainly to houses (house undermining, extensive structural damage etc.)	1	-
	b	Non-structural damage mainly to houses (hose out house, replace carpetcs etc.)	1	1
	c	Flooding of yards, sheds, garages, pools, and or downstairs areas	1	1
	d	Minor property damages	1	1
8. Environmental Damage Place tick in appropriate boxes (Existing or anticipated problems)	a	Potential damage to designated environmentally sensitive areas (SEPP Wetlands etc.)	1	-
	b	Major erosion and siltation problems causing an increase in flood levels and /or loss of waterway area	1	1
	c	Loss of Riparian Vegetation and Fauna Habitat associated with erosion of banks or bed of creek	1	-

9. Maintenance Issues	a	Tendency to require regular maintenance (blocked pits/pipes, vegetation in open drains)	1	**1**
Place tick in appropriate boxes (Existing or anticipated problems)	b	Old pipelines in area (Possibility of cracking, mis-alignment, or requiring replacement)	1	**1**

10. Development	a	Detailed investigation complete	1	**n/a**
Place tick in appropriate boxes	b	Design Complete	1	**n/a**
	c	Approval Complete (owner, DLWC, Fisheries, DA, etc.)	1	**n/a**
	d	Environmental assessment complete	1	**n/a**
	e	Management plan complete	1	**n/a**
	f	Community involvement in project	1	**n/a**
		GCC Sub-Total		**n/a**
		TOTAL		**n/a**

APPENDIX E

Submissions from the Draft Report Public Exhibition

DAVISTOWN PROGRESS ASSOCIATION INC.

"Caring for Davistown"

[redacted]
DAVISTOWN
NSW 2251

2nd November, 2009

The Project Manager, Davistown Study
Cardno Lawson Treloar
Level 3, 910 Pacific Highway
Gordon NSW 2072
andrew.reid@cardno.com.au

Dear Sir

Re: Submission – Draft Davistown Catchment Flood Study

The Association has been seeking drainage system improvements over many years and has been told that, until a comprehensive flooding and drainage study is carried out, Council will not commit funds for infrastructure or major maintenance in the area. We hope that this draft Study will provide adequate information to allow planning and funding of such works.

While we are generally in agreement with the overall risk findings of the study, it does seem that the draft Report has not provided a great deal of actual data to work with. Also, with the lack of anticipated high intensity flood events, there seems to have been low priority given to the impacts of 'nuisance' flooding on the suburb's residential properties.

Matters of concern to us include:

Community Questionnaire
The method used for the delivery of questionnaires has been abandoned by the Association as it does not get adequate, targeted penetration. We hand deliver materials using volunteers at controlled delivery times for best effect.

Rainfall
While the topography of Davistown may not lend itself to rapid flooding, the rainfall data used is not representative of reality. There are significant variations in rainfall events and volumes between the western portion of Davistown and the eastern parts of the suburb. The separator tends to be Davistown Rd, and rainfall in the upper sections of the catchment is different again.

It is well documented that there are wide variations in rainfall intensity from place to place in the Gosford LGA in terms of both frequency and volume.

Pit and Pipe Field Survey
Davistown residents, over an extended period of time, have expressed dissatisfaction with the suburb's drainage infrastructure. They have also been highly critical of what they see as poor drainage system maintenance on the potential for nuisance flooding in many areas. In fact, the Association questions whether there is an effective drain design or maintenance program at all, with most works being of an ad hoc nature in response to complaints.

In short, we feel that there has been, and is, a lack of an adequately funded and maintained drainage system for the suburb. This maintenance aspect does not seem to have been given adequate attention or coverage in this report.

Soil Type and Rainfall Loss Rates
While we are not familiar with specific details of the various soil types mentioned in the Report, the Association's members are familiar with its mobility (Council's maintenance staff are well aware of the associated road pavement problems), and its tendency to compress and reduce permeability.

The reduced permeability adversely impacts on water remaining on the ground after tidal or rainfall events and this can be demonstrated by the time that water 'ponds' and stays on Davistown Memorial Oval, an area we understand is a temporary flood detention basin.

Boundary Conditions
We do not understand the intent of this sub-section of the Report but it does seem to contain numerous 'escape' clauses.

Also, it seems quite illogical to us to consider separately flood behaviour resulting from runoff and that of elevated water levels in the estuary as they are always observed to compound each other to a greater or lesser extent depending on a range of factors, especially in times of spring tides and storm or strong winds from the southerly sector.

Assessment and management of the combined effects of sea level rise, elevated water levels in the estuary as a result of storm and rainfall events (recorded and anticipated) on residences and local transport infrastructure does not seem to have been looked at.

CONCLUSION
In paragraph three (3), reference is made to the identification of open space areas and vegetated-marsh (wetland) areas as flood storage locations. This feature is not clearly understood by many of the residents of Davistown or, in fact, many of Council's staff. Most Association members and residents do not understand why Council has not taken steps to improve drainage of the Oval.

Yours faithfully

[redacted]

President
Davistown Progress Association Inc.

c.c. Erensa Shrestha, Flooding and Drainage Planning Engineer, G.C.C.
Vic Tysoe, Gosford City Council

Response to submission from Davistown Progress Association (dated 2/11/2009)

Comment: The draft report has not provided a great deal of actual data to work with.
The purpose of the flood study is to define the nature and extent of flooding as detailed in the results of the flood modelling. This information can then be used in the next stage of the Floodplain Management Process, namely the Floodplain Risk Management Study, which will identify and assess options for management of flooding.

Comment: Low priority given to the impacts of 'nuisance' flooding on residential properties.
The key outcome of the flood study is to define the flooding impact in the catchment from frequent storms to large storms that may result in significant damage to property and potentially having a risk to public safety. The priority for addressing nuisance flooding issues in conjunction with larger events may be reviewed as part of the future Floodplain Risk Management Study.

Responses from the community questionnaire included comments regarding water ponding on properties for days. This response will be added to the community questionnaire response section of the Report.

Comment: Community questionnaire delivery method does not yield adequate penetration.
The questionnaire was hand delivered to all properties within the Davistown catchment study area. A response rate of 10% of issued questionnaires resulted with a reasonable distribution of properties across the catchment. From our experience this is a relatively good return rate for flood consultation.

Comment: The rainfall data used is not representative of reality as significant variations in rainfall events occur across Davistown.
Calibration of the model for the June 2007 event requires rainfall records of frequent time intervals. The nearest available rainfall records are at Kincumber (about 2.8km from Davistown Oval at an elevation of about 20m AHD). The rainfall depths were adjusted to be more representative of Davistown based on local records (from Mr. Evans). This is detailed in Section 5.5 'Model Calibration' in the Report.

The design Annual Exceedance Probability (AEP) storm events modelled are based on uniform areal distribution due to the relatively small area of the catchment. Design rainfall depths and temporal patterns for the modelling were developed using standard techniques provided in Australian Rainfall and Runoff (1998). This resource was developed for Australia-wide usage and detailed information for variations within small catchments is not available.

Comment: Poor drainage maintenance has potential for nuisance flooding.
The blockage sensitivity analysis assessed the impact of blockage to the drainage pipes for the 20% AEP event. Peak water levels increased in some areas by up to 0.1m but was only a couple of cms in other areas. For the larger, less-frequent events, say 1% AEP, the surface flow is well in excess of the pipe capacity. Responses from the questionnaire also advised of blockage / maintenance issues which is recorded in the report. The Flood Study process enables Council to quantify the flooding impact to areas within the catchment and subsequently utilised in determination of flood mitigation responses. The impact on flooding of maintenance may be further assessed as part of the future Floodplain Risk Management Study and Plan to examine potential management options to mitigate flood impacts.

Comment: Soils within Davistown are noted for their tendency to compress and reduced permeability, thus resulting in water remaining on the ground after tidal and rainfall events.
The effect of the soils permeability is accounted for in the model as losses applied to the rainfall. Comparatively to other areas, the losses applied to the Davistown model are relatively low which is representative of the low permeability and waterlogging of the soils. The primary outcome of the Flood Study is to evaluate the peak water levels occurring during the storm event not to examine the residual ponding areas.

Comment: It seems illogical to consider separately flood behaviour resulting from runoff and that of elevated water levels in the estuary.
The impact of elevated water levels in the estuary was examined in the "Brisbane Water Foreshore Flood Study" undertaken by Cardno Lawson Treloar for Council (May 2009). Similar to other local catchment studies, Council has decided to prepare separate studies, such as the Davistown Catchment Flood Study, to define local catchment flooding and use the Brisbane Water Foreshore study to define estuary flooding.

Comment: Assessment and management of the combined effects of sea level rise, elevated water levels in the estuary as a result of storm and rainfall events (recorded and anticipated) does not seem to have been looked at.
Modelling for the impact of climate change on flooding in the catchment has been undertaken for several scenarios as listed in the report. These scenarios include increases in the estuary level and increases to rainfall intensity. Note that the Brisbane Water Foreshore Flood Study assesses the impact of flooding in Davistown from elevated estuary levels resulting from storm events. The next stage of the floodplain management process is the Floodplain Risk Management Study and Plan which will investigate management of climate change impacts.

Comment: Reference to open space areas and vegetated-marsh (wetland) areas as flood storage locations not understood by most.
Areas are determined as "flood storage" based on the hydraulic characteristics of the flow (ie velocity and depth) for the hydraulic categorisation process. This terminology refers to areas that are important in the temporary storage of the floodwater during the passage of the flood. These areas, now listed in the Report, include the lowlands / open-space vegetated areas such as adjacent to Kincumber Crescent and Pine Avenue; north of Davistown RSL; Davistown Oval; and the channel between Davistown Road – Malinya Road – Morton Crescent. Education may thus be considered for the future Floodplain Risk Management Study and Plan.

Comment: Why has Council not taken steps to improve the drainage of the Oval?
Alterations to the drainage of Davistown Oval may be reviewed as part of the future Floodplain Risk Management Study and Plan.

[redacted]
DAVISTOWN
NSW 2251

2nd November, 2009

The Project Manager, Davistown Study
Cardno Lawson Treloar
Level 3, 910 Pacific Highway
Gordon NSW 2072
andrew.reid@cardno.com.au

Dear Sir

Re: Submission – Draft Davistown Catchment Flood Study

As the Davistown Progress Association Inc. representative, and a temporary member of Council's Floodplain Risk Management Committee, I have been able to participate to a limited extent in the preparation process of this draft Davistown Catchment Flood Study. My wife and I offer a number of comments as private residents, as below.

While we are generally in agreement with the overall risk findings of the study, it does seem that the draft Report concentrates more on the technical aspects such as Flood Modelling, Design Flood Estimation and Sensitivity Analysis rather than actual data. Also, it seems that low priority has been given to the impacts of 'nuisance' flooding of properties.

Matters of concern to us in the draft Report, shown under the relevant headings, include:

Community Questionnaire
The method of delivery of questionnaires has been abandoned by our local Progress Association as it does not get adequate, targeted penetration.

Rainfall
While the topography of Davistown may not lend itself to rapid flooding, the rainfall data used is not representative of reality. There are significant variations between rainfall events and volumes between the western portion of Davistown and the eastern parts of the suburb. The separator tends to be Davistown Rd and rainfall in the upper sections of the catchment is different again.

Pit and Pipe Field Survey
While action may have been taken for the Study to ascertain the physical detail of installed drainage infrastructure, we question whether or not adequate note has been taken of the impact of poor drainage system maintenance on the potential for nuisance flooding in many areas. In fact, we question whether there is an effective drain design at all with most works being of an ad hoc nature in response to complaints.

In short, we feel that there is a lack of an adequately funded and maintained drainage system for the suburb.

Soil Type and Rainfall Loss Rates
While we are not familiar with specific details of the various soil types mentioned as having been identified for the Davistown catchment, we are familiar with its mobility (Council's maintenance staff are well aware of the associated road pavement problems) and its tendency to compress and reduce permeability. The reduced permeability adversely impacts on water remaining on the ground after tidal or rainfall events in our immediate vicinity.

Boundary Conditions
The actual meaning of the section on Boundary Conditions is quite difficult to follow and certain comments, such as the last sentence in paragraph two, are not definitive.

Further, it seems quite illogical to us to consider separately flood behaviour resulting from runoff and that of elevated water levels in the estuary as they are always observed by us to compound each other to a greater or lesser extent depending on a range of factors.

Assessment and management of combined effects of sea level rise, elevated water levels in the estuary as a result of storm events and rainfall events (recorded and anticipated) on residences and local transport infrastructure does not seem to have been addressed

It may be of interest to note that we are able to confirm from personal observations that there has been a lift in the water table (sea level rise?) that has already taken place over the last 30 years in our immediate vicinity on the track immediately outside our property.

CONCLUSION
In paragraph three (3), reference is made to the identification of open space areas and vegetated-marsh (wetland) areas as flood storage locations.

The importance of this feature is not clearly understood by many of the residents of Davistown or, in fact, many of Council's staff. We feel that it needs to be more vigorously emphasised in the Report and generally publicised.

Yours faithfully

[redacted]

[redacted]

c.c. Erensa Shrestha, Flooding and Drainage Planning Engineer, G.C.C.

Response to submission from resident (dated 2/11/2009)

Comment:
Generally, the comments raised are discussed in the response to the Davistown Progress Association.

Comment: Boundary Conditions section – last sentence in paragraph two not definitive.
This sentence has been revised for clarity.

DAVISTOWN
NSW 2251

9th October, 2009

The Project Manager, Davistown Study
Cardno Lawson Treloar
Level 3, 910 Pacific Highway
Gordon NSW 2072

Dear Sir

Re: The Flood Study of Davistown

I have lived in Davistown for many years, so I have seen Davistown waterlogged many times after weeks of heavy rain.

Properties that have kerb and guttering, or deep gutters that drain into Brisbane Water don't seem to have water lying around like other properties have. About three quarters of gutters in Davistown are so badly dug out that the water cannot get away and in some streets there are no gutters at all. Also, properties that have had their land filled and raised up next to ones that don't cause a lot of runoff.

Because Davistown is low lying, in my opinion, I don't think one can stop nuisance flooding after weeks of rain but I think it could be improved with better drainage and, in some streets, spoon drains.

King tides are another problem when strong winds keep blowing the tides back up (it was like this yesterday with only a 1.70 metre tide but very strong winds). We are lucky we have a tidal river so when the wind drops so does the water.

I have been living at the above address for the last 23 years and I have : had water come into my yard through king tides. It came into the garage and laundry but not the house; this has happened 3 times. I also do not believe climate change has anything to do with the weather. The climate will always have changes; it is part of nature.

Yours Sincerely

Response to submission from resident (dated 9/10/2009)

Comment: Problem of nuisance flooding could be improved with better drainage

The key outcome of the flood study is to define the flooding impact in the catchment from frequent storms to large storms that may result in significant damage to property and potentially having a risk to public safety. The priority for addressing nuisance flooding issues in conjunction with larger events may be reviewed as part of the future Floodplain Risk Management Study.

Comment: King tides are another problem.

The impact of elevated water levels in the estuary was examined in the "Brisbane Water Foreshore Flood Study" undertaken by Cardno Lawson Treloar for Council (May 2009). Similar to other local catchment studies, Council has decided to prepare separate studies, such as the Davistown Catchment Flood Study, to define local catchment flooding and use the Brisbane Water Foreshore study to define estuary flooding.