EARTH TECH

North East Catchment Management Authority and the Rural City of Wangaratta

King River Tributaries Flood Mapping Study

Final Report

December 2004

Cover photograph: Black Range Creek following October 1993 flood. Aerial photograph taken looking north east across floodplain at Pettifers Road (also referred to as Edi Carboor Road).

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1. Introduction

This report documents the results of flooding investigations undertaken leading to the preparation of flood mapping for selected King River tributary streams.

The flood mapping project was commissioned by the North East Catchment Management Authority (CMA) and forms part of the CMA's implementation of its 1999 Regional Floodplain Management Strategy.

The study was funded by the Natural Disaster Risk Management Studies program, with matching funding provided by the Victorian State Government, North East CMA and the Rural City of Wangaratta.

The flood mapping of the King River tributaries follows the recent review of King River flood mapping (Water Technology, 2004). Tributaries selected for mapping as part of this project were:

- Hurdle Creek
- Boggy Creek
- Meadow Creek
- Black Range Creek

Flood mapping provides authorities with valuable information to make informed assessments in relation to the management of flood prone land and in particular land use planning decisions.

The following tasks were undertaken as part of this project:

- Review of available flood data information and historical flood events;
- Flood mapping of the subject tributaries based on the methodology described in Section 3 of this report. Mapping includes delineation of the following extents:
    - 100 year average recurrence interval (ARI) coinciding with the extent of the land subject to inundation (LSI).
    - Floodway.
- Documentation of the flood status of dwellings located within the study area.
- Overview of issues associated with floodplain obstructions located within the study area.

2. Hydrologic and Hydraulic Flood Data

2.1 Study Area Overview

The King River is a tributary of the Ovens River. It has a catchment area of 1,460 km^2 at its discharge point into the Ovens River located at Wangaratta.

The tributaries of the King River subject to flood mapping undertaken for this study are all located between Oxley and Whitfield as follows:

- **Hurdle Creek** discharges into the King River 4km south of Oxley. The creek has a catchment area of 192 km^2 located on the east side of the King River as shown on Figure 2.1. The highest point in the catchment is at 1045 m AHD, located 10km south of Carboor Upper.
- **Boggy Creek** discharges into the King River just over 1 km south of the Docker Carboor Road. The creek has a catchment area of 183 km^2 located on the west side of the King River as shown on Figure 2.1. The highest point in the catchment is at 890 m AHD, located 12 km south west of Cheshunt.
- **Meadow Creek** discharges into the King River 16 km south of the Docker Carboor Road. The creek has a catchment area of 69 km^2 located on the east side of the King River as shown on Figure 2.1. The highest point in the catchment is at 540 m AHD, located 10 km east of Moyhu.
- **Black Range Creek** discharges into the King River at Edi immediately upstream of the Edi bridge. The creek has a catchment area of 95 km^2 located on the east side of the King River as shown on Figure 2.1. The highest point in the catchment is at 1,180 m AHD, located 12 km east of Whitfield.

2.2 Hydrologic Data

Recorded streamflow data for the study area tributaries consists of the following:

- Hurdle Creek. Recorder located at Bobinawarrah since 1966. Catchment area at gauge is 158km^2.
- Boggy Creek. Recorder located at Angleside since 1967. Catchment area at gauge is 108 km^2.
- Black Range Creek. Recorder located Edi Upper between 1969 and 1982. Catchment area at gauge is 55 km^2.

Flood frequency analysis was carried out on the available Hurdle Creek and Boggy Creek streamflow data. The resulting design flood flows are given in Table 2.1. The Black Range Creek records were of insufficient length to warrant flood frequency analysis. No streamflow data exists for Meadow Creek.

The equivalent ARI of the six highest ranked flood events are given in Tables 2.2 and 2.3 for Hurdle Creek and Boggy Creek respectively.

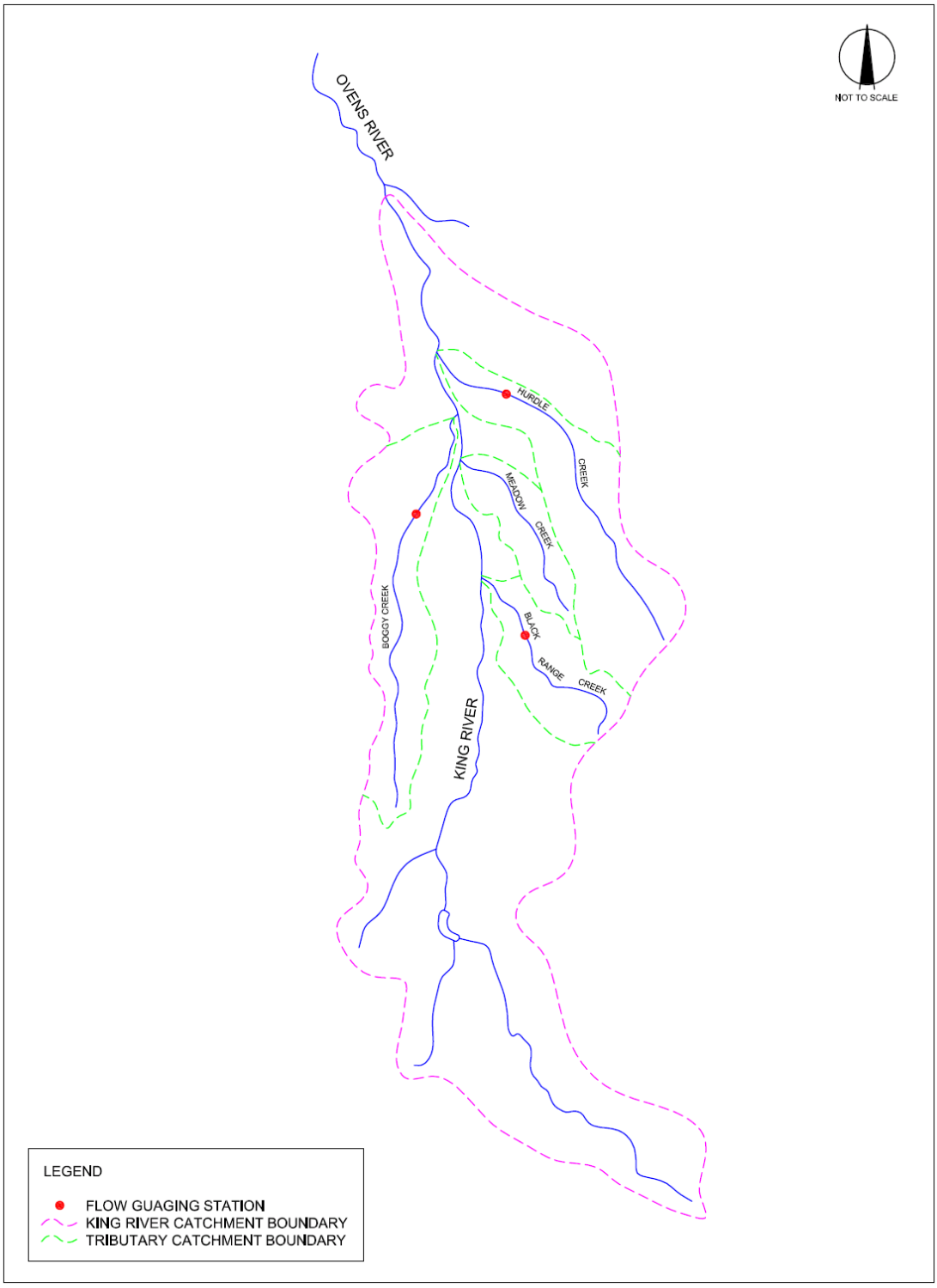

Figure 2.1 Catchment Plan

Table 2.1 Flood Frequency Analysis – Hurdle Creek and Boggy Creek

ARI (years)	Design Flow (ML/day)	
	Hurdle Creek (Ac=158km^2)	Boggy Creek (Ac=108km^2)
2	2,300	1,900
5	5,000	4,200
10	7,100	5,900
20	8,900	7,400
50	11,300	9,200
100	12,900	10,400

Note: 1. Design flows are at the streamflow gauge locations.

Table 2.2 Hurdle Creek at Bobinawarrah – Recorded Floods (1967-2003)

Rank	Event	Peak Stage (m) *	Peak Flow (ML/day)	Approx. Equivalent ARI (years)
1	October 1993	3.54	12,800	100
2	May 1974	3.44	11,800	60
3	October 1973	3.05	5,400	5 to 6
4	September 1975	3.03	5,200	5 to 6
5	September 1998	2.83	4,900	4 to 5
6	July 1981	2.99	4,800	4 to 5

Note: * Hurdle Creek streamflow gauge was moved 30 metres downstream in May 1984. Stage heights either side of this date do not relate to the same datum.

Table 2.3 Boggy Creek at Angleside – Recorded Floods (1968-2003)

Rank	Event	Peak Stage (m)	Peak Flow (ML/day)	Approx. Equivalent ARI (years)
1	October 1993	5.86	15,600	>100
2	May 1974	3.22	7,800	25
3	July 1981	2.27	5,000	6 to 7
4	September 1998	2.05	4,900	6 to 7
5	June 1968	-	4,800	6 to 7
6	July 1995	1.92	4,200	5

2.3 October 1993 Event

The October 1993 flood event is the largest Ovens River flood recorded at Wangaratta since at least the 1870 flood event. Rainfall during the 1993 event was greatest across the centre of the King River catchment extending eastwards into the adjoining Ovens River catchment.

Consequently gauged 1993 flows in the King River tributaries, which are the subject of this study, were the highest on record (refer Tables 2.2 and 2.3). The 1995 HydroTechnology report includes the following comments on the 1993 flood event:

The flows from the upper catchment (e.g. at lake William Hovell) were well below those in the 1974 event because the storm centre was located further down the catchment. Peak discharges in the mid catchment region were not as dependent on the peaks from upstream, but relied on local runoff from the steep incised hills and tributaries within the middle reaches of the King River. The small gauged tributaries were carrying well in excess of their record flows in this part of the catchment and extensive stream damage occurred.

The gauge in Black Range Creek was washed away, and the flow in this small capacity stream was well in excess of its previous record flow. For this stream and other small tributaries nearby, evidence suggests that floods were probably in excess of ARI 100 years. The character of Black Range Creek was changed from a narrow, confined stream to a much wider and shallower stream.

An adjacent valley draining Boggy Creek, one of the most severely damaged tributaries, contributed a significant flow downstream of Docker Road. Hurdle Creek on the opposite side of the King valley, where bad damage also occurred, contributed more inflow. An estimated combined flow of 30,000 ML/d is estimated to have contributed to the King River by these tributaries, subject to the degree of coincidence of their flood peaks.

The equivalent frequency of the October 1993 flood for Hurdle Creek is 100 years ARI (refer Table 2.2) based on the flood frequency derived design flows given in Table 2.1. The flood frequency analysis results indicate that the 1993 event in Boggy Creek was extreme with an estimated equivalent recurrence interval as high as 10,000 years ARI.

2.4 Recorded Flood Height Data

Recorded flood height data for the King River tributaries was obtained by the North East CMA following the September 1998 flood event. These heights were subsequently levelled to AHD and documented (SMEC and LICS).

A summary of flood height data derived from the survey undertaken in 1998/99 is as follows:

- Hurdle Creek - total of 33 recorded marks for the 1993 event.
- Boggy Creek - total of 15 recorded marks for the 1993 event and 11 recorded marks for the 1998 event.
- Meadow Creek - total of 6 recorded marks for the 1993 event.
- Black Range Creek - total of 5 recorded marks for the 1993 event.

2.5 Survey Data

The following topographic data was available for use during the study:

- 1:25,000 state topographic map series (including 10 metre contours).
- Digital orthophotography covering almost the entire study area (Agriculture Victoria, 2001).
- 2 metre contour digital elevation model (DEM) of the entire study area (Agriculture Victoria, 2001).

3. Flood Mapping Methodology

The mapping approach was developed in consultation with the North East CMA. Detailed survey and subsequent hydraulic modelling of the study area floodplains was not possible given the confines of the study budget. The following approach was adopted:

- Distribution of a landholder questionnaire to identify possible recorded flood height marks in addition to those previously obtained.
- Follow up field assessment of potential flood height marks derived from questionnaire responses.
- Field inspections of the study area floodplains.
- Mapping of the estimated 100 year ARI flood extent based on a consideration of the:
    - Delineation of flood extent at each available 1993 flood height mark based on the 2 metre DEM.
    - Delineation between the above identified extents based on a consideration of the field survey observations, landholder conveyed observations, creek bed longitudinal grades derived from the 2 metre DEM and interpolation of flood heights between the recorded 1993 flood height marks.

The delineation of floodway extents was generally based on the following considerations:

- Active or passive flood conveyance nature of the area under consideration.
- Broadness of the floodplain reach (i.e. narrow confined reaches assigned as wholly floodway).
- A depth of 100 year ARI flooding of 0.5 metre or more.

The accuracy of the two metre DEM used to assist in the delineation of flood extents would appear to vary significantly within the study area. On balance, the DEM would appear to generally assign ground elevations that are significantly lower than the actual ground elevations. This was taken into account during the mapping process to avoid overly conservative (broad) defined flood extents.

4. Hurdle Creek

4.1 Hurdle Creek Description

The Hurdle Creek floodplain merges with the King River floodplain on the downstream side of the Oxley Meadow Creek Road. The Hurdle Creek floodplain is relatively broad between the Oxley Meadow Creek Road and the Carboor Everton Road. The average creek longitudinal grade is 1 in 450 within this reach.

Upstream of Carboor Everton Road, the floodplain starts to narrow as the creek enters a 2 km wide valley. The estimated width of 100 year ARI flooding varies from 100 to 600 metres. The creek's longitudinal grade increases to an average of 1 in 260 between the Carboor Everton Road and Carboor.

Upstream of Waters Lane, the estimated extent of 100 year flooding varies in width from 150 to 400 metres. The creek's longitudinal grade increases to an average of 1 in 180.

The Carboor Everton Road is subject to road overflows at the following locations:

- Between the Mahers Lane intersection and the Holmes Lane intersection.
- At the Hurdle Creek crossing south of Bobinawarrah.

Other sections of the Carboor Everton Road may be subject to overflows from local runoff.

4.2 Structures

Structures located on Hurdle Creek are listed in Table 4.1. There are seven bridges and two culvert crossings located on the creek. None of the crossings are expected to cause significant afflux in large flood events, with road approaches being positioned at or just above natural surface level. Consequently all road crossings will be inundated in a 100 year ARI event.

The Oxley Meadow Creek culvert crossing will lead to higher flood levels on the upstream side of the crossing in minor and moderate flood events. In major flood events, the crossing will be drowned out.

There are no on-line storages located on Hurdle Creek.

Table 4.1 Hurdle Creek Structures

Name / Description	Approximate Bridge Dimension Details			Culvert Dimension Details	Comments
	Span (m)	Width (m)	Height – creek bed to soffit (m)		
Oxley Meadow Creek Road	-	-	-	11 No. 1.5 m diameter cells	Roadway approaches not raised. Negligible afflux in major floods.
Milawa Bobinawarrah Road	16	4	5	-	Bridge perched. Approaches return to natural surface. Afflux minimised in major floods.
Allans Lane	20	5	5	-	New structure. Bridge perched. Approaches return to natural surface. Afflux minimised in major floods.
Carboor Everton Road	24	6	5	-	Bridge perched marginally. Approaches raised typically by approx. 0.5 metre. Afflux not likely to be significant in major events.
Murphys Lane (northern crossing)	22	3.5	5	-	Perched bridge. Floodplain broad and flat on east side. Minimal afflux.
Murphys Lane (south crossing, proposal to rename as Mahers Lane)	20	3.5	5	-	Existing bridge due for replacement. Minimal afflux.
Waters Lane	-	-	-	3 No. 2.4 m (W) x 0.9 m (H) box cells	Low level causeway. Approaches in cut on one side. Negligible afflux.
Private local access bridge (Bellbrae property)	11	3.5	3	-	Bridge perched. Road approaches return to natural surface. Minimal afflux.
Wrights Lane	8	3	2.5	-	Road approaches at natural surface. Minimal afflux for out of channel flow conditions.

Note:1. Bridge details are approximate only (span, width, height are estimates only and are not based on actual measurements).

4.3 Houses Subject to Above Floor Flooding

Houses known to be subject to above floor flooding are listed in Table 4.2.

Three of the six houses listed in Table 4.2 are located on either side of the northern end of Murphys Lane. The floor levels of these three houses were only marginally overtopped during the 1993 flood. A further house ('Alva Loree') located at Mahers Lane was also marginally overtopped in 1993.

The remaining two houses are at most risk of above floor flooding. One is located on the south side of Hurdle Creek immediately downstream of the Carboor Everton Road and flooded to a depth of 0.50 metre above floor level in 1993. The other is located on the west side of the creek, 150 metres upstream of Waters Lane and flooded to a depth of 0.75 metre in 1993.

Table 4.2 Hurdle Creek - Houses Subject to Above Floor Flooding

Owner / Occupier	Address / Location Description	CFA Reference	Known occurrences and depth above floor
Allan Gibb	Bobinawarrah West – downstream Carboor Everton Road	297C – 18	1993 – 0.50 m (HC9 – refer Note 1) 1974 – 0.02 m below floor (HC9A)
Michael Hedderman	North end of Murphys Lane	297C - 41	1993 – in back portion of house (source – Rural City of Wangaratta records)
John Murphy	North end of Murphys Lane	297C - 43	1993 – approx 0.05 m (HC5)
Redmund Murphy	North end of Murphys Lane	297C – 42	1993 – rear rooms - approx 0.05 m (source - Rural City of Wangaratta records)
A & L Mitchell (Dale Mitchell)	'Alva Loree' – near Mahers Lane	297E - 5	1993 - 0.05 m (HC4)
Jean Box	Carboor Everton Road – upstream Waters Lane	297E -20	1993 – 0.75 m (HC2)

Note:1. HC9 reference refers to recorded Hurdle Creek flood heights as identified by the LICS documented flood height data sheets.

4.4 Floodplain Obstructions

There are no known large scale man made obstructions having a significant negative impact on Hurdle Creek flooding behaviour. All of the bridge and culvert crossings will induce relatively small afflux amounts in major flood events such as occurred in 1993. This is due to the absence of continuous elevated roadway embankments across the floodplain at any of these structures. Some of the structures are perched, however all approach roads quickly return to around natural surface level. Road approaches are subsequently overtopped by floodwaters preventing a build-up of upstream flood levels.

The Ovens River and Tributaries Levee Inventory (LICS, 2000) includes reference to the Oxley Meadow Creek Road as a listed road acting as a levee (identification number K25). The road crest is however listed as being at natural surface immediately on either side of the Hurdle Creek culvert crossing. The depth of 1993 flow over the road at the culvert crossing is estimated at more than 2 metres. Under these conditions, negligible afflux is expected.

The questionnaire responses did not include any responses specifically raising levee related concerns. Responses included the following issues / comments related to Hurdle Creek flooding behaviour:

- Runoff during the 1993 flood may have been increased due to the presence of cleared pine plantations.
- Significant debris blockage was present in the creek during the 1993 flood.

In relation to the above, it is acknowledged that runoff rates will increase in the establishment phase following clearing of pine plantations. The 1993 flood was however an extreme event with any increases in runoff from cleared plantation areas expected to have had only a very minor impact on peak flooding characteristics. It is also inevitable that significant debris accumulation will occur in flood events of the size of 1993. Debris will tend to accumulate at flow constrictions such as bridges leading to increased localised flood levels.

5. Boggy Creek

5.1 Boggy Creek Description

The Boggy Creek floodplain merges with the King River floodplain on the north side of Moyhu. The current Boggy Creek low flow course results in flows discharging into the King River upstream of Furlans Lane.

The Boggy Creek floodplain is initially quite broad between Moyhu and Top Plain Road. The creek longitudinal grade at this point is 1 in 1,000. The estimated extent of 100 year ARI flooding is up to 1 km wide downstream of Top Plain Road due to the relatively flat overbank areas on both sides of the creek.

Flooding at Moyhu from Boggy Creek encroaches into the east side of the town. There was at least one house subject to above floor flooding in 1993 (refer Section 5.3 for further details).

Upstream of Top Plain Road, the floodplain starts to narrow as the creek enters a 2 to 3 km wide valley. The creek's longitudinal grade increases to 1 in 250. By Kings Lane, the estimated extent of 100 year ARI flooding has reduced to a varying width of between 150 and 300 metres.

Further upstream where the creek crosses Boggy Creek Road (Redcamp Bridge), the creek's average longitudinal grade has increased to 1 in 100. The estimated extent of flooding continues to vary from 150 to 300 metres upstream of Redcamp Bridge.

The Boggy Creek Road is subject to road overflows at the following locations:

- On the south side of Redcamp Bridge.
- At the Evans Lane intersection.
- 1.5 km south of the Evans Lane intersection.
- North of the Myrrhee Whitlands Road.

Five additional flood height marks were collected on Boggy Creek. These additional marks were identified from the results of the questionnaire responses. The marks were particularly useful given the previous absence of any recorded marks upstream of Kings Lane.

5.2 Structures

Structures located on Boggy Creek are listed in Table 5.1.There are 14 bridges and one culvert crossing located on the creek. None of the crossings are expected to cause significant afflux in large flood events, with road approaches typically being positioned at or just above natural surface level. Consequently all road approaches will be inundated in a 100 year ARI event.

There is an on-line storage dam located 3 km south (upstream) of the Benalla Whitfield Road. The storage is located within a State Forest area and is upstream of the area for which flood mapping has been delineated.

There are no on-line storages located on Boggy Creek downstream of the Benalla Whitfield Road.

Table 5.1 Boggy Creek Structures

Name / Description	Approximate Bridge Dimension Details			Culvert Dimension Details	Comments
	Span (m)	Width (m)	Height – creek bed to soffit (m)		
Furlans Lane	7	3	1	-	Bridge and road approaches at natural surface – located on King River floodplain.
Robustelles Lane	-	-	-	3 No. 3.0 m (W) x 1.5 m (H) box culverts	Road at natural surface level – located on King River floodplain.
Moyhu Meadow Creek Road	17	6	4	-	Deck raised approx. 0.5 metre, major east side road approach at natural surface.
Wangaratta Whitfield Road	17	6	5	-	Low point in floodplain 200 metres south of bridge. Separate pedestrian bridge located immediately upstream of road bridge.
Top Plain Road	22	4	5	-	Road approaches in cut or at natural surface. Streamflow measurement gauge immediately downstream of bridge.
Kings Lane	23	3	4	-	Road approaches / bridge deck are at natural surface.
Private crossing (Willowbank property)	15	3	4	-	Bridge deck perched. Road approaches return to natural surface.
Boggy Creek Road (Redcamp Bridge)	25	5	5	-	Major road overflows in 1993 on south side road approach section. North side road approach is raised.
Evans Lane	11	4	4	-	Bridge deck perched. Road approaches return to natural surface.
Private bridge (Munari property)	10	3	3	-	Bridge deck perched. Road approaches at natural surface.
Private bridge (Willowbridge property)	14	3	3	-	Bridge deck perched. Raised west side approach will cause some upstream afflux.

Name / Description	Approximate Bridge Dimension Details			Culvert Dimension Details	Comments
	Span (m)	Width (m)	Height – creek bed to soffit (m)		
Private bridge (Tynant property)	10	3	3	-	Bridge deck perched. Road approaches return to natural surface.
Myrrhee Whitlands Road	11	6	1	-	Low point in road between bridge and Boggy Creek Road. Road approaches raised, however will drown out in major flood conditions.
Benalla Whitfield Road	14	6	1.5	-	Downstream house flooded in 1993. New bridge and approaches constructed in 1994.
Private bridge (1km upstream Benalla Whitfield Road)	9	3	3	-	Bridge deck perched. Road approaches return to natural surface.

Note:1. Bridge details are approximate only (span, width, height are all based on approximate measurements).

5.3 Houses Subject to Above Floor Flooding

Houses known to be subject to above floor flooding are listed in Table 5.2. A house located 500 metres south of Redcamp Bridge would appear to be at most risk of flooding. This house was not however subject to flooding during the September 1998 flood, which had an equivalent ARI of 6 to 7 years.

The level of risk of the house immediately downstream of the Benalla Whitfield Road (Cryer house) is difficult to assess. A new bridge and road approaches were constructed in 1994. A minor levee bank is also present on the downstream east side creek bank. A visual assessment would suggest that the level of risk is relatively low in relation to house flooding. The house was not flooded in September 1998.

The Munari house was subject to a set of freak circumstances in the October 1993 flood. A dam burst above the house on a local tributary of Boggy Creek was the cause of the flooding. The set of circumstances which initiated the house flooding in 1993 is unlikely to occur again.

A house not listed in Table 5.2, but likely to have been flooded in 1993 is located 300 metres north of the Myrrhee Whitlands Road / Boggy Creek Road intersection. The house is no longer used as a domestic residence, with a new house having been built nearby since the 1993 flood. The new house floor level is above the 1993 flood level.

Table 5.2 Boggy Creek - Houses Subject to Above Floor Flooding

Owner / Occupier	Address / Location Description	CFA Reference	Known occurrences and depth above floor
-	Moyhu, Wangaratta Whitfield Road, adjacent to Lions Park (street address No. 2)	-	1993 – 0.01 m (B13 – refer note 1).)
-	Moyhu Caravan Park – cabin flooded	-	1993 – 0.1 m (B15)
David Jones	RMB 1010 Boggy Creek Road (just north of Top Plain Road)	296F - 8	1993 – 0.01 m above rear door step (B17)
Rocklea (previous owner Shirley Barber)	Boggy Creek Road – first house south of Redcamp Bridge on east side of road)	296F - 48	1993 – David Evans estimates depth 3 feet above floor, not flooded in 1998.
John Munari	RMB 1280 Boggy Creek Road	331B – 52	1993 – up to window sill. Flooding caused by local catchment runoff, not Boggy Creek itself.
L Cryer	1400 Benalla Whitfield Road – on east side of creek downstream of bridge.	331B - 105	1993 – unknown depth – adjoining bridge & road has since been reconstructed.

Note:1. B13 reference refers to recorded Boggy Creek flood heights as identified by the SMEC documented flood height data sheets.

5.4 Floodplain Obstructions

There are no known large scale man made obstructions having a significant impact on Boggy Creek flooding behaviour aside from the on-line storage dam located 3 km south (upstream) of the Benalla Whitfield Road.

All of the bridge and culvert crossings will induce relatively small afflux amounts in major flood events such as occurred in 1993. This is due to the absence of continuous elevated roadway embankments across the floodplain at any of these structures. Some of the structures are perched, however approach roads generally quickly return to around natural surface level. Road approaches are subsequently overtopped by floodwaters preventing a substantial build-up of upstream flood levels.

The Ovens River and Tributaries Levee Inventory (LICS, 2000) includes reference to Furlans Lane (K4) and Robustelles Lane (K5). The Furlans Lane approaches and bridge are listed as being at natural surface. Robustelles Lane is listed as being raised by 0.5 metre at the culvert itself, with approaches generally at natural surface.

The Redcamp Bridge north side road approach is raised. In major flood events such as 1993, road overflows are free to occur on the south side approach. This prevents any significant build-up of flood levels upstream of the bridge.

The questionnaire responses did not include any responses specifically raising levee related concerns. Responses included the following issues / comments related to Boggy Creek:

- Alignment training works undertaken since 1993 have assisted in stabilising sections of creek bank.
- Focus should be on reducing creek erosion with little that can be done to reduce flooding.
- Removal of debris / fallen trees and gravel would improve in-channel capacity.

6. Meadow Creek

6.1 Meadow Creek Description

The Meadow Creek floodplain is initially quite broad upstream of the Meadow Creek Hall Road where the creek enters the King Valley. The estimated extent of 100 year ARI flooding is up to 600 metres wide prior to the merger with the King River floodplain. The average creek longitudinal gradient is 1 in 250.

The floodplain starts to narrow downstream of the Meadow Creek Hall Road. At the Hills Lane bridge, the extent of flooding has reduced to 150 metres. The Moyhu Meadow Creek Road is subject to Meadow Creek flooding adjacent to the Hills Lane intersection as occurred in 1993. This is the only confirmed location where the Moyhu Meadow Creek Road was overtopped by Meadow Creek floodwaters.

The average creek longitudinal gradient upstream of Hills Lane increases to 1 in 150 where the creek parallels the Moyhu Meadow Creek Road. The extent of flooding varies from 150 to 300 metres wide. An on-line farm dam is located 5km upstream of Hills Lane. The average creek longitudinal gradient between Hills Lane and the farm dam is 1 in 140.

The flood extent continues to vary between 100 and 300 metres upstream of the on-line dam. The average creek longitudinal grade gradually increases until it reaches 1 in 80, 5 km upstream of the dam.

Further upstream, the creek has been notably deepened within the reach immediately downstream of the Carboor Upper Road. The road culvert structure is at significant risk of undermining due to the lowered bed level immediately downstream of the culvert outlet.

6.2 Structures

Structures located on Meadow Creek are listed in Table 6.1. There are six bridges, two road culvert crossings and one on-line storage dam.

None of the bridge and culvert crossings have substantial raised embankments across the floodplain. A number of bridges are perched, with road approaches returning to natural surface. Consequently the afflux in flood events will be quite minimal.

The on-line storage dam is located 1 km upstream of the Gwandallon access bridge. The dam pool extends for a distance of approximately 600 metres upstream of the embankment. A major concrete lined spillway drop structure is located on the west side of the dam embankment.

Table 6.1 Meadow Creek Structures

Name / Description	Approximate Bridge Dimension Details			Culvert Dimension Details	Comments
	Span (m)	Width (m)	Height – creek bed to soffit (m)		
Kooringal Park Lane	24	4	3.5	-	Road approaches are close to natural surface. Floodplain very broad at bridge.
Private bridge – 500 metres downstream of Meadow Creek Hall Road	17	3	3	-	Bridge is perched. Approach roads return to natural surface. Floodplain very broad at bridge.
Meadow Creek Hall Road	-	-	-	4 No 1.2m (W) x 0.3m (H) box culverts	Low level causeway crossing. Road approaches in cut.
Hills Lane	13	3.5	4	-	Bridge perched. Road approaches close to natural surface. Bridge located at floodplain constriction.
Private bridge (Gwandallon property)	8	3	1.5	-	Low level bridge. Road approaches at natural surface.
On-line farm dam (1 km upstream of Gwandallon bridge)	-	-	-	-	Low flow valve controlled pipe outlet. Concrete spillway chute (estimated drop 5 metres).
Private bridge (Avondale property)	8	3	2	-	Bridge at top of bank level (not perched). Road approaches at natural surface.
Private bridge (Handcock property)	5	2.5	1	-	Low level bridge. Road approaches raised less than 1 metre above natural surface on both sides of bridge.
Carboor Upper Road	-	-	-	2 No 1050mm diameter culvert cells	Downstream drop of approx. 0.5 metre to channel bed. Threatens to undermine culvert. Downstream reach channel banks unstable.

Note:1. Bridge details are approximate only (span, width, height are estimates only and are not based on actual measurements).

6.3 Houses Subject to Above Floor Flooding

There is only one house located on Meadow Creek upstream of Kooringal Park Lane known to have flooded to above floor. Details are as follows:

- Location Description: House is located 150 metres downstream of the Hills Lane bridge on the west side of the creek.
- CFA Reference: 297C – 35B.
- Number of known occurrences and depth above floor: 1993 – approximately 0.2 metre above floor level (flood mark M5).

The above house has not been flooded since the 1993 event and the relatively shallow depth of flooding experienced in 1993 would suggest the house is only at risk in major flood events.

6.4 Floodplain Obstructions

The most significant man made obstruction to flows on the Meadow Creek floodplain is the on-line dam located 5 km upstream of the Hills Lane bridge. The floodplain is very confined upstream of the dam embankment. The dam is not causing any adverse impacts on flooding behaviour. The dam's spillway has considerable capacity with the risk of failure likely to be low. A hydrological review to quantify the risk of dam failure has not been carried out as part of this study.

Bridge and culvert crossings are not expected to cause significant afflux. This is due to the absence of elevated approach roads spanning the full floodplain width. Where bridges are perched, approach roads return to natural surface level allowing for overflows and preventing a build-up of upstream flood levels.

The Ovens River and Tributaries Levee Inventory (LICS, 2000) includes reference to Kooringal Park Lane (K24). The approach roads are listed as being at natural surface with the exception of the bridge which is slightly raised.

The questionnaire responses did not include any responses specifically raising levee related concerns. Responses included the following issues / comments related to Meadow Creek:

- Reference to road crossings causing elevated flood levels for short distance upstream.
- Creek in need of clearing of flow obstructions (e.g. willow trees, debris, accumulated gravel) to increase discharge capacity.
- Base flow during dry weather months has ceased on occasions in recent years (e.g. early 2004).
- Off-line dam constructed on south side of Meadow Creek downstream of the Meadow Creek Hall Road may be impacting on creek flows / flooding behaviour.

In relation to the above, road crossings are not considered to be causing significant increases in upstream flood levels as previously discussed. The removal of willows from the creek channel area is desirable both for channel discharge capacity reasons and for waterway stability reasons. The absence of base flow during the early 2004 months has more likely been due to the severe protracted drought

experienced rather than upstream water extraction, although the on-line dam may have contributed to the absence of downstream base flows.

7. Black Range Creek

7.1 Description

Black Range Creek merges with the King River floodplain at the Edi Cheshunt Road. On the upstream side of the Edi Cheshunt Road, overflows to the north down the eastern side of the road occurred during the 1993 flood.

The estimated extent of 100 year ARI flooding upstream of the Edi Cheshunt Road is narrow on the west bank and quite broad on the east bank. The overall flood width varies from 200 metres to 500 metres. The creek longitudinal grade is 1 in 160 between the Edi Cheshunt Road and Forges Lane.

Upstream of Forges Lane, the floodplain characteristics reverses, becoming very confined on the east bank and opening up on the west bank. The overall flood width between Forges lane and Pettifers Road (Edi Carboor Road) varies from 100 metres to 400 metres. The creek longitudinal grade increases to 1 in 130 within this reach.

Further upstream between Pettifers Road and Pratts Lane, the overall flood width varies from 150 metres to 500 metres. The creek longitudinal grade remains at 1 in 130.

Upstream of Pratts Lane, the average creek longitudinal grade increases to 1 in 80. The flow width is confined to between 100 and 250 metres.

7.2 Structures

Structures located on Black Range Creek are listed in Table 7.1. There are seven bridges within the study area reach.

The Edi Cheshunt Road bridge has the most potential to impact on flooding behaviour. The south side road approach is raised. The north side road approach is initially raised before returning to natural surface 130 metres north of the bridge. Overflows away from the bridge in major floods are directed northwards down the Edi Cheshunt Road. Overflows did not occur during the 1998 flood.

The current Edi Cheshunt Road bridge constructed in 1994 significantly reduces the likelihood of debris blockage accumulation within the bridge waterway opening due to the bridge structure being elevated (perched) higher than the previous bridge. Debris blockage at the old bridge during the 1993 flood is reported to have been significant.

The remaining six bridges are all located and configured such that any impacts on flooding behaviour are minimal. This is due to bridges being positioned at broad floodplain locations, with approach roads elevated either at or only marginally above the adjoining natural surface (floodplain) level.

There are no on-line storage dams located on Black Range Creek.

Table 7.1 Black Range Creek Structures

Name / Description	Approximate Bridge Dimension Details			Comments
	Span (m)	Width (m)	Height – creek bed to soffit (m)	
Edi Cheshunt Road	23	6	4	Bridge perched, roadway approaches raised, overflows spill to north. Current bridge constructed in 1994. Previous bridge was significantly lower.
Private bridge (300 metres upstream of Edi Cheshunt Road)	15	3	4	Bridge not perched, east side floodplain flat for 200 metres.
Private bridge (Camelon Brae property)	11	3	5	Bridge not perched, east side floodplain flat for 200 metres.
Forges Lane	21	4	4	Bridge not perched, west side floodplain flat for 200 metres.
Pettifers Road (Edi Carboor Road)	12	4	1.5	Bridge not perched, west side floodplain flat for 250 metres. Streamflow gauge downstream of bridge.
Pratts Lane	10	3	1.5	Bridge not perched, floodplain flat on both sides (overall width approx 250 metres).
Private bridge (600 metres upstream of Pratts Lane)	9	3	2	Bridge perched, road approaches return to natural surface. River management works upstream and downstream.

Note:1. Bridge details are approximate only (span, width, height are estimates only and are not based on actual measurements).

7.3 Houses Subject to Above Floor Flooding

Houses known to be subject to above floor flooding are listed in Table 7.2.

The house at most risk is located on the east side of the Edi Cheshunt Road / Edi Meadow Creek Road intersection. Breakaway flows down the west side of the Edi Cheshunt Road will have contributed to flooding of this house in 1993. The house is however located on the King River floodplain, with flooding in September 1998 caused solely by King River floodwaters.

The second house listed in Table 7.2 is located on the north side of Black Range Creek immediately downstream of the Edi Cheshunt Road bridge. Given the magnitude of the 1993 flood event and the only marginal (0.01 metre) depth of above floor flood depth, the risk of flooding of this house is extremely low.

The third house listed is located on the north side of Black Range Creek immediately upstream of the Edi Cheshunt Road bridge. This house was reported to have been flooded to a depth of 0.9 metre in the 1993 flood. This house was not flooded in 1998.

A further house not listed in Table 7.2, located on the east side of Black Range Creek, immediately downstream of Pratts Lane, was flooded to window sill level in 1993. This house has since been demolished.

A house located on the west bank, immediately upstream of Pratts Lane reportedly only just avoided being flooded in 1993. Floodwaters reportedly peaked 0.05 metre below the house floor level. The floor level of this house is raised 0.6 metre above natural surface level.

Table 7.2 Black Range Creek - Houses Subject to Above Floor Flooding

Owner / Occupier	Address / Location Description	CFA Reference	Number known occurrences and depth above floor
Sold in June 2004.	Edi Cheshunt Road / Edi Meadow Creek Road intersection	296F - 79	1993 – 0.23 m (BRC6) 1998 – 0.06 m (BRC6) Owner prior to 2001 was Neal Dickson.
Howard White	Edi Cheshunt Road downstream side of bridge	296F – 103	1993 – 0.01 m over house rear flood level, only small area of house affected, flood level at front door step 0.01 m below floor level (adjacent to BRC5)
Ian Forge	Edi Cheshunt Road upstream side of bridge	296F - 104	House flooded in 1993. Depth of above floor flooding reported to be 3 feet (0.9 metre) by the then resident Tanya White.

7.4 Floodplain Obstructions

The Ovens River and Tributaries Levee Inventory (LICS, 2000) includes reference to the Edi Cheshunt Road at the Black Range Creek bridge crossing (K8). The approach road to the south remains elevated between 1.0 to 1.5 metre above natural surface until meeting high ground 150 metres south of the bridge. The north side approach embankment reduces from 1.5 metre high at the bridge abutment back to natural surface by 130 metres north of the bridge. The existing perched bridge reduces the likelihood of significant debris blockage within the bridge waterway opening as occurred at the old bridge in 1993.

The other bridge crossings are not expected to cause significant afflux. This is due to the absence of elevated approach roads spanning the full floodplain width. Where bridges are perched, approach roads typically return to natural surface allowing for overflows and preventing a build-up of upstream flood levels.

The questionnaire responses did not include any responses specifically raising levee related concerns or other general flood related issues associated with Black Range Creek.

8 Summary

Flood mapping has been produced for the King River tributary streams of Hurdle Creek, Boggy Creek, Meadow Creek and Black Range Creek. The flood maps given in Appendix B delineate the following:

- Extent of 100 year ARI flooding.
- Extent of the floodway zone.

The 100 year ARI flood extent has been determined using a combination of available recorded flood heights from past floods, landholder observations during past floods and the available ground survey information including a 2 metre DEM of the study area.

The floodway extent has been determined based on a consideration of the frequency and severity of flooding, the active or passive flood conveyance nature of the area under consideration and the local reach floodplain characteristics (i.e. narrow confined floodplain reaches classified as wholly floodway).

The delineated flood extents have been added to the Flood Data Transfer Project database, having been attributed in accordance with the metadata standards. Recorded flood heights from the October 1993 and September 1998 flood event have also been attributed in accordance with the metadata standards and added to the database.

Structures (bridges / culverts / storages) located within the study area reaches have been inspected in relation to their influence on flooding behaviour (refer Tables 4.1, 5.1, 6.1 and 7.1). The majority of these structures have negligible impact on flooding behaviour in major flood events. This is due to the absence of elevated embankments spanning across the floodplain, with bridges being typically perched and road approaches retained close to natural surface level.

An assessment of houses at risk of flooding has also been compiled. The number of houses known to be subject to flooding is as follows:

- Hurdle Creek – six (refer Table 4.2 for details).
- Boggy Creek – five plus one caravan park cabin (refer Table 5.2 for details).
- Meadow Creek – one only (refer Section 6.3 for details).
- Black Range Creek – three (refer Table 7.2 for details).

9 References

Hydro Technology (March 1995). Documentation and review of 1993 Victorian Floods – Ovens River Catchment Floods October 1993 – Volume 3, prepared for the Department of Conservation and Natural Resources.

Appendix A

Summary Landholder Questionnaire Responses

Table A1 Summary of Questionnaire Responses

No.	*Landholder*	*Address*	*Years owned and/or occupied*	*Previous flooding experienced*	*House subject to flooding*	*Flood height marks recorded*	*Other Issues / Comments*
1.	Raymond Norman	RMB 1320 Upper Carboor	13	No	No	No	Increased runoff in 1993 due to cleared pine plantations. Significant debris blockage of waterways due to uncollected logs.
2	Raymond Bussell	RMB 1285 Carboor	64	No	No	No	1993 largest flood observed.
3	GJ & PI Hayes	Whitfield Road Moyhu	46	Yes	Verandah flooded in 1993	Yes – 1993 - pin on dairy wall (mark B2 – surveyed in 1999).	1993 largest flood observed.
4	C Chopping & G Powell	Meadow Creek Road, Meadow Creek	2	No	No	No	
5	Ron Moorhead	RMB 1257, Evans Lane, Moyhu	57	Yes	No	Yes – 1993 – peg in ground.	1993 largest flood observed.
6	Kevin Shanley	RMB 1160 Moyhu (Tullamore property, Boggy Creek Road), CFA Ref 296F-40	43	Yes	No	Yes – 1993 – mark (plate) on tree. Coincides with peak. Inspect	1993 largest flood observed.
7	Julie Williams	84 Kings Lane Moyhu	4 months	No	No	No	
8	Roger Leslie	RMB 1290 Myrrhee (Willowbridge, 1371 Boggy Creek Road) CFA Ref 331B-53	25	Yes	No	Yes – 1993 – second bale in hayshed. Inspect	1993 most severe followed by winter 1981. Alignment training in creek (1995) has assisted stability.

No.	*Landholder*	*Address*	*Years owned and/or*	*Previous flooding experienced*	*House subject to flooding*	*Flood height marks recorded*	*Other Issues / Comments*
9	John Kennedy	RMB 1485 Milawa (Moyhu Meadow Creek Road), CFA Ref 297C-36	50	Yes	No	Yes – 1993 – approx 300mm above based haystack. Inspect	Largest floods in order 1993, 1974, 1956. Three road culvert crossing cause elevated flood levels on upstream sides of crossings – no associated adverse impacts.
10	D Evans	Redcamp, Moyhu	53	Yes	No	Yes – based on memory of areas inundated in various floods.	1993 highest. Also notable 1966, 73, 74, 75 and 98.
11	RG, WD & DP Bowers	RMB 1460 Meadow Creek via Milawa (Avondale) CFA Ref 297E-23	59	Yes	No	Yes – 1993 – marks on trees, sheds, fence posts. Inspect	1993 largest. Significant flood damage to equipment / sheds / fences. Creek in need of willow removal, gravel extraction to improve flood conveyance and also to reduce blockage of summer base flow.
12	Minifie (on King River floodplain fringe, Sheep Station Creek)	RMB 1550 Oxley Meadow Creek Rd	25	Yes	No	Yes –1993 – has been surveyed previously	Runoff rates have increased in past 25 years. Floods bigger for same rainfall. Little or no ground cover common
13	Barry & Petrea Vincent	'The Garden' RMB 1610 Milawa, CFA Ref 296B-59.	68	Yes	No	Yes – mark on wall. On King River and has been surveyed previously.	1993 biggest. Also 1996, 1983, 1974. Flood warning system could be improved.
14	KN & MI Jenvey	RMB 9735 Edi Cheshunt Road, Edi Upper	28	Yes	No	Yes – 1998 - ground mark previously recorded by surveyors.	1998 largest flood experienced

No.	*Landholder*	*Address*	*Years owned and/or*	*Previous flooding experienced*	*House subject to flooding*	*Flood height marks recorded*	*Other Issues / Comments*
15	LA & LR Leitch	RMB 9800 Edi Upper	48	Yes	No	Yes – 1993 – mark on tree. Tree on tributary Whisky Creek) of Black Range Creek however.	1993 most severe observed.
16	John Munari	RMB 1280 Boggy Creek Road, CFA Ref 331B-52.	35	Yes	Yes – 1993 up to window height	Yes – 1993 – wall in house. Flood height due to local runoff however, not Boggy Creek. Inspect anyway.	1993 most severe. Also 1974, 81 & 97. Debris blockage and gravel build up not helping conveyance. Suggest remove in strategic place to improve.
17	Mark Thompson	572 Black Range Creek Road	10	No	No	No	On high ground, not affected by flooding.
18	Jeremy Fournier	RMB 1488 Meadow Creek Road, Milawa, CFA Ref 297C-35B.	12	Yes	No	Yes – 1993 - 300 mm above highest point on property. Inspect.	1993 event most severe. Mark from 1993 event on washing machine in shed. Dam burst upstream during 1993 flood did not help.
19	Kevin Wolfel	RMB 1060, Moyhu	3	No	No	No	No flooding experienced in 3 years at current address.
20	Robert Cherubin	RMB 9840 Pettifers Rd, Edi Upper.	30	Yes	No	1993 water level 600mm above Black Range Creek Pettifers Rd bridge. Not at peak however (daylight observation only).	Road cut for 3 days in 1993 event.
21	Rod Leavold	RMB 2060, Moyhu	16	Yes	No	No	1993 event most severe. Meadow Creek flooding observed.

No.	*Landholder*	*Address*	*Years owned and/or*	*Previous flooding experienced*	*House subject to flooding*	*Flood height marks recorded*	*Other Issues / Comments*
22	David Lewis	RMB 1120, Moyhu	25	Yes	No	Mark on tree in creek – 1993 mark	1993, 1998 & 1981 flooding experienced. Favours clearing obstructions in creek to improve conveyance.
23	GF & MH Ray	1657 Boggy Creek Road Myrrhee	26	Yes	No	Visual recognition only.	1993 most severe experienced. Erosion more a concern than flood height. Have implemented creek stabilisation measures over years.
24	Robert Bridgefoot	RMB 1195 Carboor Road, Bobinawarrah (Bynong), CFA Ref 297C- 30.	12	Yes	No	1993 mark recorded on fence post. Visual only, not necessarily at peak. HC7 is at Bynong (mark on shed wall).	1993 most severe.
25	Robin Box	RMB 1273 Milawa, CFA Ref 297E-12.	33	Yes	No	1993 mark at culvert east of Hurdle Creek bridge. Inspect.	1993 most severe. Landholder also owns Bell Brae property further south CFA Ref 297E-29A.
26	NR & MA Gibb	RMB 1205 (Carnarvon), CFA Ref 297C-31.	-	Yes	No	Yes – mark on wall of shed – accurate. Has been surveyed (HC6).	1993 most severe. Also 1974.
27	David A Jones	RMB 1010 Moyhu	44	Yes	Yes	None stated (B17 however).	1993 easily most severe. Land clearing has increased runoff from catchment.
28	Russell Leaton	RMB 1400 Carboor	23	Yes	No	No	1993 most severe.

No.	*Landholder*	*Address*	*Years owned and/or*	*Previous flooding experienced*	*House subject to flooding*	*Flood height marks recorded*	*Other Issues / Comments*
29	Bob & Marg Falconer	Wards Lane (Kalimna), Moyhu	17	Yes	No	1993 – marks on cattle yards	Dam has been constructed upstream of property – impacts on creek.
30	Graham Howard	Oxley Meadow Creek Road	-	Yes	No	No	1993 most severe.
31	Dianne Moore	RMB 1270 Myrrhee, CFA Ref 331B-50.	20	Yes	No	Approx. mark location based on 2 feet up line fruit tree trunks. In garden at rear house.	1993 most severe. Most concern is creek bank erosion within 30 to 40 metres of homestead.
32	De Bortoli Wines	RMB 1006 Moyhu	6	Yes	No	September 1998 mark recorded on pump station wall.	-
33	Ken Lewis	RMB 1130 Moyhu	50	Yes	No	Marks on wall sheds.	1993 most severe event seen. Erosion protection works on creek bends needed.

Appendix B
Flood Maps

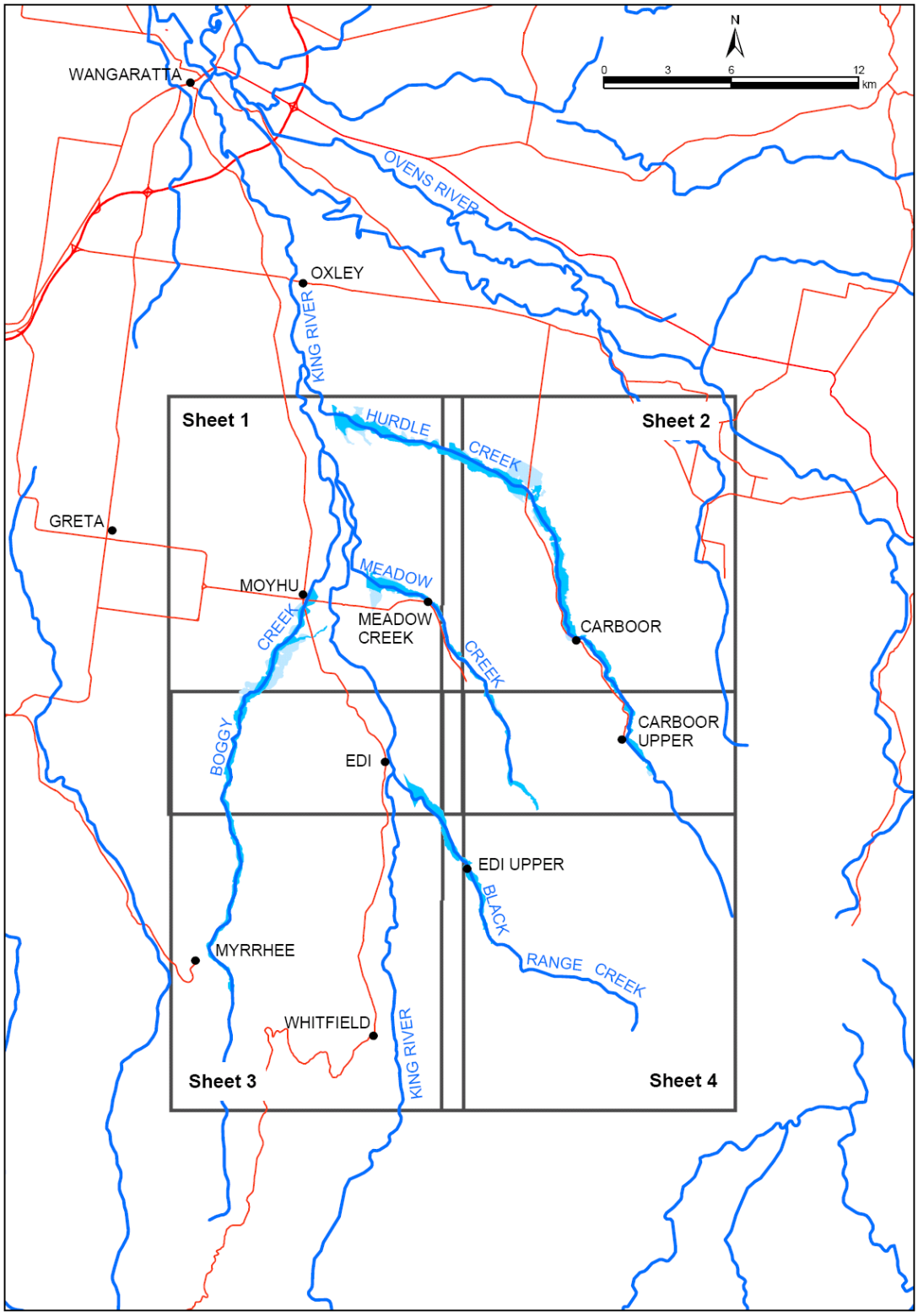

Figure B1 Key Plan for Flood Map Sheets 1 to 4

Appendix C
Recorded Flood Heights

Table C1 Recorded Flood Height Marks

Mark ID No.	Creek	Easting	Northing	Elevation	Description
1855 (HC1)	Hurdle	460360	5943900	265.17	1993 flood mark. Shed wall mark. Moderately reliable.
1856(HC1A)	Hurdle	460370	5943910	265.13	1993 flood mark. Shed wall mark. Moderately reliable.
1857 (HC1B)	Hurdle	460280	5944060	263.43	1993 flood mark. Mark on hop post. Moderately reliable.
1858 (HC2)	Hurdle	459390	5946660	244.06	1993 flood mark. Mark above door step. Moderately reliable.
1859 (HC3)	Hurdle	458540	5948320	231.58	1993 flood mark. Shed post mark. Moderately reliable.
1860 (HC4)	Hurdle	457460	5949880	223.50	1993 flood mark. Mark above front door step. Highly reliable.
1861 (HC5)	Hurdle	456640	5951510	211.36	1993 flood mark. Mark above door step. Moderately reliable.
1862 (HC6)	Hurdle	456000	5954530	196.37	1993 flood mark. Shed wall mark. Moderately reliable.
1863 (HC7)	Hurdle	455920	5954780	194.90	1993 flood mark. Shed wall mark. Moderately reliable.
1864 (HC8)	Hurdle	455130	5955960	189.06	1993 flood mark. Shed wall mark. Moderately reliable.
1865 (HC9)	Hurdle	454740	5956360	186.81	1993 flood mark. House wall stain. Highly reliable
1866 (HC9A)	Hurdle	454750	5956370	186.28	1974 flood mark. House wall mark. Moderately reliable
1867 (HC10)	Hurdle	457030	5949890	220.93	1993 flood mark. House mark. Highly reliable
1868 (HC11)	Hurdle	450590	5958660	169.98	1993 flood mark. Pump shed wall mark. Highly reliable
1869 (HC11A)	Hurdle	450570	5958710	169.78	1993 flood mark. Depth above bridge deck. Moderately reliable
1870 (HC11B)	Hurdle	450510	5958720	169.63	1993 flood mark. Ground level in garden. Low reliability.
1871 (HC11C)	Hurdle	450560	5958760	169.47	1993 flood mark. Streamflow gauge 403224. Very reliable.
1872 (HC12)	Hurdle	448060	5959270	161.85	1993 flood mark. Bridge mark. Moderately reliable.
1873 (HC12A)	Hurdle	448100	5959150	161.94	1993 flood mark. Ground mark. Moderately reliable.
1874 (HC12B)	Hurdle	448140	5959130	162.45	1993 flood mark. Shed wall mark. Low reliability.
1875 (HC13)	Hurdle	445680	5960360	158.54	1993 flood mark. Tree mark. Moderately reliable.
1876 (HC14)	Hurdle	452710	5957570	178.44	1993 flood mark. Gate post mark. Low reliability.
1877 (HC14A)	Hurdle	452710	5957580	178.28	1993 flood mark. Fence post mark. Low reliability.
1878 (HC14B)	Hurdle	452610	5957620	177.79	1993 flood mark. Ground mark. Low reliability.
1879 (HC14C)	Hurdle	452980	5957500	178.80	1993 flood mark. Fence post mark. Low reliability.
1880 (HC14D)	Hurdle	452980	5957505	178.46	1993 flood mark. Pump shed water mark. Moderately reliable.
1881 (HC14E)	Hurdle	453080	5957450	178.91	1993 flood mark. Fence post mark. Low reliability.

1882 (HC14F)	Hurdle	453070	5957370	179.09	1993 flood mark. Fence post mark. Low reliability.
1883 (HC14G)	Hurdle	453020	5957350	178.88	1993 flood mark. Ground mark. Low reliability.
1884 (HC15)	Hurdle	452160	5958290	175.37	1993 flood mark. Ground mark. Low reliability.
1759 (B1)	Boggy	approx.444440	approx. 5951550	171.16	1998 mark. Shed with mark. Moderately reliable.
1885 (B2)	Boggy	444170	5950310	176.19	1993 flood mark. Mark in workshop. Highly reliable.
1760 (B3)	Boggy	approx.444200	approx.5950300	175.68	1998 mark. Tree mark. Low reliability.
1886 (B4)	Boggy	442040	5947110	192.23	1993 flood mark. Tree axe cut mark. Moderate reliability.
1761 (B5)	Boggy	approx.442050	approx.5947090	189.26	1998 mark. Bridge mark. Low reliability.
1762 (B6)	Boggy	approx 442050	approx 5947100	189.33	1998 mark. Bridge mark. Low reliability.
1887 (B7)	Boggy	444360	5951080	173.05	1993 flood mark. Mark in pump shed. Highly reliable.
1776 (B8)	Boggy	approx 444400	approx 5951100	172.20	1998 mark. Ground mark. Moderately reliable.
1764 (B9)	Boggy	444330	5951610	171.12	1998 mark. Shed wall mark. Moderately reliable.
1888 (B10)	Boggy	444330	5951610	171.59	1993 flood mark. Mark on gateway post. Highly reliable.
1765 (B11)	Boggy	approx 444350	approx 5951620	171.13	1998 mark. Shed wall mark. Low reliability.
1889 (B12)	Boggy	444340	5951600	171.50	1993 flood mark. Point on driveway. Moderately reliable.
1890 (B13)	Boggy	444300	5951570	171.64	1993 flood mark. Mark above door step. Moderately reliable.
1766 (B14)	Boggy	approx 444380	approx 5951750	170.62	1998 mark. Cabin wall mark. Low reliability.
1891 (B15)	Boggy	444390	5951740	171.03	1993 flood mark. Mark in caravan park. Moderately reliable.
1892 (B17)	Boggy	443170	5949050	182.06	1993 flood mark. Mark above house door. Highly reliable.
1893 (B18)	Boggy	443200	5949160	181.46	1993 flood mark. Mark on piggery. Moderately reliable.
403226	Boggy	442860	5948430	184.51	1993 flood mark. Angleside streamflow gauge (403226). Highly reliable.
1773 (B19)	Boggy	approx 444370	approx 5951800	170.57	1974 flood mark. Fence post mark. Low reliability.
ET 2004 1	Boggy	440770	5943530	217.58	1993 flood mark. Metal plate labelled Oct 93 attached to tree. Very reliable.
ET2004 2	Boggy	440992	5938154	269.60	1993 flood mark. Mark in garden at rear of house. Moderately reliable.

ET2004 3	Boggy	440932	5937936	272.50	1993 flood mark. Mark on mailbox (1 foot above NS) Low reliability.
ET2004 4	Boggy	441050	5937468	279.70	1993 flood mark. Level marked at top first bale in hayshed. Low reliability.
ET2004 5	Boggy	441047	5937388	281.40	1993 flood mark. Mark on power pole. Low reliability.
1849 (M1)	Meadow	453970	5944770	255.34	1993 flood mark. Based on extent of flooding on vehicle track. Low reliability.
1850 (M2)	Meadow	452950	5947140	231.88	1993 flood mark. Mark on shed. Highly reliable
1851 (M3)	Meadow	451860	5948580	217.86	1993 flood mark. Ground mark. Moderately reliable.
1852 (M4)	Meadow	450790	5950350	200.27	1993 flood mark. Flood mark on doorway of dairy. Low reliability.
1853 (M5)	Meadow	450190	5951440	189.39	1993 flood mark. Mark on wall house. Highly reliable.
1854 (M6)	Meadow	447210	5952830	168.66	1993 flood mark. Mark inside shed. Highly reliable.
1843 (BRC1)	Black Range	452610	5937140	248.40	1993 flood mark. Recorded height on house slab. Highly reliable.
1844 (BRC2)	Black Range	451110	5940320	215.45	1993 flood mark. Tree mark. Low reliability.
1845 (BRC3)	Black Range	451050	5940790	212.03	1993 flood mark. Fence post mark. Moderately reliable.
1846 (BRC4)	Black Range	450610	5941370	208.79	1993 flood mark. Fence post mark. Moderately reliable.
1847 (BRC5)	Black Range	449550	5942360	197.68	1993 flood mark. Garage door mark. Highly reliable.
1848A (BRC6)	Black Range	448700	5943850	188.61	1993 flood mark. Furniture mark. Highly reliable.
1848B (BRC6)	Black Range	448700	5943850	188.44	1998 flood mark. Furniture mark. Highly reliable.