SOFALA
FLOODPLAIN RISK MANAGEMENT STUDY
Prepared for Bathurst Regional Council

Final Report

AUGUST 2007
JOB NO. W4641

Front page photo showing the Turon River bridge crossing at Sofala.

Bathurst Regional Council

SOFALA
FLOODPLAIN RISK MANAGEMENT STUDY

FINAL REPORT

August 2007

Project No. W4641-2

CLIENT:	**Bathurst Regional Council**
DOCUMENT NAME:	**Sofala Floodplain Risk Management Study**
STATUS:	**Final**

Prepared:	Authors	Robert Spry and Christina Roman
Date		30 July 2007
Reviewed:	Reviewer	Robert Spry
Signature:		Robert B. Spry
Date		28 August 2007
Approved:		B. C. Phillips
Signature:		Brett C. Phillips
Date		28 August 2007

CONTENTS

APPENDICES

LIST OF FIGURES

SUMMARY

Sofala is located within the Bathurst Regional Council local government area on the Turon River, a tributary of the Macquarie River. The Turon River at Sofala has a catchment area of 883 square kilometres (see **Figure 1**). It has a history of flooding with the largest recorded flood occurring in August 1986.

The purpose of this Floodplain Risk Management Study is to examine the flood liability and effects on flooding of the village, and to assess a range of potential floodplain management options. The study builds on a preliminary Scoping Study by SMEC (2003).

Existing Flooding

The village has been affected by several floods, including large floods in 1986 and 1990. The flood of 1986 was the highest recorded in the village. Historical records including stream gauging data have been reviewed to investigate the frequency and magnitude of floods. A computer hydraulic model has been set up in order to examine the flow and depth behaviour in detail, and to test the impacts of potential flood management options.

Hydrology

A flood frequency analysis was previously carried out by SMEC, using data from a flow gauging station at Sofala. This gave information on the magnitude of historical floods, including that of the 1986 event, and design floods up to 1% AEP.

Hydraulic Model

A HEC-RAS hydraulic model previously set up by SMEC has been retained for this study. Flow estimates are derived from the hydrologic studies described above.

The model was run for the peak discharge in the 1%, 5%, 10% and 20% AEP floods as well as a flood of magnitude equal to the 1986 flood, and an extreme flood. Maps have been prepared showing the approximate extent and nature of flooding, and the hazard identified in terms of depth and velocity of floodwaters. The results show that two properties would be flooded above floor level in the 1% AEP flood event. 21 properties would be flooded in a flood of magnitude equal to the 1986 flood. The Average Annual Damage (AAD) at Sofala is estimated to be $ 13,840.

Floodplain Risk Management Options

Based on the nature of flooding as identified by modelling, and on the first round of community consultation, a range of suitable management options were identified for further assessment.

1. **Options to reduce flood impacts on existing development**
    - Vegetation management,
    - Clearing of debris at bridge.

The hydraulic studies confirm that any accumulation of debris would contribute to upstream flooding and potential damage to the Crossley bridge during a large storm event.

The hydraulic impact of vegetation management measures was tested by hydraulic modelling. Selective clearing of vegetation in the entire study reach to reduce the hydraulic roughness to 0.035 in the main channel and also the over banks would reduce flood levels by 0.35 to 1.25 metres. Vegetation management is the only flood control measure which can be implemented at reasonable cost and can effectively reduce, but not eliminate, flooding.

It is noted that any actions to control or clear vegetation for flood management purposes must be sustainable and would need to comply with applicable legislation including the NSW Government's *Native Vegetation Act 2003*. The vegetation proposed to be cleared are *casuarina*, which are common along inland rivers, and various woody weed species. It is not expected that any sensitive vegetation will be affected.

2. Planning controls to ensure that new development is compatible with flood hazards

- Select flood planning level,
- Set minimum Floor levels for new development,
- Restrictions on rezoning of non-urban land,

This study recommends that the 1% AEP flood level be adopted as the Flood Planning Level (FPL) plus a freeboard of 0.5m. Draft Planning and Development Controls for Sofala are listed in Table 10 of the report.

3. Actions to manage the ongoing flood risk

- Flood information,
- Improved flood warning,
- Update of emergency management plan (DISPLAN).

Measures are proposed to improve flood warning and emergency management.

Assessment of Options

The Vegetation Management Plan is recommended, but its implementation will take some time to complete. Accordingly the following High-priority actions have been identified to help manage the flood risk:

- Vegetation clearing in the immediate vicinity of the bridge,
- Improved flood warning,
- Update of emergency management plan (DISPLAN).

Significant social benefits are expected to accrue from the vegetation management option, by reducing the flood risk and damage to existing buildings in the town. The Vegetation Management option is expected to have an economic benefit to the village by assisting tourism.

A detailed cost-benefit analysis of the options is difficult to prepare at this time due to the limited information available on costs. It is recommended that a cost-benefit analysis form part of the Vegetation Management Plan.

Recommendation

It is recommended that the attached draft Floodplain Risk Management Plan, be adopted for the village of Sofala.

Draft Floodplain Risk Management Plan for Sofala

Action	Priority	Indicative Budget Cost Estimate	Social & Environmental Impact	Cost-Benefit Assessment
Remove casuarinas in the immediate upstream vicinity of the bridge to avoid structural damage during large storm events.	High Essential to protect the bridge.	up to $ 10,000	Very positive as this would assist in protecting the bridge in severe storm events. This work refers only to clearing that is needed to protect the bridge from damage and can therefore be justified prior to a VMP being prepared. The VMP may include additional removal.	N/a
Continue debris removal program at Crossley Bridge.	High	On-going	Very positive as this would reduce the likelihood of the bridge waterway being blocked during large storm events.	N/a
Prepare Vegetation Management Plan (VMP) for Sofala and obtain approvals	High	up to $ 40,000	Positive – the VMP is required in order to gain approvals for management actions to reduce flood impacts	Undertake as part of VMP
Improve communication link between Sofala and Upper Turon	High	up to $ 50,000	Very positive - improves accuracy of flood level warnings and provides other social benefits	N/a
Prepare or update emergency management plan (DISPLAN) for Sofala	High	SES and Council staff time	Positive – ameliorate social impact caused by flooding	-
Confirm and implement development controls as part of revised LEP	High	low – staff time	Ensure that limited development can occur while preventing an increase in flood risk.	-
Conduct survey and flood routing study to relate flood levels at Upper Turon and Sofala. Tie in to AHD.	Medium - High	$ 40,000	Positive – improves accuracy of flood level warnings, facilitates setting of minimum floor levels.	-

Action	Priority	Indicative Budget Cost Estimate	Social & Environmental Impact	Cost-Benefit Assessment
Implement VMP following CMA approval	Medium, subject to funding	to be determined	Positive impacts – reduced flooding, improved tourism attractions. Monitor implementation to avoid adverse ecological impacts	-

1. INTRODUCTION

1.1 BACKGROUND

The village of Sofala is located approximately 42 km north of Bathurst on the Bathurst to Ilford Road. Sofala is located within the Bathurst Regional Council local government area on the Turon River, a tributary of the Macquarie River. The Turon River at Sofala has a catchment area of 883 square kilometres **(see Figure 1)**. The Turon River has a history of flooding with the largest recorded flood at Sofala occurring in August 1986.

Sofala is a small community with an population of 136 people in 1997 (BRC, draft DCP - Village). The Sofala village study area is presented in **Figure 2.** Consistent with the size of the community, a flood scoping study was undertaken in 2003 ("Georges Plains & Sofala Flood Scoping Study, Final Report: Sofala", SMEC, December 2003). The study investigated flood events from 20% to 1% Annual Exceedance Probability (AEP). The Probable Maximum Flood (PMF) or other extreme floods were not investigated.

At a public meeting to discuss the Sofala Flood Scoping Study a number of issues were raised as being of concern to the community:

- Vegetation growth and the build-up of gravel within the river bed are viewed by the community as the major cause of flooding in Sofala.
- The road bridge (Crossley Bridge) and its approaches may be an obstruction to flow.
- Debris collecting on the bridge may exacerbate flooding.

1.2 OBJECTIVES

The overall objective of the study is to develop a draft Floodplain Risk Management Plan for the study area that addresses the existing, future and continuing flood problems, in accordance with the NSW Government's Flood Policy, as detailed in the "Floodplain Development Manual: the management of flood liable land", New South Wales Government, April 2005 (FDM). The study is being undertaken in two phases:

Phase 1 - Extensions to the existing modelling and a Floodplain Risk Management Study in which the floodplain management issues confronting the study area are assessed, management options investigated and recommendations made. The scope and detail of the investigations undertaken should be consistent with the size of the community, the relative magnitude of the flood problems and should concentrate on the major local issues.

Phase 2 - Draft Floodplain Risk Management Plan developed from the Floodplain Risk Management Study detailing how flood prone land within the study area is to be managed.

1.3 FLOODPLAIN RISK MANAGEMENT ISSUES

The following issues specific to Sofala were identified in the Brief.

- Vegetation growth and the build-up of gravel within the river channel. In considering these issues the Consultant is to ensure that the requirements of the Department of Energy & Climate Change (DECC) under the Native Vegetation Act and the Rivers and Foreshores Improvement Act are addressed. The potential for vegetation removal to increase channel velocities and hence erosion is also to be addressed.
- The impact of the road bridge (Crossley Bridge) and its approaches as an obstruction to flow.
- The impact of debris collecting on the bridge may exacerbate flooding.
- In consultation with the local NSW SES, the study is to identify which emergency management issues would assist the community in being prepared for flood events. This should include flood intelligence, information forecasting, flood warning etc.
- Identify specific flood mitigation options available.
- Identify specific guidelines for new release areas, major rezoning as subdivisions, including lot sizes, allowable fill, building and development controls, section 94 plans etc.

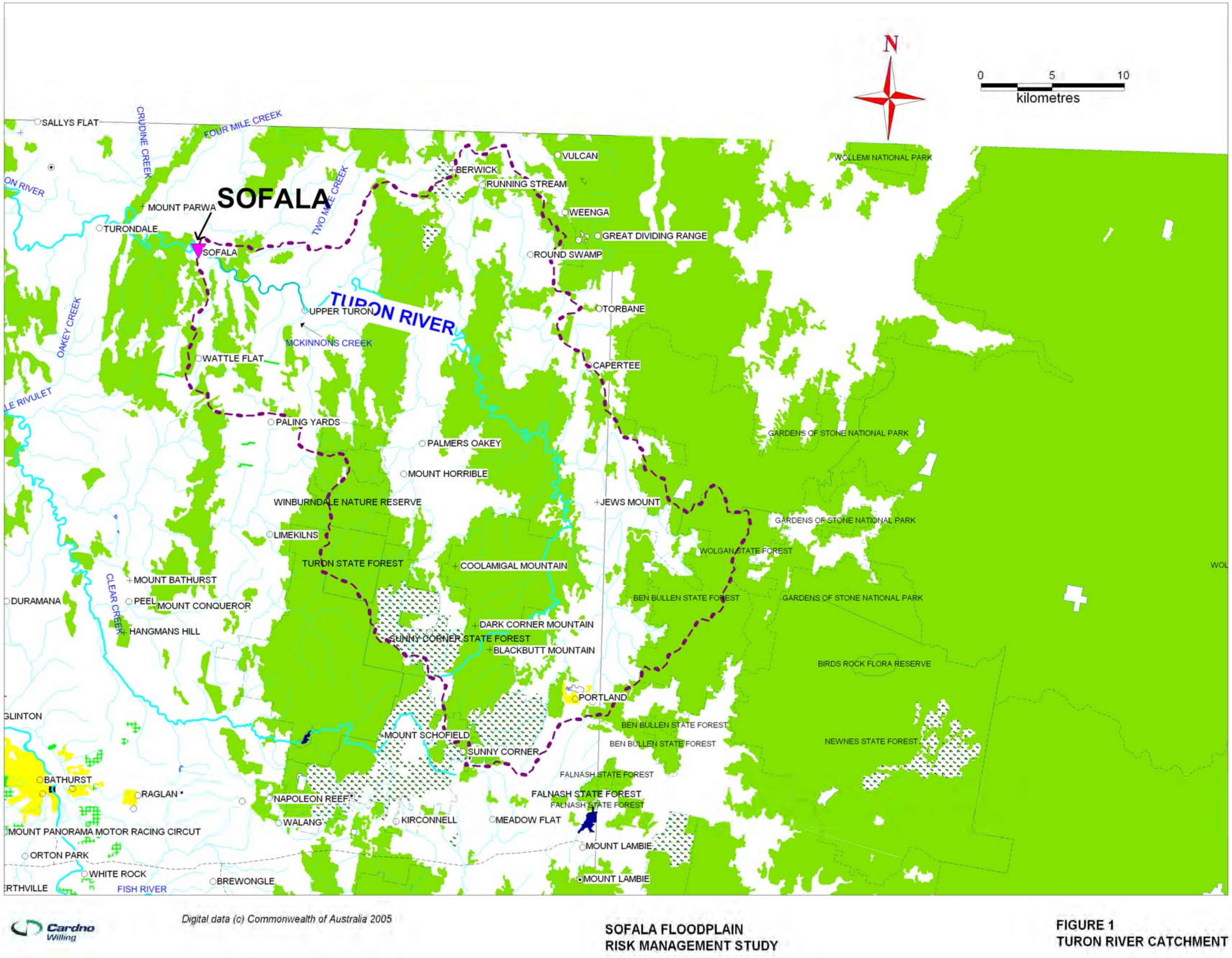


FIGURE 1
TURON RIVER CATCHMENT

SOFALA FLOODPLAIN
RISK MANAGEMENT STUDY

FIGURE 2
STUDY AREA

1.4 STUDY PROCESS

The Floodplain Risk Management Study process as specified in the 2005 *Floodplain Development Manual* (FDM), is shown diagrammatically in **Figure 3**.

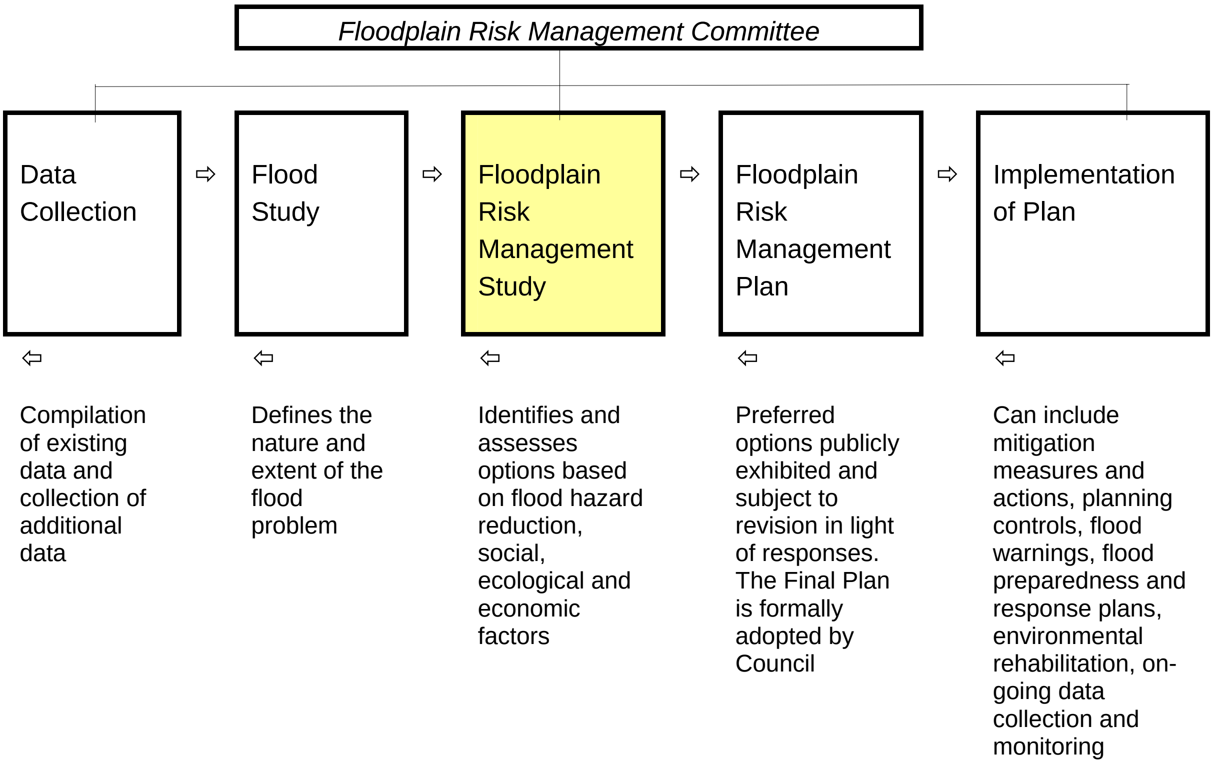


Figure 3 Floodplain Risk Management Process
(adapted from NSW Floodplain Development Manual, 2005)

The Floodplain Risk Management Study is usually preceded by a Flood Study which examines the behaviour of floods. In this case, the Flood Study was combined with the Floodplain Risk Management Study (FRMS). The FRMS was divided into a series of concurrent tasks that are summarised as follows:

- Existing Flood Damage Analysis
- Identification of Management Options
- Assessment of Management Options, including:
  - Options Identification
  - Hydraulic Assessment of Structural Measures
  - Post-Works Flood Damage Assessment
  - Preliminary Cost Estimates
  - Economic Evaluation
  - Environmental Implications, and
  - Social Impacts
- Review of the Planning Requirements for Flooding
- Mechanism for Implementation
- Preparation of Draft Report for Community Consideration

In accordance with the Brief, a Stage 1 Report was presented in May 2006 covering the following study tasks:

- review and re-running of hydrologic studies and hydraulic models,
- calculation of flood damages, and
- identification of floodplain risk management options

The Stage 1 report was reviewed by the Sofala Floodplain Management Committee in August 2006. Comments received from that review have been incorporated in this Draft Final Report.

This report is the Draft Final Report and is expected to form the basis of further consultation leading to the adoption of the Final Floodplain Risk Management Study and Plan.

1.5 STATUTORY REGULATION

Native Vegetation Act 2003

It is noted that any actions to control or clear vegetation for flood management purposes would need to comply with applicable legislation including the NSW Government's *Native Vegetation Act 2003*. The Native Vegetation Act 2003 (NV Act) regulates the clearing of native vegetation on all land in NSW except for national parks and other conservation areas, state forests and reserves and urban areas. The NV Act replaced the Native Vegetation Conservation Act 1997 on the 1 December 2005.

The objectives of the NV Act are:

> (a) To provide for, encourage and promote the management of native vegetation on a regional basis in the social, economic and environmental interests of the State, and
>
> (b) To prevent broadscale clearing unless it improves or maintains environmental outcomes, and
>
> (c) To protect native vegetation of high conservation value having regard to its contribution to such matters as water quality, biodiversity, or the prevention of salinity or land degradation, and
>
> (d) To improve the condition of existing native vegetation, particularly where it has high conservation value, and
>
> (e) To encourage the revegetation of land, and the rehabilitation of land, with appropriate native vegetation, in accordance with the principles of ecologically sustainable development.

Under the Native Vegetation Act the local Catchment Management Authority (CMA) can approve the clearing of remnant vegetation or protected regrowth when the clearing will improve or maintain environmental outcomes.

2. EXISTING SITE CONDITIONS

2.1 DESCRIPTION

The general area of Sofala is shown on **Figure 2**. The village is located on the left bank of Turon River looking downstream. The catchment area upstream of Sofala is 883km^2. The upstream catchment comprises largely of forest and rural areas (see **Figure 1**). The Turon River has a history of flooding and the largest recorded flood occurred in August 1986.

Located within Sofala is the Crossley Bridge (see **Photo 1)**.

Photo 1 Crossley Bridge

The bridge is made of reinforced concrete and the Turon River has a gravel bed from which casuarinas and some exotics grow. In a large flood event debris is likely to be washed down the river and may block and reduce the capacity of the waterway under the bridge. During the historic event in 1986 a large build up of debris occurred in the vicinity of the bridge.

2.2 DIGITAL MAPPING

The catchment area was derived from topographic mapping of the Turon River using 1:250,000 scale digital data supplied under licence from Geoscience Australia (GA). **Figure 1** shows the catchment area of the Turon River upstream of Sofala. The Turon River catchment lies to the east of Sofala and extends to the Great Dividing Range between Running Stream, Capertee and Portland.

Digital cadastral plans were provided (under licence from LPI) by Bathurst Regional Council, together with digital aerial photographs. This digital data was set up into a MapInfo Geographic Information System (GIS) to facilitate map and plan preparation.

2.3 STREAM GAUGES

A stream gauge is located on the Turon River about 200m upstream of the Crossley bridge at Sofala (AWRC no. 421026, easting 751000 northing 6336400[1]). The gauge commenced operation on 01/09/1949 and continues to be in operation. The available data from DLWC was analysed by SMEC (2003) and was further reviewed for this study (Pineena 8, 2004).

Current streamflow data is accessible on the NSW Government's Waterinfo website, www.waterinfo.nsw.gov.au. Data has continued to be collected by the gauge since the SMEC study. Apart from a small river 'fresh' which occurred in November 2005, no significant flood events have occurred since the 2003 Scoping Study was prepared.

2.4 CLIMATE AND RAINFALL DATA

Only limited information is available on climate and rainfall conditions at Sofala, or elsewhere in the Turon River catchment. Design rainfall intensity data for flood modelling was available from *Australian Rainfall & Runoff*, (AR& R) Volume 2 (1987) but for reasons explained later, was not used.

2.5 SURVEY

Survey data was required in order to establish the hydraulic model for carrying out the flooding investigations presented in the 2003 Scoping Study. Surveyors at the (former) Evans Shire Council undertook the survey and supplied data in an ASCII format. The survey included spot levels for the following:

- 10 cross sections along the watercourse;
- ground survey along road centrelines;
- ground survey of Crossley Bridge;
- historical flood levels from the August 1986 flood event; and
- floor levels of 31 dwellings and 9 additional structures (sheds, and the toilet at Sofala Royal Hotel).

Evans Shire Council surveyors made every attempt to survey as many historical flood marks as possible. However, some residents could not be contacted, as was the case of the residence just downstream of the bridge. Plans of Crossley Bridge were obtained from Council.

It was intended that all survey work be based on Australian Height Datum (AHD). However, at the time there was no AHD survey mark at Sofala so a reference datum was used, with an

[1] All map references are to MGA, Zone 55, grid zone 55H

assumed elevation of 200 m AHD and assumed horizontal co-ordinates. Assumption of a datum does not affect the results of this study; however it needs to be taken into account when setting minor floor levels. It is recommended that the survey be tied in to AHD and the flood levels be adjusted once the AHD connection is established.

The locations of the surveyed model cross sections are shown in **Figure 4** which is reproduced from the Scoping Study report.

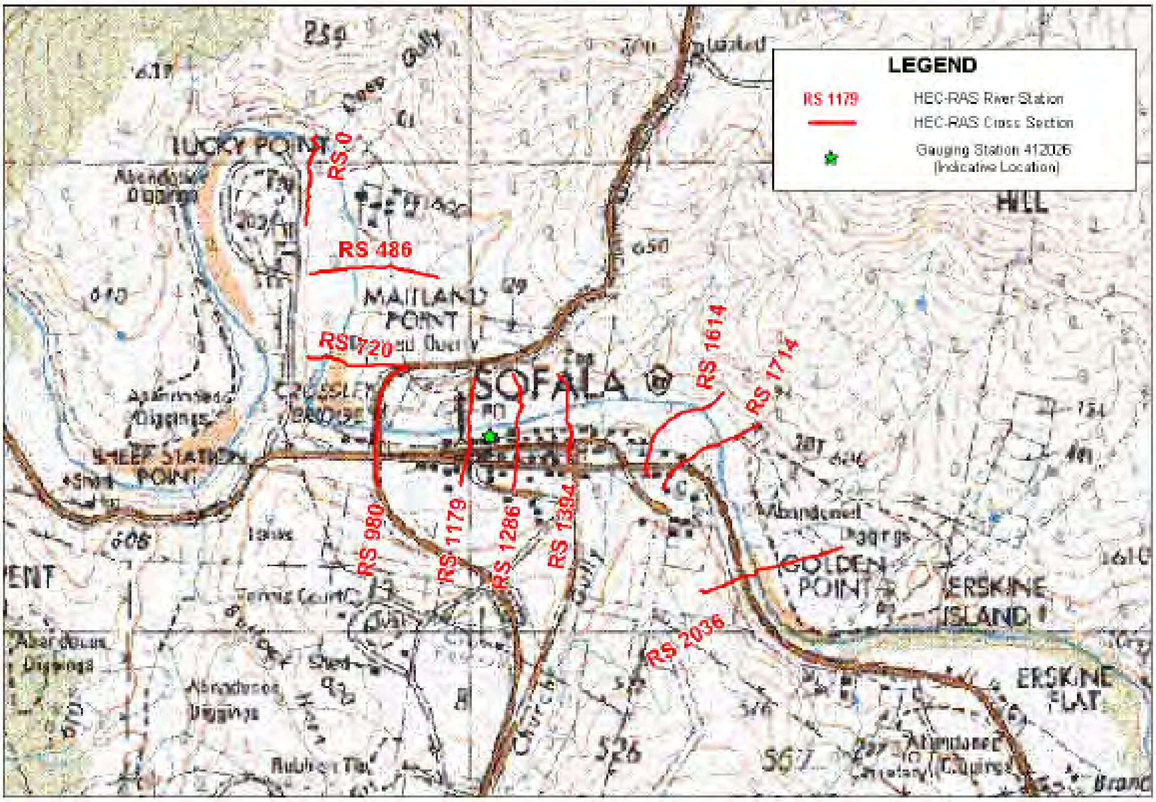


Figure 4 Surveyed Cross Section Locations
Source: Scoping Study, SMEC (2003)

2.6 PREVIOUS STUDIES

Georges Plains and Sofala Flood Scoping Study – Final Report: Sofala

A Flood Scoping Study for Sofala was carried out for the former Evans Shire in 2003 (SMEC, 2003). The objective of the Scoping Study was to undertake a preliminary investigation of the flood issues in the village to allow Council to determine whether more detailed studies are required in order to satisfy the principles and guidelines in the NSW Flood prone land Policy and (former) Floodplain Management Manual. The following information is reproduced from the *Flood Scoping Study* report.

For the Scoping Study, hydrologic investigations were based on a flood frequency analysis of the gauging station records for the Turon River. The results of the flood frequency analysis are shown in **Figure 5** which is reproduced from the SMEC Report.

Ten cross-sections and other hydraulic details were surveyed and a steady-state hydraulic model of Turon River was also set up for the scoping study. This model used HECRAS software.

The hydraulic model was calibrated using the recorded flood event in August 1986. Four observed flood levels were surveyed and compared with the calculated water surface profile for the measured discharge of 158,800 ML/d (ie 1,838 m^3/s). The profile showed a close match between the recorded and simulated results. All of the recorded flood levels were within 0.15 metre of the model profile, indicating that a good calibration had been achieved.

The calibrated model was then used for testing of two flood scenarios, using peak flow estimates derived from the gauging station data and the flood frequency analysis, **Figure 5**.

1. a flood of magnitude equal to the August 1986 flood, and
2. an extreme flood event with discharges equal to three times the discharge in the 1986 event.

A sensitivity analysis was conducted to investigate the effect that channel roughness has on flooding. The removal of vegetation along the main channel was considered in sensitivity run 1, where the Manning's n values (roughnesses) along the main channel were reduced from 0.060 to 0.035, while the overbank roughness was kept between 0.045 and 0.06. Relative to the August 1986 flood results, the model indicated that flood levels decrease while velocities increase along the river. Of the 31 dwellings with surveyed floor levels, the results indicate that 14 would be inundated with floodwaters compared to 20 in the August 1986 flood event.

However, the increase in velocity may increase the risk of erosion and bank stability. Such risks may require supplementary investigations such as scour and geomorphology.

For sensitivity run 2, the roughness throughout the river system was increased to 0.065 as may be the case if there was a more mature growth of vegetation. It should be noted that the adoption of this roughness value assumes that much of the vegetation in the channel is flattened or removed during the rising limb of the flood. Anecdotal evidence from the August 1986 flood suggests that this assumption is appropriate.

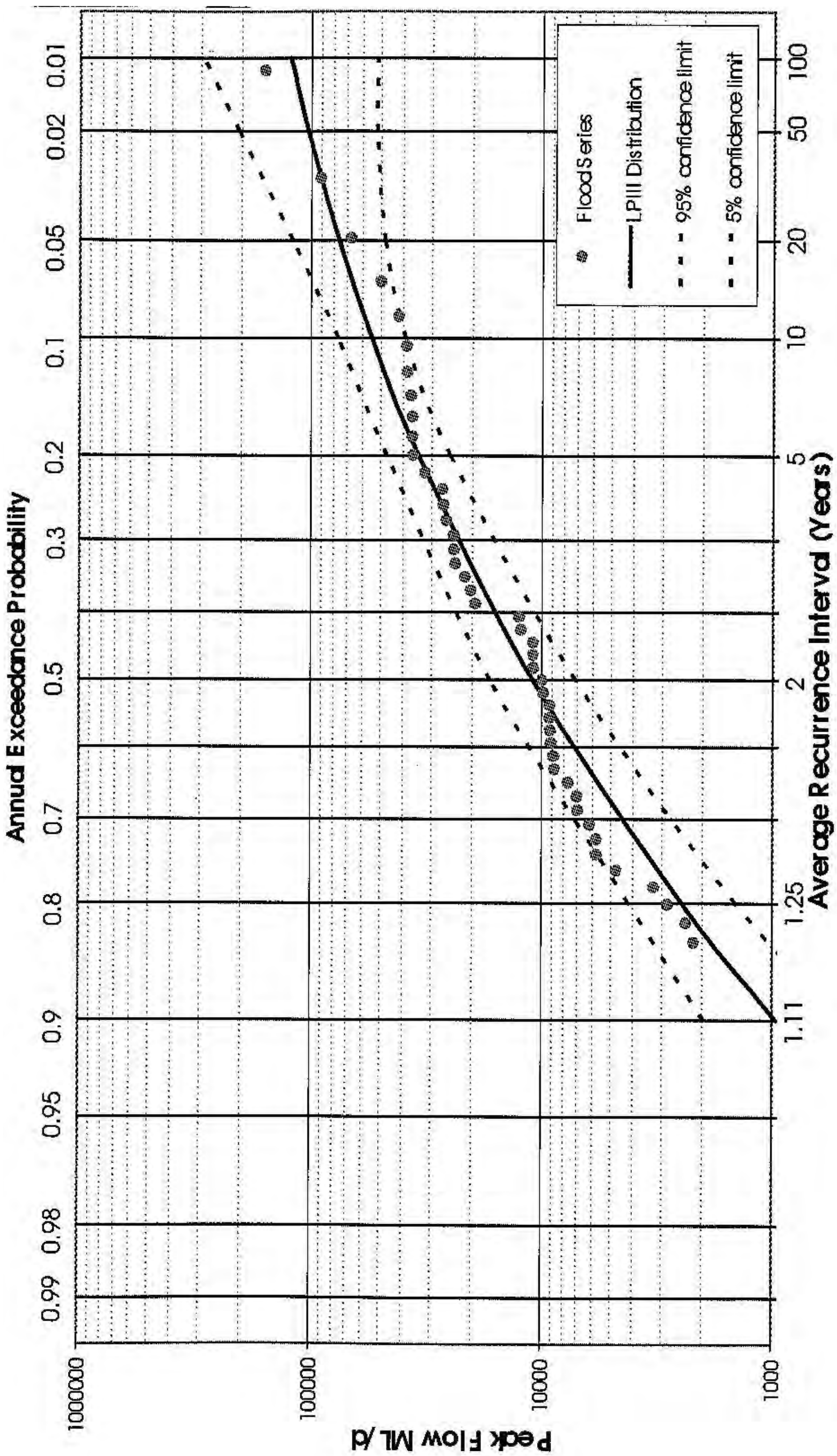


FIGURE 5 Annual Series Analysis for Turon River at Sofala (SMEC, 2003)

Relative to the August 1986 flood event calibration, results of sensitivity run 2 suggest that flood levels increase and velocities decrease significantly with higher roughness values. For this run, the model indicated that 28 of the dwellings surveyed would be inundated with floodwaters.

Key findings of the Scoping Study are set out below.

"The results of the hydrologic and hydraulic modelling suggest that flooding of dwellings commences in a flood with an ARI of 25 - 30 years (0.25-0.3% AEP). Inundation of additional structures, such as sheds, begins to occur during a flood event with an ARI of 20 - 25 years (0.2-0.25%AEP). By comparison, the flood frequency analysis suggests that the August 1986 flood event was of magnitude greater than a 100 year ARI (1% AEP)."

"Results of the modelling in HEC-RAS indicate that 20 of the 31 dwellings that were surveyed for floor levels would be inundated in a repeat of the August 1986 flood. During the extreme flood event, 30 of the 31 dwellings would be inundated."

"Based on the results of the sensitivity analysis, it appears that reducing the roughness of the main channel (i.e. removing vegetation) can reduce the number of properties inundated by flood. However, by removing trees and other vegetation from the channel, flow velocities also increase significantly. Such conditions are likely to increase the risk of erosion and bank stability and these risks should be further investigated before any action is taken. Relevant environmental legislation must also be considered. This would typically include (but not be limited to) the following:

Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999;*
NSW *Threatened Species Conservation Act 1995;*
NSW *Rivers and Foreshores Improvement Act 1948;*
NSW *Fisheries Management Act 1994;*
NSW *Native Vegetation Conservation Act 1997;*
any relevant State Environment Planning Policies (SEPPs), and
local planning instruments."

"It should be noted that there is a high degree of uncertainty involved in the peak discharge estimates used for the hydraulic modelling as part of this study, due to extrapolation of the rating curve. Potential errors in the peak discharge adopted will impact on the roughness coefficients required for calibration. The results of the sensitivity analysis suggest that a 13% change in the adopted peak flow (ie ± 20,000 ML/d) could result in a difference in flood level in the order of 0.4 m.

The reliability of the model results is also affected by:

- uncertainties about the extent and impact of debris build-up behind the bridge;
- the availability of additional historical flood marks; and
- uncertainties regarding the behaviour of vegetation within the channel during major floods, in terms of the extent and timing of vegetation flattening and removal."

SMEC considered that detailed studies, as part of the development of a Floodplain Risk Management Plan (FRMP), would not provide more reliable results than achieved in these preliminary investigations, due to the limited data that is available.

Once more gaugings are taken over the full range of flows and the rating curve can be further developed, the hydraulic model should be revised. More confidence can then be placed on the modelling results for use in developing a FRMP.

2.7 EXISTING POLICIES, PLANNING CONTROLS AND MANAGEMENT MEASURES

Planning Controls

Bathurst Regional Council (BRC) was created on the 26th May 2004. Prior to this, policies and planning controls that operated in Sofala were discussed in the Evans Shire Council, interim Floodplain Management Policy 1987.

BRC has prepared a Draft Interim Local Environmental Plan which is a combination of the Bathurst LEP and Evans Interim Development Order producing one planning instrument for the BRC to operate under.

The Interim LEP was placed on public exhibition from 16 November 2004 to 21 January 2005. A discussion forum was held on 6 April 2005. Council adopted the draft instruments on 20 April 2005.

The Interim LEP provides interim/transitional planning controls for the new local government area until a comprehensive local strategic plan can be prepared and a new Local Environmental Plan (LEP) drafted based on the outcomes of the strategic plan. At this time the preparation of a local strategic plan and subsequent LEP is expected to take approximately 3 to 4 years. The need for interim/transitional controls is therefore imperative for the short term administration of the planning system in the new local government area.

Bathurst Vegetation Management Plan

The Bathurst Vegetation Management Plan provides directions and recommendations on how land is to be managed throughout the Bathurst Local Government Area with respect to vegetation issues.

The Plan generally concentrates on community land that is managed by Bathurst Regional Council, however the recommended actions and management strategies detailed within the document can also be adopted by land owners.

The Plan can be utilised by:

- Home Owners
- Interest Groups
- Other Land Owners
- Developers
- Government

Floodplain Management Policy

Currently, a Floodplain Management Policy only applies to the City of Bathurst. The objective of the Floodplain Management Policy for Bathurst City is to implement and maintain a Floodplain Management Strategy. In addition to outlining the areas affected by flooding and the criteria for assessing proposals for development within these areas, the Policy makes provision for development of flood protected land. There are currently four identified areas of flood protected land within Bathurst City being:

- Behind the Havannah Street Levee;
- Morrisset Street Levee;
- Stockland Drive Levee; and
- Kelso Industrial Area Levee.

This study is intended to produce a Floodplain Risk Management Plan for the village of Sofala.

Other Management Measures

Bathurst Regional Council has a program of removing woody debris and willow trees from the creeks in its area. This includes removal of debris on and around bridges and piers, to prevent blockage.

An informal flood warning system also exists within the Turon River community. We understand that this is based on telephone communication of information from upstream properties including the hamlet of Upper Turon, which is located approximately 12 river km upstream of Sofala.

3. EXISTING FLOOD CONDITIONS

3.1 FLOOD FREQUENCY ANALYSIS

The results of the flood frequency analysis performed by SMEC (2003) are shown in **Figure 5**. The analysis is described in more detail in **Appendix A**.

The results of the flood frequency analyses indicate that, using the LP111 distribution adopted for this study, the August 1986 flood event had an ARI greater than 100 years (AEP < 1%). **Table 2** below shows the results of the flood frequency analysis using annual series for a range of design floods. The gauged flow in the August 1986 flood is also shown, for comparison. Flow units are megalitres per day.

It should be noted that there is a large range in values between the two confidence limits for larger flows. Accordingly, great care should be taken in quoting flows, ARIs or AEPs for floods at Sofala. As noted previously, the flood frequency analysis will be significantly improved when more gauging data is available to extend the rating curve at GS 421026.

Table 2: Flood Frequency Analysis Results - Annual Series
Turon River at Sofala

Average Recurrence Interval (ARI) (years)	Annual Exceedance Probability (AEP)	Flow (ML/d)		
		5% Confidence Limit	LP111 Fitted Distribution	95% Confidence Limit
Extreme	assumed 10^{-6}		476,500	
100	1%	51,700	122,900	291,900
20	5%	47,800	75,800	120,200
10	10%	39,000	54,600	76,400
5	20%	25,000	35,000	48,000
Aug 1986 flood	-	-	158,800	-

*Source: based on SMEC (2003). Values for 5 year ARI have been read from **Figure 5**.*

The flood frequency analysis was examined as part of this study. An additional 2 years of data are available from the Turon River gauge at Sofala. This data included a record of a small flood that occurred in November 2005, not long before the community consultation meeting. The gauged level and flow hydrographs are shown in **Figure A.1** and the state of the river after the flood is shown in photographs in **Appendix A**. The November 2005 event had a measured peak discharge of 32,000 ML/d which is estimated to be close to a 5 year ARI event (20% AEP).

The additional 2 years of data is not significant in terms of the flood frequency analysis, and accordingly the analysis was not updated. The discharge figures in **Table 2** have been adopted as the most reliable discharge estimates available for this study.

SMEC (2003) noted the large uncertainty in estimates of high flow due to extrapolation of the rating curve. The uncertainty range of flow estimates is given in **Table 2**. The suggested method of reducing this uncertainty is to undertake more gaugings during periods of high flow.

3.2 FLOODPLAIN HYDRAULIC MODEL

Hydraulic modelling of the Turon River at Sofala was undertaken for the Scoping Study (SMEC 2003) by establishing a steady-state one-dimensional hydraulic model using the HEC-RAS computer program. Survey information was supplied by Council at the cross section locations. Cross Section locations and IDs are presented in **Figure 6.** Details of the hydraulic investigation are described in **Appendix B**.

The hydraulic model has been reviewed by Cardno Willing to ensure that it is suitable for the purposes of this study. In general, it is considered to be satisfactory and it has been retained for this study. Minor changes were made to improve the usefulness and presentation of results, as follows:

- conversion of the model plan geometry to MGA Zone 55 coordinates.
- interpolated cross-sections added.

3.3 CALIBRATION AND VERIFICATION

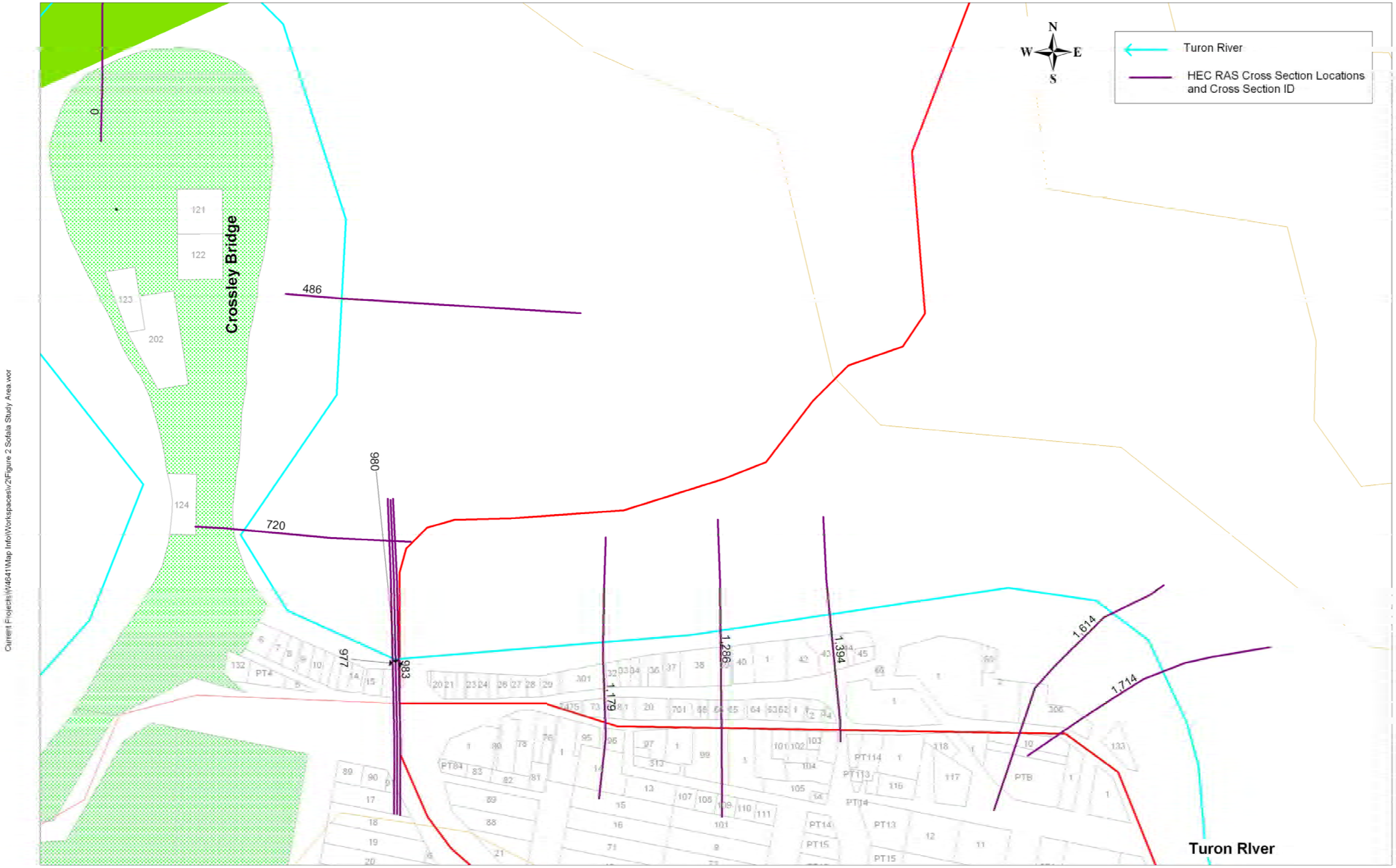
Surveyed flood levels from the August 1986 flood were used to calibrate the HEC-RAS model for the 2003 Scoping Study. The calibration process and results are described in **Appendix B**.

The flood levels indicate that a good calibration has been achieved with 100% of the model results within 0.15m of the historic flood levels.

The local behaviour of the model was also checked by comparison with local observations of the November 2005 flood, which occurred only 2 weeks prior to the first community consultation meeting. In general the flood observations are consistent with a flood of an estimated 20% AEP (5 year ARI) event.

3.4 SELECTION OF DESIGN FLOOD SCENARIOS

The design flood event scenarios, as specified in the Brief, are the 1%, 2%, 5% and 10% AEP floods. An extreme flood was also modelled. Due to limited data and the large size of the catchment, the scope of the study did not include a rigorous calculation of the Probable Maximum Flood (PMF). Therefore, the extreme flood chosen was that with discharge equal to three times the peak discharge of the 1986 flood.



Cardno Willing

SOFALA FLOODPLAIN
RISK MANAGEMENT STUDY

FIGURE 6
HYDRAULIC MODEL CROSS-SECTION LOCATIONS

3.5 FLOOD FLOWS

The peak flows in the nominated design, historical, and extreme floods are listed in **Table 3.** Flows have been converted from units of ML/d to m^3/s for modelling.

Table 3: Design Peak Flood Flows
Turon River at Sofala

Flood, Annual Exceedance Probability	Peak Flow	
	(ML/d)	(m^3/s)
Extreme	476,500	5,515
1% AEP	122,900	1,422
5% AEP	75,800	877
10% AEP	54,600	632
20% AEP	35,000	405
Aug 1986 flood	158,800	1,838

3.6 FLOOD LEVELS AND FLOOD EXTENT

The hydraulic model was re-run for the flows listed in **Table 3**. Peak water levels at model nodes in the 1%, 2%, 5% and 10% AEP floods and in the extreme flood and an August 1986 flood are listed in **Table 4**.

Note that all the flood levels reported here and elsewhere in this report are to the arbitrary survey datum, refer to Section 2.5.

Table 4
Calculated Peak Flood Levels

Chainage (m) (see **Figure 4**)	Invert level	Flood Level (m #)					
		Extreme Flood	August 1986	1% AEP Flood	2% AEP Flood	5% AEP Flood	10% AEP Flood
2036	159.23	173.07	168.01	167.10	166.55	165.74	165.02
1714	158.41	171.04	166.68	165.74	165.16	164.31	163.54
1614	157.43	171.34	166.69	165.69	165.07	164.16	163.34
1394	157.59	170.08	165.74	164.79	164.18	163.30	162.51
1286	157.09	169.85	165.46	164.46	163.81	162.93	162.12
1179	156.87	169.60	165.20	164.16	163.50	162.59	161.78
983	156.26	168.99	164.35	163.43	162.83	162.05	161.32
980 *							
977	156.26	167.92	163.65	163.02	162.58	161.88	161.20
720	156.06	167.44	162.98	162.29	161.80	161.13	160.52
486	154.93	167.21	162.79	162.10	161.57	160.83	160.16
0	153.5	165.46	161.32	160.66	160.16	159.46	158.81

* Chainage 980 is the location of Crossley Bridge.

levels are to the arbitrary survey datum, refer to Section 2.5 for details

Upstream of Crossley Bridge, the 1986 flood levels are about 0.8 to 0.9m higher than the 1% AEP levels.

The peak 1% AEP flood levels at the model cross-sections are shown in **Figure 7**. The Figure also shows the estimated indicative 1% AEP flood extent. The flood extent is indicative because it has only been plotted relative to survey data along the surveyed cross-section lines. The flood extent at other locations can only be determined by comparing the flood levels, shown in **Table 4**, with surveyed ground levels.

Figure 8 shows the extreme flood extent and extreme flood levels. **Figure 9** shows the same information for the 1986 flood.

Longitudinal flood profiles in the design floods are shown in **Figure 10**. Also shown for comparison, is the longitudinal profile for the modelled extreme flood. The water surface profile along the main channel for the August 1986 flood is presented in **Figure B.1.**

3.7 HYDRAULIC CATEGORIES

The three types of Hydraulic Categories as described in the *Floodplain Development Manual* (2005) are:

- Floodways, which carry the main flow of floodwaters. Obstruction of floodways would cause a significant re-distribution of flows and/ or rise in flood levels.
- Flood Storage, which areas in which filling would have a significant effect on flood levels due to loss of floodplain storage, and
- Flood Fringe, which are the remaining flood-liable areas that are neither Floodway nor Flood Storage.

For this study, preliminary mapping of Hydraulic Categories was undertaken for the 1% AEP design flood as shown in **Figure 7**. The main river channel is classed as Floodway. No areas are classed as Flood Storage. Flood Fringe areas were determined using the encroachment option in HEC-RAS, and represent the areas which if filled would raise the flood levels by less than 0.1 metre (1% AEP and 1986) or 0.3 metre (Extreme Flood). Figures 8 and 9 show the floodway and flood fringe areas for the Extreme flood and for the 1986 flood, respectively.

3.8 FLOOD HAZARD

Figure 11 shows the calculated provisional 1% AEP flood hazard ratings based on the flow velocity and depth obtained from cross-section survey. In calculating the provisional hazard rating the product of depth (metres) and velocity (m/second) was used in accordance with the FDM (NSW Government, 2005):

V x D < 0.4	Low Hazard
0.4 < V x D < 0.6	Transitional zone, intermediate Hazard
V x D > 0.6	High Hazard

At the scale of mapping shown and the steep nature of the banks, the transition zone is very small and it is not considered appropriate to map any of the area as Intermediate Hazard.

Figure 12 shows flood hazard areas in the 1986 flood. In the Extreme flood, due to the steep valley sides almost all of the flood extent (shown on Figure 8) will be classed as High Hazard.

3.9 SENSITIVITY ANALYSES

Several sensitivity analyses have been carried out using the HEC-RAS model to test the effects of changes in the assumed model parameters.

Full details and results of the sensitivity tests are given in **Appendix B**. The main findings are summarised in **Table 5** below. These findings are also relevant to the identification and consideration of potential management options, in the following chapter.

Table 5
Summary of Sensitivity Test Results

Type and Magnitude of Change	Area Affected	Effect of 1% AEP Flood Levels
Bed level rise by 300 mm, representing river bed aggradation	Entire study reach	flood levels *rise* by 0.02 to 0.04 metre
Bed level rise by 300 mm, representing river bed aggradation	The reach between Crossley Bridge (river station 980) and river station 1714	flood levels *rise* by up to 0.01 metre
Reduced hydraulic roughness; n = 0.035 in main channel only	Entire study reach	Flood levels *fall* by 0.17 to 1.17 metres
Reduced hydraulic roughness; n = 0.035 in main channel and overbanks	Entire study reach	Flood levels *fall* by 0.35 to 1.25 metres
Increased hydraulic roughness; n = 0.065 in main channel and overbanks, representing tree growth	Entire study reach	Flood levels *rise* by 0.53 to 1.74 metres

From the above results it is concluded that flood levels in the reach of Turon River through the village, are very sensitive to the density of vegetation both in the main river channel and on the overbank areas. This finding is consistent with the reports of residents, and is relevant to the choice of floodplain risk management options.

Although there is some evidence that the river bed may be aggrading (rising of the bed level), it is concluded that for large floods at least the flood level is not very sensitive to this effect.

A run was undertaken to test what impact debris blocking the bridge would have on water levels. To represent blockage two alternatives were considered:

- 30% obstruction was applied to the cross sections immediately upstream and downstream of the bridge.
- A debris factor was applied to all the piers at the Crossley Bridge.

The results are presented in **Table 6** and show that a 30% blockage of the Crossley Bridge results in an increase of flood levels by up to 1.16m upstream of the bridge and a reduction in water levels immediately downstream.

The blockage makes the bridge act like a retarding basin. A 2m width of debris collecting on the bridge piers was found to increase flood levels by 0.06m immediately upstream of the bridge. The reduction in water level downstream of the bridge is a local effect considered to be due to draw down at the bridge.

Table 6 1% AEP flood levels with 30% blockage of the Upstream and Downstream Cross-section and with debris collecting on the bridge.

Chainage (m) (refer to Figure 4)	1% AEP Flood	1% AEP Flood Level with 30% blockage of U/s and d/s bridge cross sections	Change due to blockage (m)	1% AEP Flood Level with debris collecting on piers of bridge	Change due to blockage (m)
2036	167.10	167.30	0.20	167.11	0.01
1714	165.74	166.25	0.51	165.75	0.01
1614	165.69	166.24	0.55	165.7	0.01
1394	164.79	165.62	0.83	164.81	0.02
1286	164.46	165.45	0.99	164.49	0.03
1179	164.16	165.32	1.16	164.2	0.04
983	163.43	164.19	0.76	163.49	0.06
980 *	Bridge				
977	163.02	162.91	-0.11	163.02	0
720	162.29	162.29	0.00	162.29	0
486	162.10	162.10	0.00	162.1	0
0	160.66	160.66	0.00	160.66	0

* Chainage 980 m is the location of Crossley Bridge

3.10 FLOOD DAMAGE

Detailed flood damage calculations have been carried out using surveyed floor level data from the 2003 Scoping Study. A stage-damage relationship was adopted from SKM (2005), who investigated flood damages in the Lower Parramatta River floodplain. The types of houses considered in the Lower Parramatta River stage-damage relationship are similar to the houses on the floodplain at Sofala. The detailed calculations are described in **Appendix D**.

Figure 13 shows the buildings estimated to have overground or over floor flooding during the 1% AEP flood event. In the 1% AEP flood event 2 buildings were estimated to have over floor flooding.

One of these buildings lies upstream of the extent of the hydraulic model. The water level at this location was determined by extrapolating the water level from the downstream cross section assuming a similar water level slope.

Figure 14 shows the number of buildings estimated to have over floor flooding during the 1986 historic event.

As ground level data is not available and the flood extent of events other than the 1% AEP flood event has not been mapped, the number of properties affected by damage to gardens and lawns has been estimated. A flat value of $1,000 has been applied to properties that have been found to have overground flooding.

The total damage figures have been multiplied by a factor of 2.0 so as to include indirect damage. Indirect damage results from the interruption of community activities including traffic flows, trade, industrial production, costs to relief agencies, education of people and contents as well as clean up after the flood.

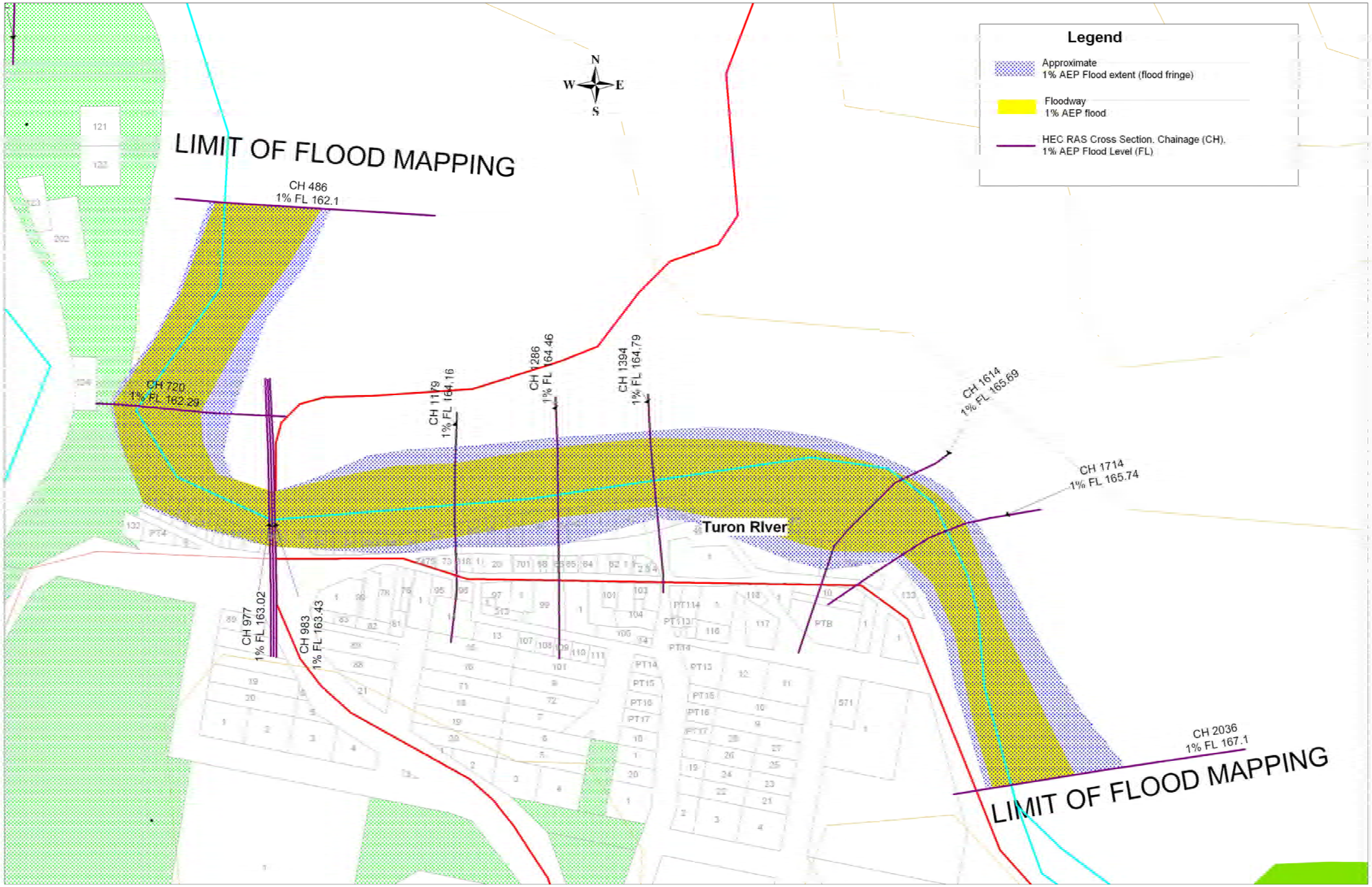
The estimated total flood damage in the 1% AEP flood event at Sofala is $ 63,200. Other events are listed in **Table 7**.

Table 7
Summary of Flood Damage Estimate

	Extreme flood	1986	1% AEP	2% AEP	5% AEP	10% AEP
Buildings flooded above floor level	30	21	2	1	0	0
Estimated total number of properties with overground flooding	31	30	20	10	5	0
Estimated direct flood damage	$1,551,000	$149,000	$13,600	$5,600	$0	$0
Estimated total flood damage	$3,103,000	$298,000	$27,200	$11,200	$0	$0
Estimated total flood damage including overground flooding	$3,104,730	$315,850	$63,200	$29,200	$10,000	$0

In order to calculate the Average Annual Damage (AAD) it is necessary to assign a probability to the Extreme Flood, and to the August 1986 flood. For the purposes of damage calculation, the extreme flood probability is assumed to be 10^{-6}. By extrapolation of the line of best fit in Figure 5 the 1986 flood is estimated to have a probability of 0.007 (0.7% AEP), representing an ARI of greater than 100 years.

The Average Annual Damage for Sofala is estimated to be $ 13,840. Further details of this calculation are given in **Appendix D**.

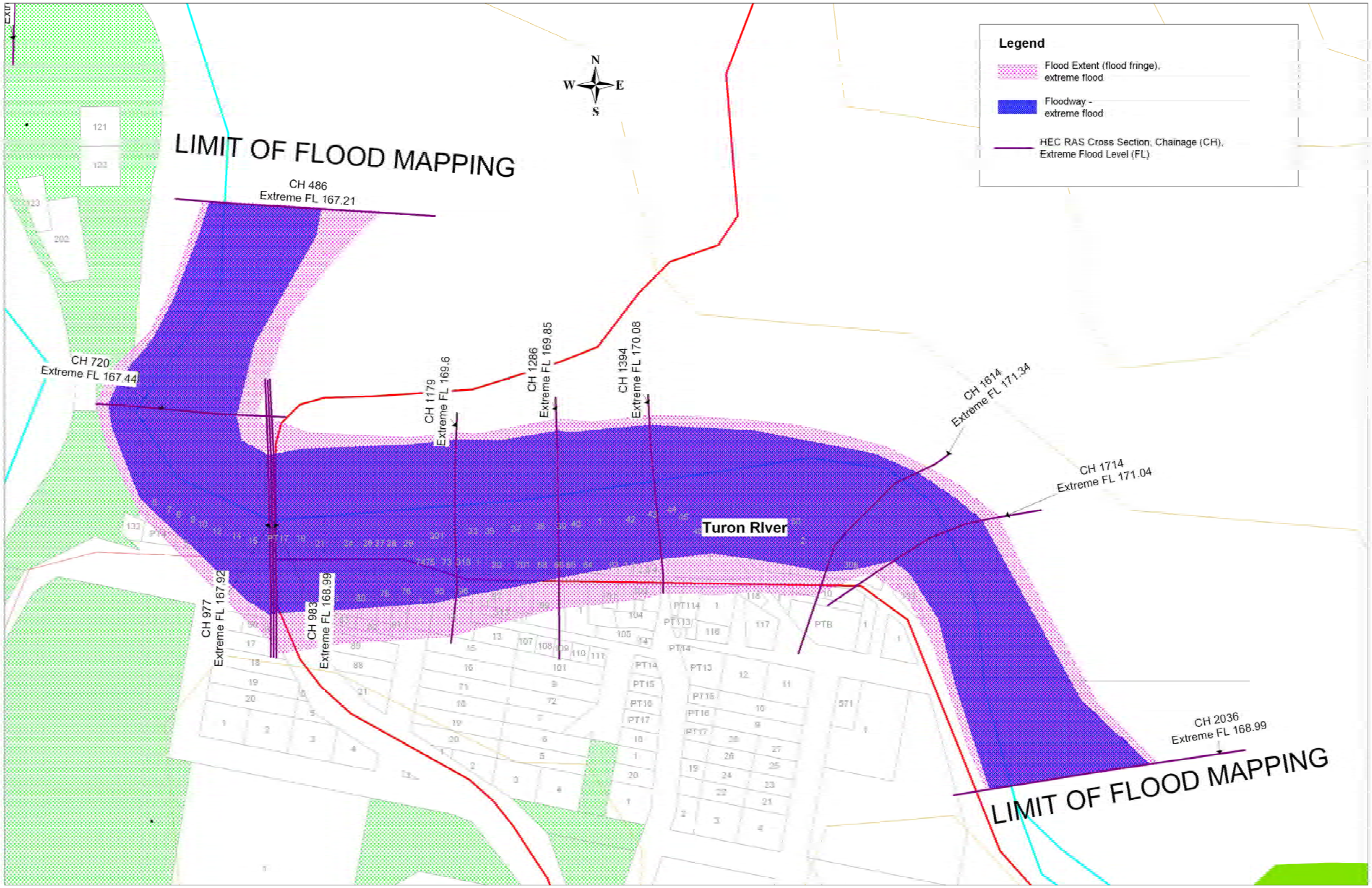


SOFALA FLOODPLAIN
RISK MANAGEMENT STUDY

NOTE: Flood extent is approximate, based on interpolation between surveyed cross-sections. The indicated flood extent should not be used to determine if properties are flood affected.

FIGURE 7 FLOOD EXTENT AND HYDRAULIC CATEGORIES, 1% AEP FLOOD

Cardno Willing

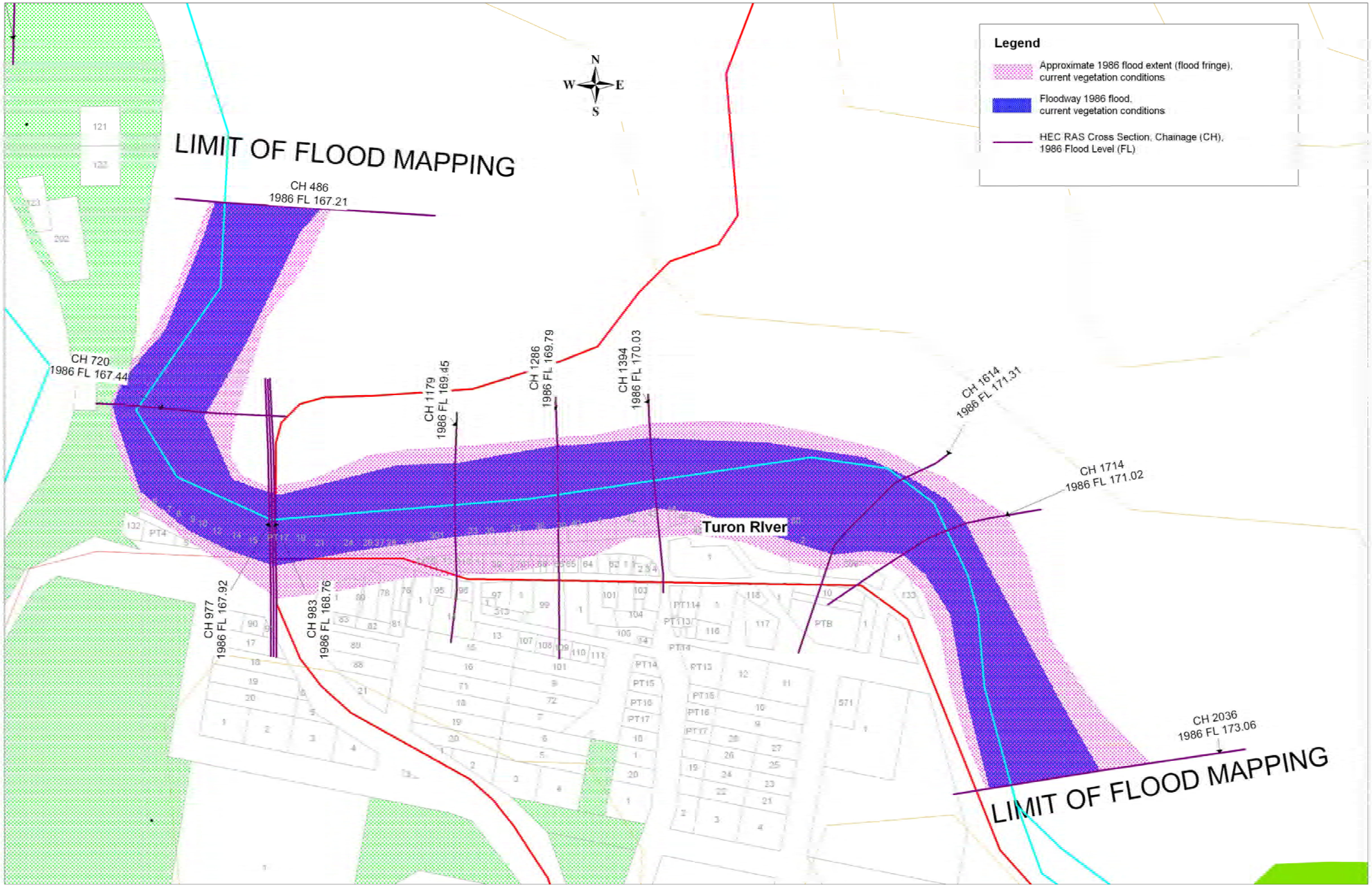


SOFALA FLOODPLAIN
RISK MANAGEMENT STUDY

FIGURE 8 FLOOD EXTENT AND HYDRAULIC CATEGORIES, EXTREME FLOOD

Cardno Willing

NOTE: Flood extent is approximate, based on interpolation between surveyed cross-sections. The indicated flood extent should not be used to determine if properties are flood affected.



SOFALA FLOODPLAIN
RISK MANAGEMENT STUDY

FIGURE 9 FLOOD EXTENT AND HYDRAULIC CATEGORIES, 1986 FLOOD

NOTE: Flood extent is approximate, based on interpolation between surveyed cross-sections. The indicated flood extent should not be used to determine if properties are flood affected.

Cardno Willing

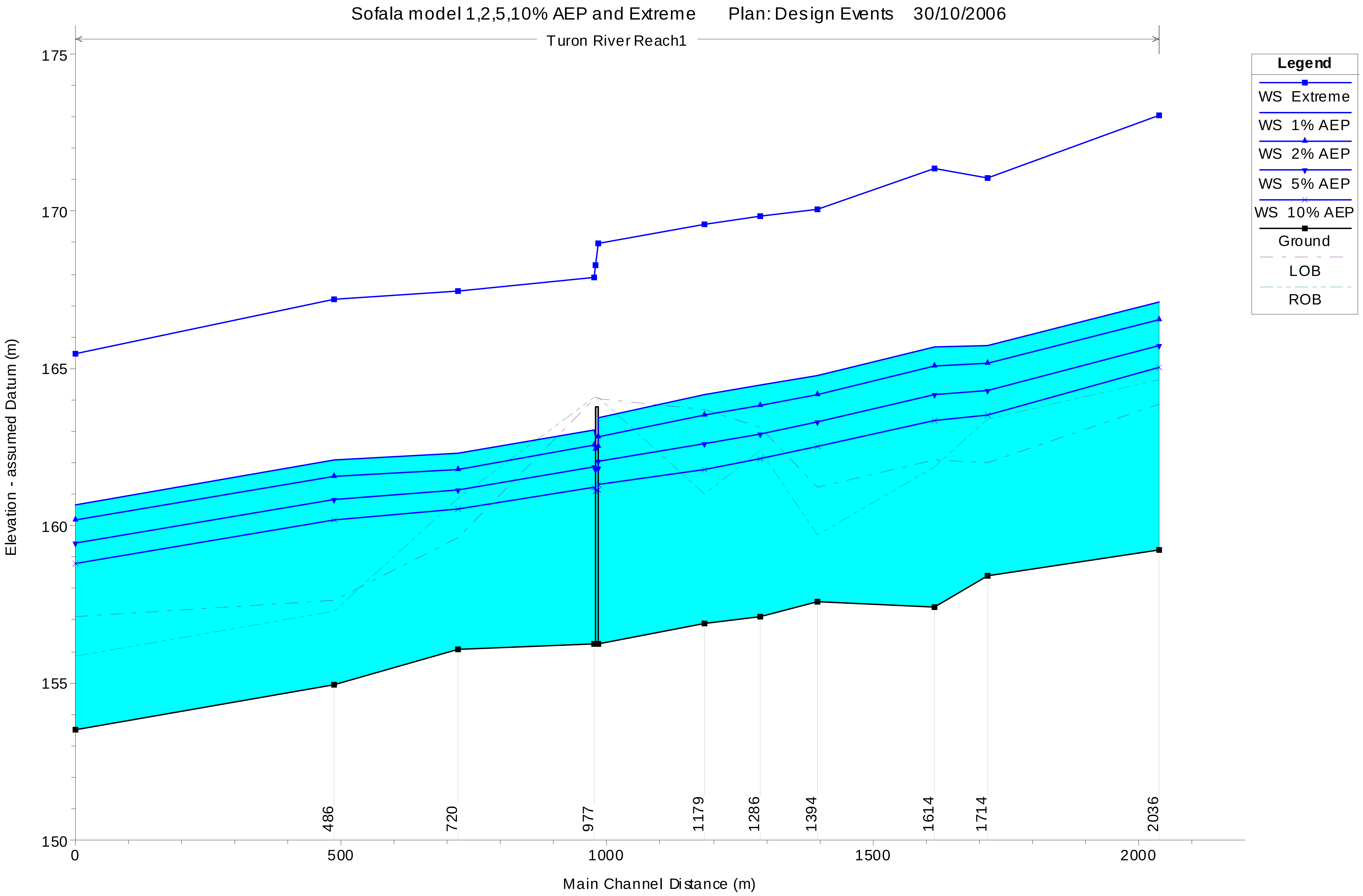


FIGURE 10
Flood Profiles in Design Floods and Extreme Flood

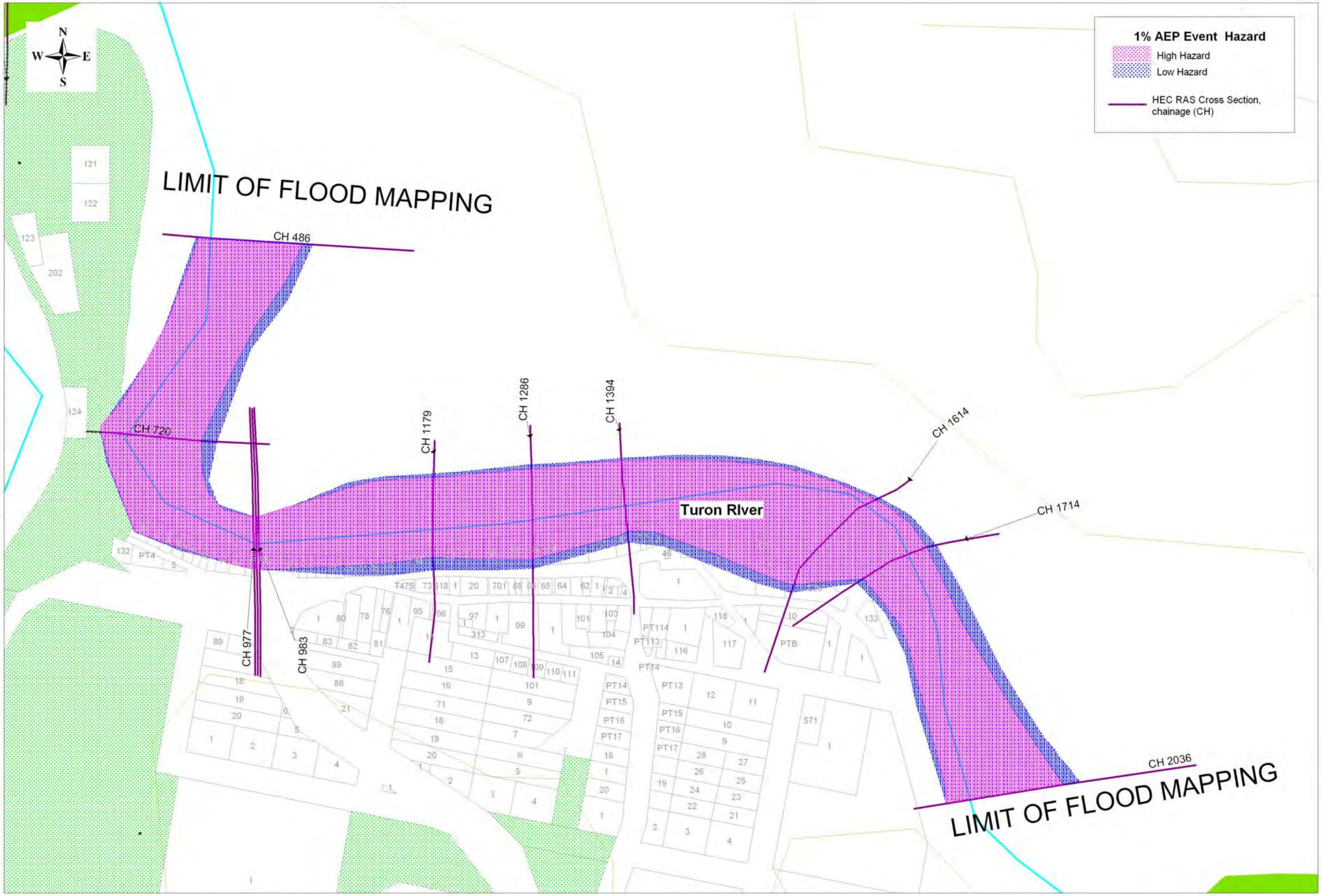


Figure 7 Hydraulic Cat 1% Sofala

Cardno Willing

SOFALA FLOODPLAIN
RISK MANAGEMENT STUDY

FIGURE 11 1% AEP FLOOD
PROVISIONAL HAZARD RATING

NOTE: Flood extent is approximate, based on interpolation between surveyed cross-sections.
The indicated flood extent should not be used to determine if properties are flood affected.

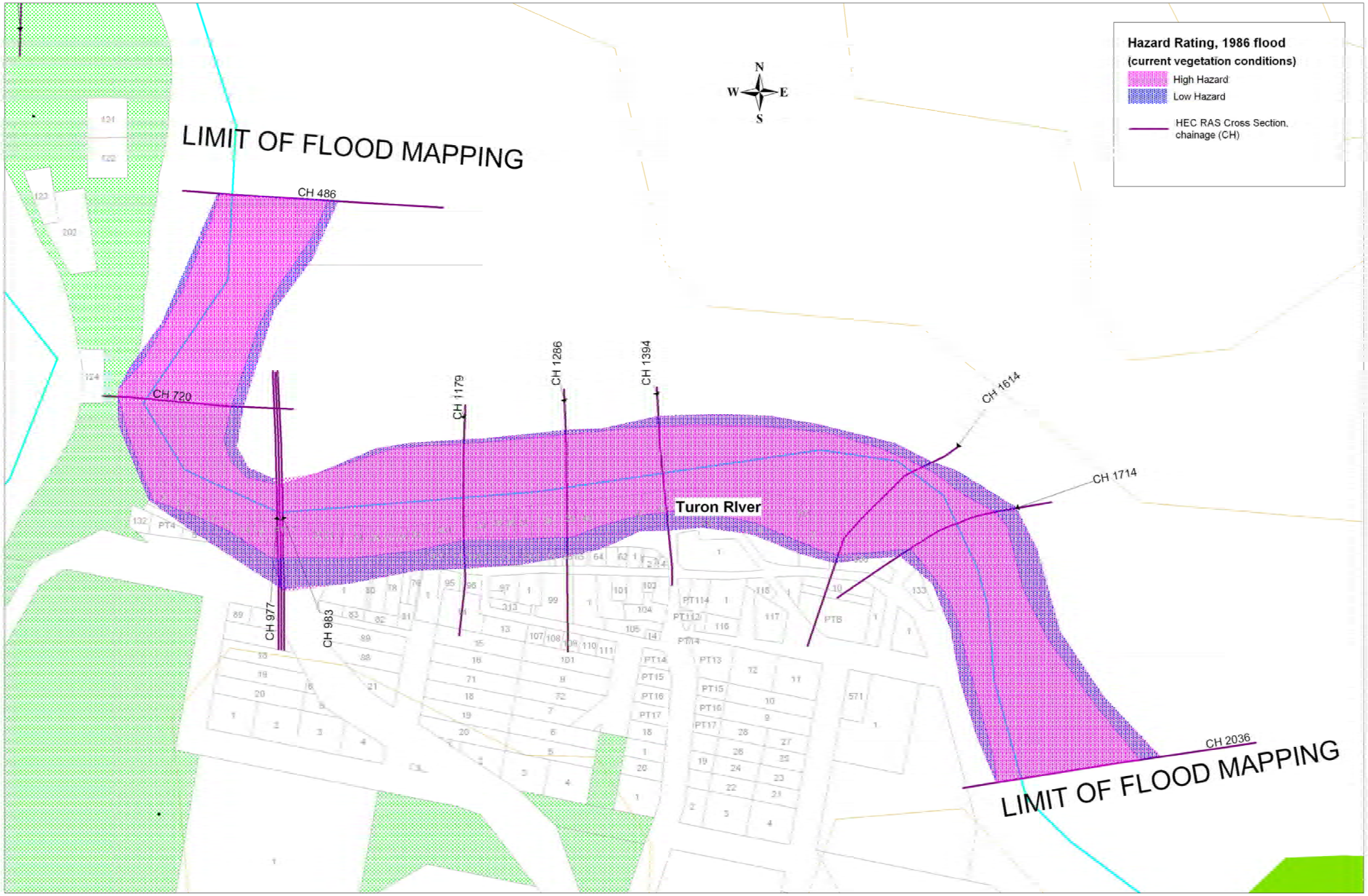


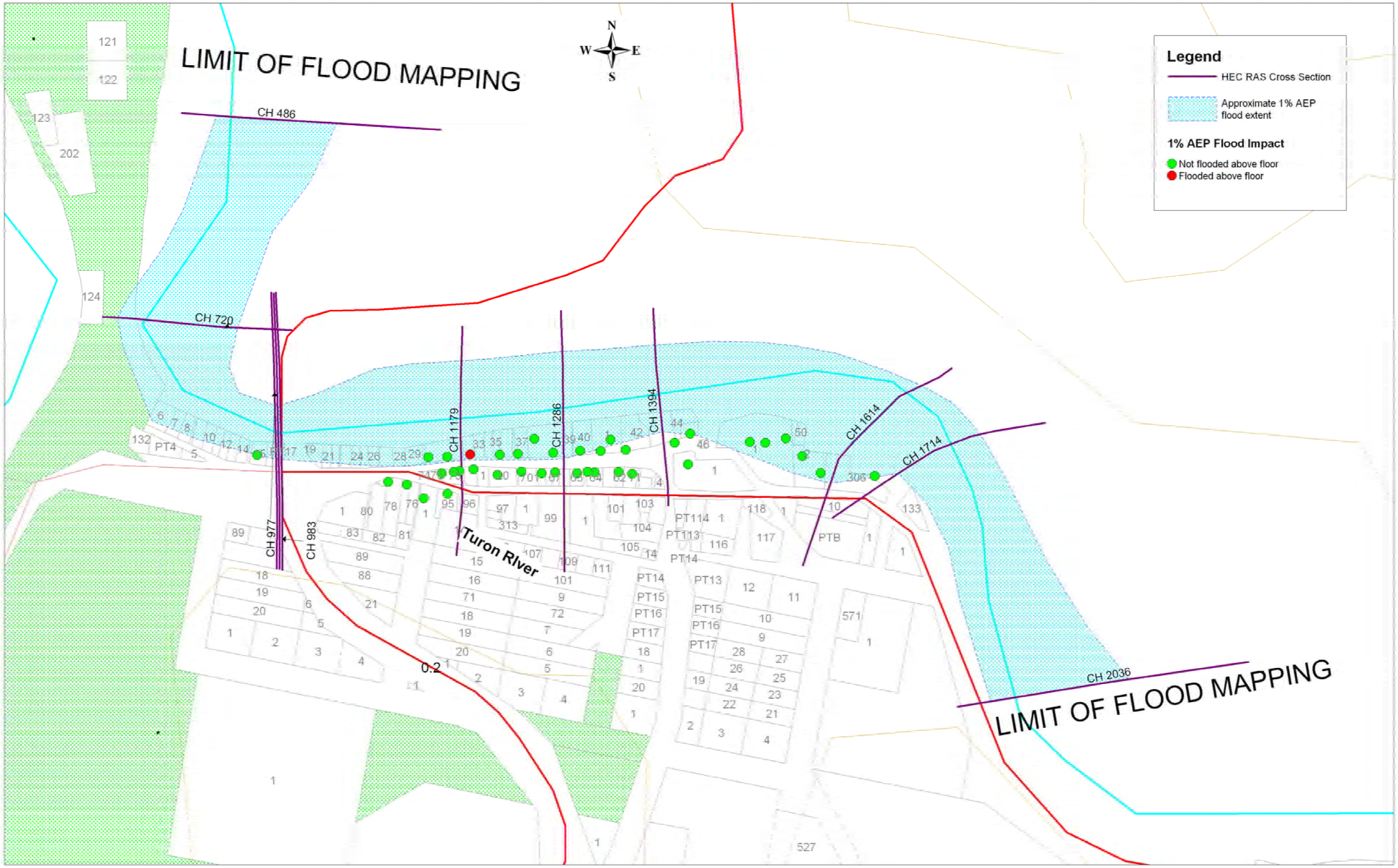
Figure 7 Hydraulic Cat 1% Sofala

Cardno Willing

SOFALA FLOODPLAIN
RISK MANAGEMENT STUDY

NOTE: Flood extent is approximate, based on interpolation between surveyed cross-sections.
The indicated flood extent should not be used to determine if properties are flood affected.

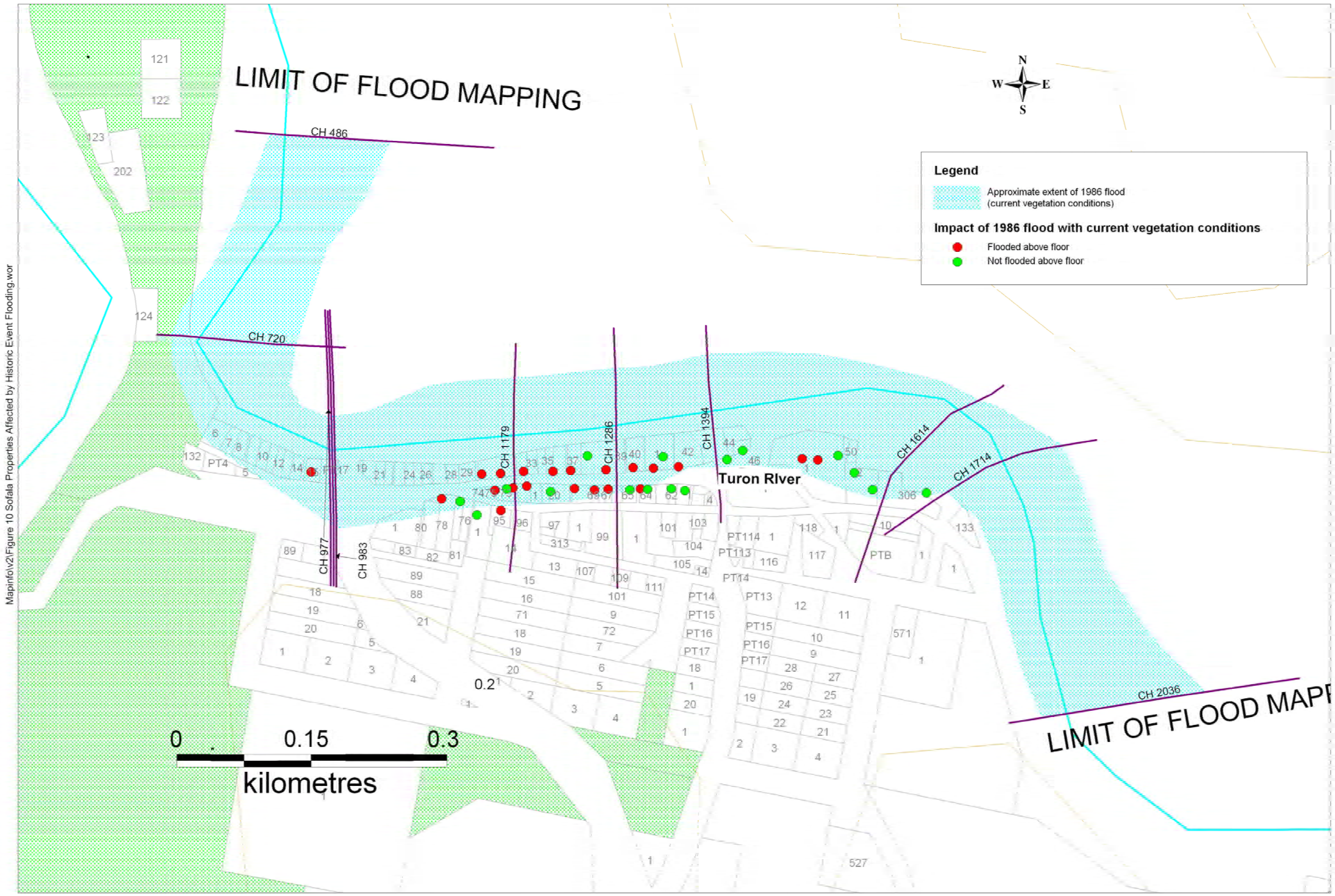
FIGURE 12
APPROXIMATE FLOOD HAZARD AREAS
1986 FLOOD (current vegtation conditions)



Cardno Willing

SOFALA FLOODPLAIN
RISK MANAGEMENT STUDY

FIGURE 13
PROPERTIES AFFECTED BY FLOODING
1% AEP FLOOD



Cardno Willing

SOFALA
FLOODPLAIN RISK MANAGEMENT STUDY

FIGURE 14
PROPERTIES AFFECTED BY FLOODING
1986 FLOOD WITH CURRENT VEGETATION CONDITIONS

4. COMMUNITY CONSULTATION

4.1 CONSULTATION PROCESS

The normal floodplain management process as per the FDM includes a series of stages as set out in **Figure 3**. However in view of the small size of Sofala and the relatively simple nature of the issues, these stages have been combined to give a simpler process. The community also indicated by feedback from the first site meeting, that they were not interested in a long drawn-out consultation process.

4.2 PREVIOUS CONSULTATION

Community consultation was previously undertaken for the Scoping Study carried out for the former Evans Shire Council. The results of that previous study are included in the *Scoping Study Final Report: Sofala (2003)*.

A number of community members expressed frustration at being the subject of two successive consultation processes. This frustration is understandable, however it was necessary to follow the process set out in the *Floodplain Development Manual* in order to ensure that the plan has community support and meets Government requirements for possible funding applications.

4.3 CONSULTATION MEETING

A consultation meeting was held at Sofala in the evening of November 21, 2005. The attendance and comments received are detailed in **Appendix C**.

The key outcomes from the meeting included:

- information on historical flood behaviour
- need for vegetation management including stream clearing
- need for improvements in information, and in emergency management
- a range of floodplain management options were suggested, and these are discussed in the next section.

4.4 FLOODPLAIN MANAGEMENT COMMITTEE

The Sofala Floodplain Management Committee (FMC) was convened by Council following expressions of interest from the November 2005 meeting. The FMC includes Sofala residents as well as representatives from Bathurst Regional Council, DECC and the SES.

The Sofala FMC met in August 2006and subsequently in 2007 to review draft study reports. Their comments and Minutes of meetings are attached in **Appendix C**. The FMC's comments have been taken into account in preparing this Draft Study Report.

5. OPTION ASSESSMENT

5.1 OPTIONS SELECTED FOR ANALYSIS

The floodplain risk management options selected for detailed consideration and evaluation at Sofala are listed in **Table 8.**

Table 8
Options Selected for Analysis

	Description	Comments / Issues
Options to reduce flood impacts on existing development	Vegetation Management, including channel clearing, Clearing of debris at bridge.	Compliance with legislative requirements.
Planning controls to ensure that new development is compatible with flood hazards	Select Flood Planning Level. Minimum Floor levels for new development & redevelopment. Restrictions on rezoning of non-urban land.	Does not assist existing development.
Actions to manage the ongoing flood risk	Flood information, flood warning, Emergency management plan (DISPLAN)	SES involvement

Options to reduce flood impacts on existing development

- Vegetation management along the Turon River,
- Clearing of debris at the bridge.

The local community has expressed its concern about the growth of casuarinas and other trees and woody shrubs in and alongside the stream bed. It is claimed that this growth has caused an increase if flood levels, due to (a) increased hydraulic roughness, and (b) the trapping of bed sediment causing an increase in river bed levels.

The historical (photographic) evidence, hydraulic analyses and the review of gauging data all tend to support the community's concerns. For this reason a Vegetation and Sediment Management Plan for Sofala prepared under the *Native Vegetation Management Act*, is favoured as a management option.

During the historic event in 1986 a large build up of debris occurred in the vicinity of the bridge. It is essential that the debris is pulled out and cleared regularly to minimise blockage and potential damage to the bridge during a large storm event.

As the bridge crosses the boundary of two local government areas maintenance of this bridge may be split over two local government areas: Bathurst City and Mid Western Regional Council.

Planning controls to ensure that new development is compatible with flood hazards

- Restrictions on rezoning of non-urban land.
- Minimum floor levels for new development.

Even though Sofala does not currently experience much development pressure, planning controls should still be applied so as to ensure that new development is compatible with the existing flood hazard (as described in this report), and to ensure that any new development or redevelopment does not increase the flood risk.

Actions to manage the ongoing flood risk

- Flood information,
- Flood warning, and
- Emergency management plan.

It has been noted in Section 2.7, that the local community has an informal flood warning system involving telephone warnings from upstream residents, particularly at Upper Turon. As the village is compact, dissemination of the warning to residents is by word of mouth.

The river height at Upper Turon should provide a reasonable indication of flooding at Sofala. Opportunities exist to expand and formalise this system. In order of increasing costs, improvements can be made by:

(a) improved telephone communications,
(b) automatic telemetry of upstream flood heights, or
(c) real-time computer modelling to predict flood heights from telemetered rainfall data in the catchment.

The cost of real-time computer modelling for flood prediction is very difficult to justify for such a small community. The upstream catchment is sparsely populated, with rugged terrain and poor mobile phone coverage, and an extensive data collection network would need to be provided.

Management of emergencies including flooding is the responsibility of the SES. The SES should update its emergency management plan (DISPLAN) to incorporate the information provided in this Study.

5.2 SELECTION OF THE FPL

The Flood Planning Level (FPL) defines the limit of land subject to flood-related planning controls. It usually involves a combination of historic floods or floods of specific AEPs, and a freeboard selected for floodplain risk management purposes.

In selecting the FPL consideration was given to the appropriate flood level for which protection to the residential and commercial properties is desired as well as an appropriate freeboard. In the case of Sofala it is recommended that the FPL be the 1% AEP flood level plus a free board of 0.5m.

The 1% AEP flood event was considered as the Planning Flood and the 1986 flood level as the FPL. However the freeboard between the level of the Planning Flood (1% AEP event) and the FPL is between 0.9m and 1m upstream of the bridge. This is considerably higher than the 0.5m freeboard recommended in the Floodplain Development Manual and as such the FPL of 1% AEP flood level plus a free board of 0.5m was considered to be more appropriate for Sofala.

It is recommended that the FPL be the 1% AEP flood level plus a freeboard of 0.5m.

5.3 OPTIONS EXCLUDED

Of the common types of structural Floodplain Risk Management Options canvassed in the *Floodplain Development Manual*, a number were excluded based on preliminary site observation and feedback from community consultation. The excluded options were either clearly impractical when site conditions are taken into account, and/or were not supported by the community.

Levee banks are not considered to be a viable management option. There is insufficient land to accommodate a levee or flood wall on the south bank of the river, and it would destroy the heritage character of the village.

Detention basins on the Turon River were suggested, but are not considered to be a viable option. To be of significant benefit any flood detention structure would have to take the form of a large dam upstream of the village. The limitations of detention basins in this situation are as follows:

- very high cost, which could not economically justified,
- impacts on upstream landowners, as to be effective the basins would need to occupy a large land area,
- DECC does not support the use of on-line basins on major watercourses due to their ecological impact.

Replacement of the main road bridge (Crossley Bridge) was also not considered, due to its high cost. The concrete bridge is ageing however is in a fair to average condition. However, when it does require replacement the opportunity should be taken in the design to reduce its risk of blockage and hydraulic impact on the surrounding properties.

5.4 ASSESSMENT OF OPTIONS

The options have been assessed in terms of their:

- hydraulic effectiveness
- social impact
- economic impact

Further discussion and the results of this assessment are given in the following sections.

5.5 HYDRAULIC IMPACT

The hydraulic impact of vegetation management measures is shown by the results of the sensitivity tests in **Section 3.9**. Selective clearing of vegetation in the entire study reach to reduce the hydraulic roughness to 0.035 in the main channel and also the over banks would reduce flood levels by 0.35 to 1.25 metres. Vegetation management is the only flood control measure which can be implemented at reasonable cost and can effectively reduce, but not eliminate, flooding. However it has the potential to increase the risk of bank erosion and bank instability and these risks should be investigated before action is taken.

It will be necessary to ensure that the clearing is environmentally responsible and can be maintained in the long term, and therefore a Vegetation Management Plan for Sofala is recommended. The VMP for Sofala will also help to satisfy the requirements of the Vegetation Management Act. A draft Brief to prepare a VMP is provided in **Appendix E**.

5.6 SOCIAL AND ENVIRONMENTAL IMPACT

Significant social benefits are expected to accrue from the vegetation management option, by reducing the flood risk and damage to existing buildings in the town.

The community anticipates further benefits by "opening up" the river so that it can be seen by visitors, enhancing the tourism attractions of the village. A common complaint expressed at the community meeting and confirmed on site, is that visitors cannot even see the Turon River at the village due to the dense vegetation.

The recommended Vegetation Management Plan for Sofala will need to ensure that environmental impacts are minimised while achieving sustainable management practices. The vegetation proposed to be cleared are *casuarina*, which are common along inland rivers, and various woody weed species. It is not expected that any sensitive vegetation will be affected.

5.7 ECONOMIC IMPACT

The Vegetation Management option is expected to have an economic benefit to the village by assisting tourism.

A detailed cost-benefit analysis of the options is difficult to prepare at this time due to the limited information available on costs. It is recommended that a cost-benefit analysis form part of the Vegetation Management Plan. A Draft Brief for a VMP for Sofala is attached as **Appendix E**.

6. RECOMMENDATIONS

6.1 DRAFT FRMP

The recommended draft Floodplain Risk Management Plan for Sofala is listed in **Table 9**.

Table 9
Draft Floodplain Risk Management Plan for Sofala

Action	Priority	Indicative Budget Cost Estimate	Social & Environmental Impact	Cost-Benefit Assessment
Remove casuarinas in the immediate upstream vicinity of the bridge to avoid structural damage during large storm events.	High Essential to protect the bridge.	up to $ 10,000	Very positive as this would assist in protecting the bridge in severe storm events. This work refers only to clearing that is needed to protect the bridge from damage and can therefore be justified prior to a VMP being prepared. The VMP may include additional removal.	N/a
Continue debris removal program at Crossley Bridge (see **Photo 1**)	High	On-going	Very positive as this would reduce the likelihood of the bridge waterway being blocked during large storm events.	N/a
Prepare Vegetation Management Plan (VMP) for Sofala and obtain approvals	High	up to $ 40,000	Positive – the VMP is required in order to gain approvals for management actions to reduce flood impacts	Undertake as part of VMP
Improve communication link between Sofala and Upper Turon	High	up to $ 50,000	Very positive - improves accuracy of flood level warnings and provides other social benefits	N/a
Prepare or update emergency management plan (DISPLAN) for Sofala	High	SES and Council staff time	Positive – ameliorate social impact caused by flooding	-

Action	Priority	Indicative Budget Cost Estimate	Social & Environmental Impact	Cost-Benefit Assessment
Confirm and implement development controls as part of revised LEP	High	low – staff time	Ensure that limited development can occur while preventing an increase in flood risk.	-
Conduct survey and flood routing study to relate flood levels at Upper Turon and Sofala. Tie in to AHD.	Medium - High	$ 40,000	Positive – improves accuracy of flood level warnings, facilitates setting of minimum floor levels.	-
Implement VMP following CMA approval	Medium, subject to funding	to be determined	Positive impacts – reduced flooding, improved tourism attractions. Monitor implementation to avoid adverse ecological impacts	-

6.2 IMPLEMENTATION PROGRAMME

Implementation of the VMP will take time to occur, given that it will occur in stages involving commissioning, plan preparation, approval and implementation. Short term actions have been identified for early implementation. Short-term actions are listed in **Table 9.**

Management of the development of flood prone land can be undertaken by a combination of land use restrictions and development controls.

Flood Planning Level

The Flood Planning Level (FPL) defines the limit of land subject to flood-related planning controls. It usually involves a combination of historic floods or floods of specific AEPs, and a freeboard selected for floodplain risk management purposes.

The Floodplain Management Policy adopted by Bathurst Regional Council in 2005 (see Section 2.7) defines flood prone land as either:

- Within the 1% AEP line defined by computer studies and mapping in the Bathurst Urban area, or
- Land which has been flood affected in the 1964, 1986 and/or 1990 floods, or
- Land likely to be affected by inundation from a natural watercourse or drainage channel.

Significantly, the definition also includes all lands outside the 1% AEP flood line but contiguous to it, less than 0.5 metres above the designated flood level.

In the case of Sofala it is recommended that the FPL be the 1% AEP flood level plus a free board of 0.5m.

Planning and development controls should be applied to properties that lie within the limit of the FPL extent.

Flood Information

The Floodplain Management Policy enables Council to provide advice on planning certificates under Section 149(2).

Section 149 certificates of the Environmental Planning and Assessment Regulation, 1994 (EP&A Act) are attached to a contract when a property is sold in NSW. They provide information on whether there are flood related development controls on the land. The wording of these certificates should be clear and unambiguous. Care is required when preparing the wording to ensure that the information is not interpreted by the general public to mean the land is flood free when it is only free of development constraints. This is a common misunderstanding of the threat of extreme event flooding.

Section 149(2) and 149(5) of the EP&A Act provide information on the flood risk.

Section 149(2) Certificates are prescribed within Schedule 4 of the EP&A Act and includes whether or not Council has by resolution adopted a policy to restrict the development of land because of the likelihood of flooding or any other risk.

A Floodplain Management Policy was adopted by Bathurst Regional Council in 2005 (See Section 2.7). This policy relates to flood prone land and can enable Council to provide advice on planning certificates under Section 149(2). Typical sentences sourced from the Floodplain Development Manual (NSW Government, 2005) that may be incorporated on Section 149(2) certificates include:

A property above the flood planning level (FPL)

"Council considers the land in question to be above the flood planning level and therefore its local flood risk management policy does not impose flood related development controls. However, the property may be subject to flooding in very rare flood events. Information relating to this flood risk may be obtained from Council."

A property below the FPL

"Council considers the land in question to be below the flood planning level and therefore subject to flood related development controls. Information relating to this flood risk may be obtained from Council.

Restrictions on development in relation to flooding apply to this land as set out in Council's local flood risk management policy, which is available for inspection at the Council".

Section 149(5) of the Act allows Council to include advice on other relevant matters affecting the land of which it maybe aware.

Where information on various design floods is known
"the information available to Council indicates that the estimated 1% and 0.2% Annual Exceedance Probability (AEP) flood levels are XXX[2] *and YYY respectively. The probable maximum flood or extreme flood level is ZZZ."*

Where only historical information is known

"Flooding to a level of XXX, as determined by debris marks, occurred in the storm event of August 1986". The average chance of a storm of this magnitude happening in any given year is greater than the 1% AEP event.

Hazard

For watercourses not included in the Bathurst Computer Based Flood Model, Council has resolved that low hazard flood areas are those areas affected by 0.5 metre of flood water, or less.

Development Controls

Part 8 of the draft BRC *"Development Control Plan – Villages"* includes proposed development controls for Sofala, based on zones displayed on a map. The development controls are intended to preserve the special visual and historic relationship between the village and the river.

There are also general flood-related development controls under Part 5 of the draft DCP. The following **Table 10** discusses the existing draft provisions and provides recommended changes in wording.

Table 10 Draft Planning and Development Controls

Heading	Existing provisions (Draft DCP)	Recommendations
Part 5 Natural Environment Page 6	*"Council will not approve the residential subdivision of land where…. the land is considered by Council to be affected by the 1% AEP flood . .* "	Retain existing clause.
Part 5 Natural Environment - Land subject to inundation Page 6	". . .the flood of August 1986 has been adopted as the flood standard . . "	Should be changed to "The 1% AEP flood with a freeboard of 0.5m has been adopted as the flood standard".
" "	Freeboard of 0.5 metres above the flood standard with provision for departure where damage potential is low.	The existing clause is confusing. It should read that all new floor levels should be set at 0.5 metres above the flood standard.

[2] Insert appropriate levels relating to the specific property, using data from this Report.

Heading	Existing provisions (Draft DCP)	Recommendations
" "	Flood proofing may be required at the discretion of Council.	Flood proofing should be required for the portion of the structure below the Flood Planning level, unless it conflicts with heritage design guidelines. Electrical fixtures should be placed above the FPL.
" "	Where floor area of extension < 50% of existing area and the floor level of the existing house is above the designated flood level, the floor level of the extension may be constructed to the same level. Where floor area of extension > 50% of existing floor area, the extension is to be constructed with a floor level 500mm above the designated flood level.	Existing clause is confusing. It should read that for floor areas > 50% of existing area, the floor level of the extension is to be constructed a minimum of 500mm above the FPL, otherwise the extension maybe constructed to the existing floor level providing the extension is not within a floodway. Where the extension is within a floodway it must be demonstrated to the satisfaction of Council that there is zero adverse effect on adjacent properties. (This provision is justified in order to minimise impacts on the heritage aspects of the existing village).
" "	No consent will be issued unless the development is capable of withstanding flood water pressure.	No consent will be issued unless the development within the FPL extent is able to withstand the forces of floodwater, debris (including impact) and buoyancy when inundated to the level of the FPL.
		Placement of fill should not increase the flood risk on adjacent properties for floods up to and including the FPL. Filling within a floodway will not be acceptable unless it can be demonstrated to Council's satisfaction that there would be zero increase in flood risk for adjacent properties.
Part 5 Natural Environment - Land subject to inundation Page 7	At the request of Council a flood impact assessment may be required.	Flood impact assessment to be required for all land that is flooded by more than 0.5 metre in the 1% AEP event.

7. REFERENCES

1. Bathurst Regional council (2005a), “Floodplain Management Policy”, Minute Book No. 9495
2. Bathurst Regional Council (2005b), “Development Control Plan – Rural Lands”, adopted 20 April 2005
3. Bathurst Regional Council (?) “Development Control Plan – Village”, undated draft
4. DLWC (2000), "Geomorphology and Hydrology of the Turon River", December.
5. DNR (2006), "Pinneena, version 9", software and HYDSYS database
6. Engineers Australia (1998), “Australian Rainfall and Runoff”.
7. HEC (2002), "HEC-RAS, River Analysis System, User's Manual", US Army Corps of Engineers, Hydrologic Engineering Centre, CA, U.S.A.
8. NSW Government (2005), “Floodplain Development Manual", April.
9. SKM (2005), "Lower Parramatta River Floodplain Management Study and Plan", August
10. SMEC (2003), “Georges and Sofala Flood Scoping Study – Final Report: Sofala", for Evans Shire Council.
11. Evans Shire Council (1987), Interim Floodplain Management Policy

APPENDIX A

HYDROLOGY

Sofala is located on the Turon River, a tributary of the Macquarie River. The Turon River at Sofala has a catchment area of 883 square kilometres. It has a history of flooding with the largest recorded flood occurring in August 1986.

A.1 PREVIOUS HYDROLOGIC STUDY

The following information is reproduced from the Flood Scoping Study report on Sofala by SMEC (2003).

HISTORICAL FLOODS

The largest flood ever recorded at the Sofala gauge, GS 421026 occurred on 6 August, 1986. It has been adopted for the calibration of the hydraulic model and used as a basis for subsequent model runs in this study. **Table A.1** lists the ten largest floods recorded at Sofala, in chronological order.

Table A.1
Ten largest floods from recorded at GS 421026 on the Turon River at Sofala

Date	Estimated Peak Discharge (ML/d)
Feb 1955	41,600
Jan 1974	49,800
Jan 1976	67,200
Jul 1984	38,300
Aug 1986	158,800
Apr 1989	36,900
Apr 1990	60,000
Jul 1990	57,900
Aug 1990	91,100
Aug 1998	38,500

FLOW ESTIMATES FROM RATING CURVE

The rating curve at GS 421026 is shown in **Figure A.1**. The stage reached a maximum value of 9.19m during the August 1986 flood event with an estimated peak discharge of 158,800 ML/d. While this value is adopted for this study, there are some qualifications on this, as discussed below.

The maximum gauged stage used in developing the rating curve was 7.12m with an estimated discharge of 81,300 ML/d. The rating curve shows that the majority of gaugings have been taken below a stage of about 4m and only two gaugings, both taken on 06/08/1986, were recorded at higher stages.

With only a small number of gaugings available at high flows, and the rating curve being extrapolated by over 2m beyond the last gauging, there are large confidence limits on the extrapolation of the rating curve and a high degree of uncertainty involved in the discharge estimates. As new data becomes available and a revised rating curve is developed, the accuracy of flow estimates is likely to improve.

FLOOD FREQUENCY ANALYSIS

A flood frequency analysis of the gauging station records was undertaken where mathematical distributions were fitted to both partial series and annual series data. The methods used are based on those described in detail in *Australian Rainfall and Runoff* (IEAust, 1998). Plots of the flood frequency analyses for annual and partial series are shown in **Figures A.2 and A.3** respectively.

The results from a flood frequency analysis conducted on partial series will generally vary to those obtained using annual series. However the difference in results is relatively small when the Average Recurrence Interval (ARI) is greater than about 10 years (IEAust, 1998). When the ARI is less than 10 years, the partial series is preferred as it includes many of the smaller floods that are disregarded by the annual series.

For the annual series, the Log-Pearson Type 111 (LPIII) distribution was adopted as it is the recommended distribution for general use when applied to annual series data (IEAust, 1998). For the partial series a negative exponential distribution was initially fitted to the data by plotting the data on semi-log paper and fitting a straight line. However, a better fit was obtained by using the LPIII distribution and was adopted for this study.

The results of the flood frequency analyses indicate that, using the LPIII distribution adopted for this study, the August 1986 flood event had an ARI greater than 100 years (AEP < 1%). **Table A.2** below shows the results of the flood frequency analysis using annual series for a range of design floods. It should be noted that there is a large range in values between the two confidence limits for larger flows. Accordingly, great care should be taken in quoting flows or ARIs for floods at Sofala. As noted previously, the flood frequency analysis will be significantly improved as more gauging data is available to extend the rating curve at GS 421026.

Table A.2: Flood Frequency Analysis Results - annual series

Average Recurrence Interval (years)	Annual Exceedance Probability	Flow (ML/d)		
		5% Confidence Limit	LP111 Fitted Distribution	95% Confidence Limit
100	1%	51,700	122,900	291,900
20	5%	47,800	75,800	120,200
10	10%	39,000	54,600	76,400

A.2 REVIEW OF GAUGING DATA

The HEC-RAS model was verified for the recorded flood in November 2005. During this process, several points were noted:

The original model is based on a survey done in 2003, nearly 20 years after the flood. The river has a mobile bed and river conditions such as vegetation thickness and hydraulic roughness, are reported to have changed since 1986.

Accordingly the gauging station rating curves for the Turon River gauge no. 421026 (DNR, Pineena Version 9) were reviewed. This review showed that the river bed level has apparently risen due to either natural or man-made influences. The reported cease-to-flow level increased from 1.30m (10/10/1986) to 1.80m in 19/03/1987. An analysis of the station rating curves and historical gaugings over different time periods since commencement in 1949 was undertaken using HYDSYS, and is shown in **Figure A.1**.

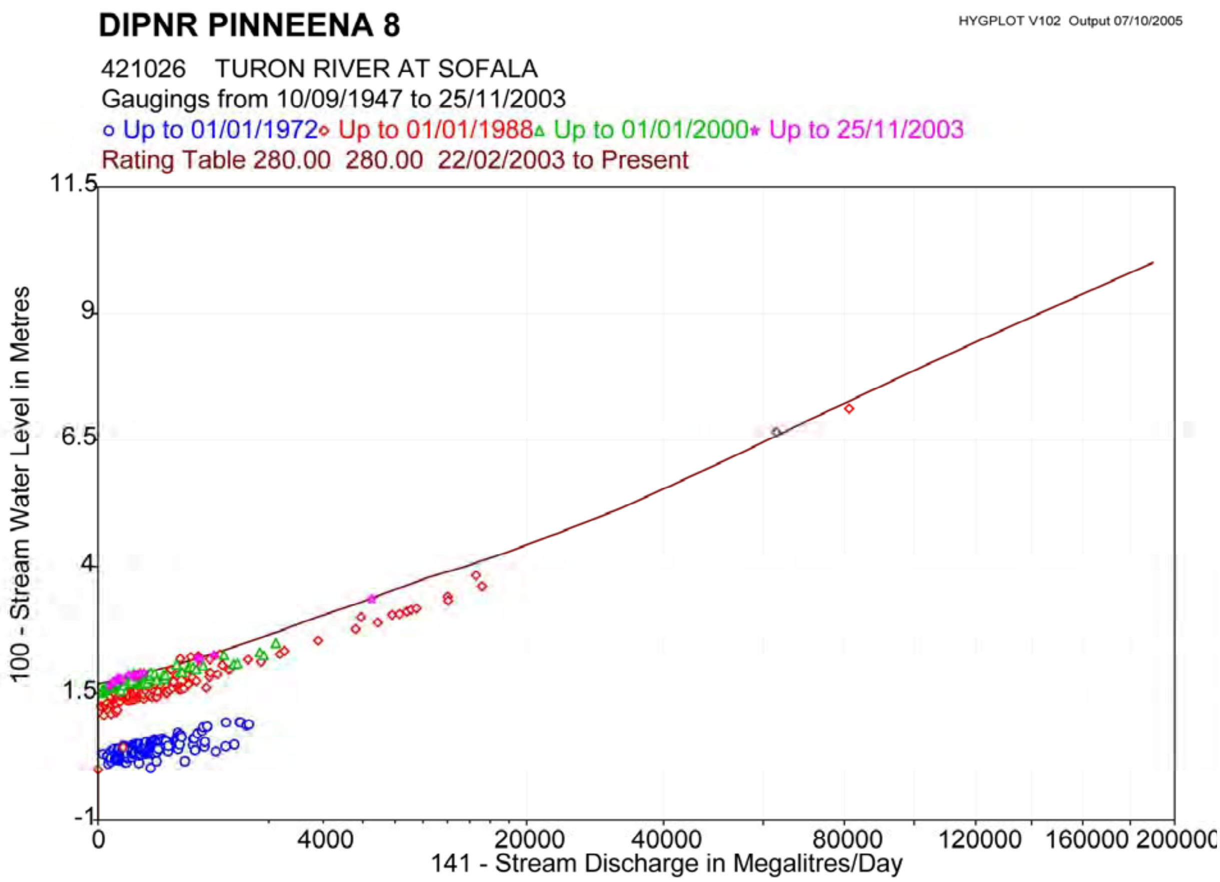


Figure A.1 Plot of Gaugings by Time, Station 421026

The plot clearly shows that the zero-discharge or "cease-to-flow" gauge level has risen over time. The lowest levels occurred before 1972 (blue circles). Since that time the plotted values have steadily risen to 1988 (red circles), 2000 (blue circles) and finally 2003 (mauve circles).

The station history mentions several instances of the equipment being destroyed or moved after floods. On 25/3/1986, there is a remark *"Bulldozers had scoured the bed and control"*.

The station records are accepted as being reliable because it is regularly re-gauged. However, there is a lack of flow gaugings at high flows. The change in bed levels is mainly a concern for the hydraulic modelling and is discussed in **Appendix B.**

An additional 2 years of data are now available from the Turon River gauge at Sofala. This data included a record of a small flood that occurred in November 2005, not long before the community consultation meeting. The gauged flow is shown in **Figure A.1** and the state of the river after the flood is shown in the photographs. The November 2005 event had a measured peak discharge of 32,000 ML/d which is estimated to be about a 5 year ARI (20% AEP).

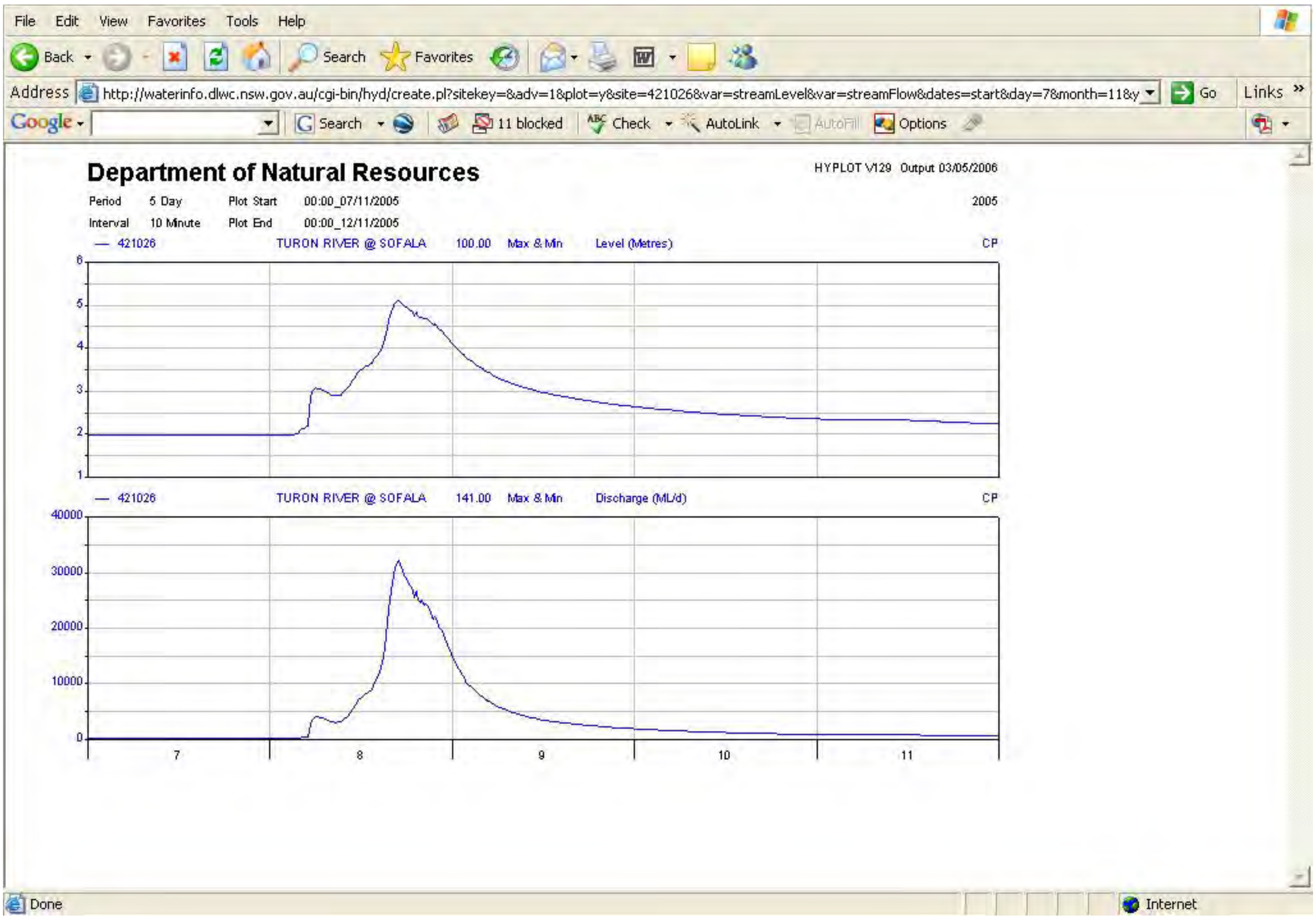


Figure A.2 Gauge Record, Flood of 8 November 2005
(Source: DNR website)

Turon River at Sofala Gauge. Date 21/11/2005

The additional 2 years of data is not significant in terms of the flood frequency analysis, and accordingly the Flood Frequency analysis has not been updated. The estimates in **Table 3** of the report text have been adopted as the most reliable discharge estimates available for this study.

SMEC (2003) noted the large uncertainty in estimates of high flow due to extrapolation of the rating curve. The uncertainty range of flow estimates is given in **Table A.2**. The suggested method of reducing this uncertainty is to undertake more gaugings during periods of high flow.

APPENDIX B

HYDRAULIC MODELLING

B.1 INTRODUCTION

Hydraulic modelling of the Turon River at Sofala was undertaken for the Scoping Study (SMEC 2003) by establishing a steady-state one-dimensional hydraulic model using the HEC RAS computer program. Survey information was supplied by Council. Calibration of the model was undertaken using the August 1986 flood event and then the model was run for the following design flood events:

- an extreme flood event;
- flood at which overfloor flooding of dwellings commences; and
- flood at which overfloor flooding of dwellings or additional structures (sheds and toilet at Sofala Royal Hotel) commences.

A sensitivity analysis was then undertaken to help assess the effects that vegetation may have on flooding. Details of the hydraulic investigation are described below.

B.2 DESCRIPTION

The following description is reproduced from the Scoping Study.

The Hydrologic Engineering Center River Analysis System (HEC-RAS) is public domain software, developed by the U.S. Army Corp of Engineers for carrying out steady or unsteady flow analyses of river systems (HEC, 2002).

The steady flow model was used for the 2003 Scoping Study. It is based on the solution of the one-dimensional energy equation for gradually varied flow and the momentum equation in situations where there is rapidly varied flow such as at bridges, hydraulic jumps, and stream junctions.

Other features include:

- modelling of bridges with provisions for multiple openings, piers, contraction and expansion losses, as well as overtopping of the bridge;
- culverts;
- ineffective flow areas;
- blocked obstructions;
- skewed cross sections;
- levees; and
- bridge scour computations.

Some new features of the unsteady flow component in the latest HEC-RAS 3.1.1 include:
dam-break analysis;

- levee breaching;
- mixed flow regime;
- pump stations;
- navigation dams;
- culvert flap gates; and
- floodway encroachments.

B.3 MODEL CALIBRATION

Surveyed flood levels from the August 1986 flood were used to calibrate the HEC-RAS model. A water surface profile along the main channel showing the results of the calibration is shown in **Figure B.1**. The profile shows a close match in the flood slope between the recorded and simulated results. **Table B.1** shows the simulated and historic flood levels for the August 1986 flood event.

The flood levels also indicate that a good calibration was achieved in the Scoping Study with 100% of the model results within 0.15m of the historic flood levels. It should be noted that the model results indicate flooding just over the deck of the Crossley Bridge (RL 164 to 164.5 m).

Table B.1: Comparison of simulated and historic flood levels – August 1986 flood (Source: based on SMEC 2003)

River Station (m)	Flood Level (m)		
	Simulated	Historic	Error
1174	165.03	164.97	+ 0.06
1262	165.25	165.10	+ 0.15
1270	165.27	165.25	+ 0.02
1673	166.62	166.77	- 0.15

During our review, several points were noted.

- The original model is based on a survey done in 2003, nearly 20 years after the 1986 flood. The river has a mobile bed and its level may have changed since 1986.
- river conditions ie vegetation thickness and hydraulic roughness, are reported to have changed since 1986.

SMEC noted that the hydraulic roughness used to achieve calibration (n =0.035 between the bridge and cross-section 1179) was at the low end of the expected range for the observed river conditions. Cardno concur with this opinion although the river conditions at the time of the August 1986 flood may have been less vegetated than at the present date. We consider that the roughness value for 2005 conditions should be not less than n = 0.04.

The reason for having to use this low roughness value for calibration may also be partly due to the river having aggraded since 1986 (see discussion in Appendix A). This uncertainty cannot be tested as no cross-section surveys are available from 1986.

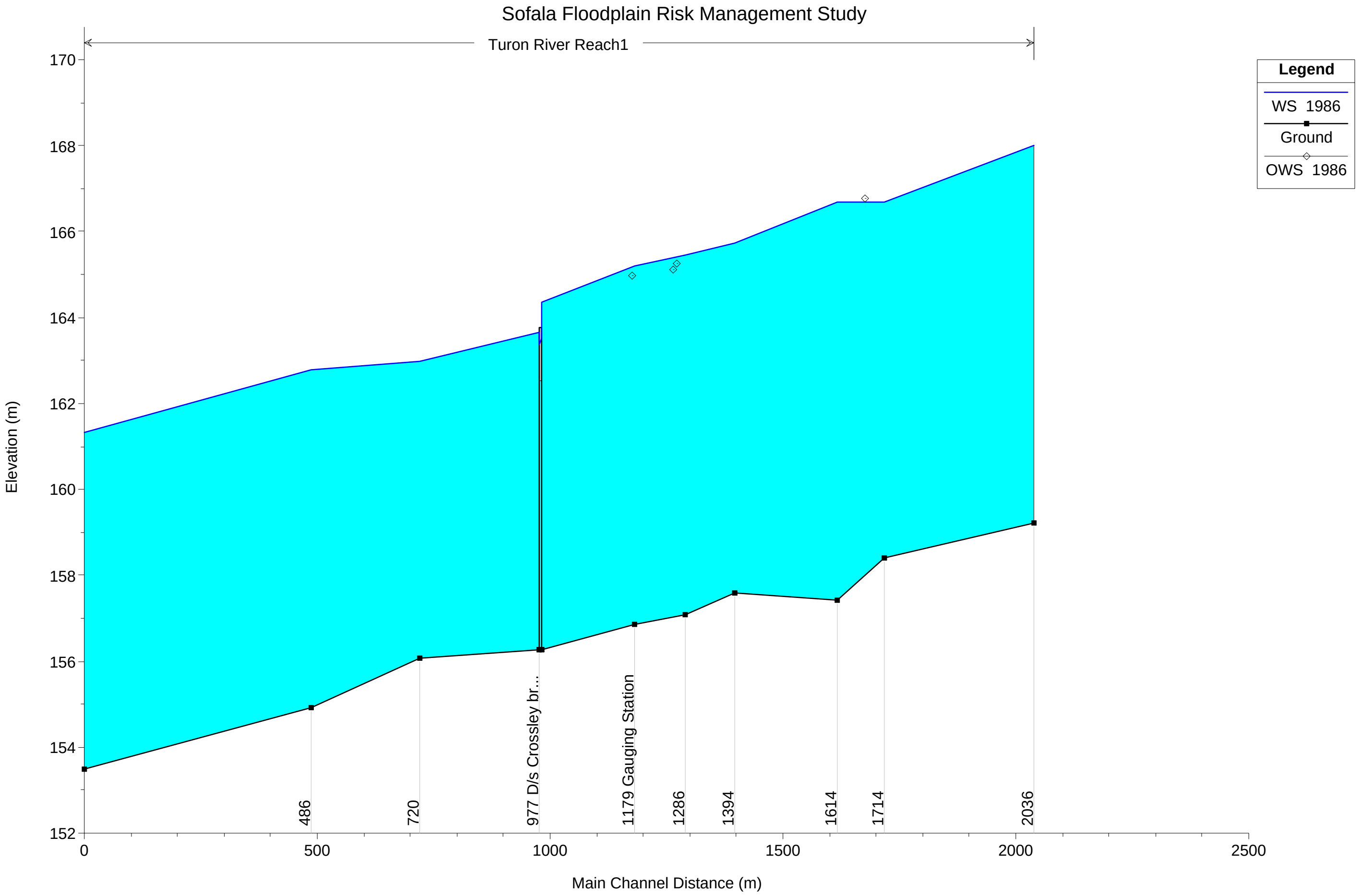


Figure B.1 Calibration Water Surface Profile August 1986 Flood

B.4 VERIFICATION, REVIEW AND RE-RUNNING OF HYDRAULIC MODEL

The hydraulic model has been reviewed by Cardno Willing to ensure that it is suitable for the purposes of this study.

To improve the usefulness and presentation of results, the model plan geometry was converted to MGA Zone 55 coordinates by reference to GIS data. This does not affect the model calibration.

Verification

The Hec-RAS model was verified for the recorded flood in November 2005. The verification model used 2003 survey geometry, and it is considered to be representative of hydraulic conditions up to the present time (2006). No significant flood events which could have reworked the river bed occurred between 2003 and November 2005, the time generally being one of drought in the mid-west of NSW.

Table B.2: Comparison of simulated and historic flood levels – November 2005 flood

River Station (m)	Flood Level (m)		
	Simulated	Historic	Error
1179 – Gauging station	160.93	160.9 (see note)	+ 0.03

Note: Gauge zero assumed to be at level 155.8.

Based on the limited data and assumptions, this single result indicates that the model is reliable.

B.5 DESIGN EVENT RUNS

The model with 2003 geometry was re-run for design events of a range of probabilities, using the peak flows set out in **Table 2**.

The resulting Design Event Flood Levels are listed in **Tables B.3 to B.6**. As with all other levels quote din this study, the tabulated flood levels are to an arbitrary datum.

Table B.3
1% AEP Design Event Flood Levels

	River Station (m)	Profile	Q Total (m3/s)	Min Ch El (m)	Steady W.S. Elev (m)
Reach1	2036	100 YR	1423	159.23	167.10
Reach1	1714	100 YR	1423	158.41	165.74
Reach1	1614	100 YR	1423	157.43	165.69
Reach1	1394	100 YR	1423	157.59	164.79
Reach1	1286	100 YR	1423	157.09	164.46
Reach1	1179	100 YR	1423	156.87	164.16
Reach1	983	100 YR	1423	156.26	163.43
Reach1	980		Bridge		
Reach1	977	100 YR	1423	156.26	163.02
Reach1	720	100 YR	1423	156.06	162.29
Reach1	486	100 YR	1423	154.93	162.10
Reach1	0	100 YR	1423	153.50	160.66

Table B.4
2% AEP Design Event Flood Levels

	River Station (m)	Profile	Q Total (m3/s)	Min Ch El (m)	Steady W.S. Elev (m)
Reach1	2036	50 YR	1192	159.23	166.55
Reach1	1714	50 YR	1192	158.41	165.16
Reach1	1614	50 YR	1192	157.43	165.07
Reach1	1394	50 YR	1192	157.59	164.18
Reach1	1286	50 YR	1192	157.09	163.81
Reach1	1179	50 YR	1192	156.87	163.5
Reach1	983	50 YR	1192	156.26	162.83
Reach1	980		Bridge		
Reach1	977	50 YR	1192	156.26	162.58
Reach1	720	50 YR	1192	156.06	161.8
Reach1	486	50 YR	1192	154.93	161.57
Reach1	0	50 YR	1192	153.50	160.16

Table B.5
5% AEP Design Event Flood Levels

	River Station (m)	Profile	Q Total (m3/s)	Min Ch El (m)	Steady W.S. Elev (m)
Reach1	2036	20 YR	877	159.23	165.74
Reach1	1714	20 YR	877	158.41	164.31
Reach1	1614	20 YR	877	157.43	164.16
Reach1	1394	20 YR	877	157.59	163.30
Reach1	1286	20 YR	877	157.09	162.93
Reach1	1179	20 YR	877	156.87	162.59
Reach1	983	20 YR	877	156.26	162.05
Reach1	980		Bridge		
Reach1	977	20 YR	877	156.26	161.88
Reach1	720	20 YR	877	156.06	161.13
Reach1	486	20 YR	877	154.93	160.83
Reach1	0	20 YR	877	153.50	159.46

Table B.6
10% AEP Event Flood Levels

	River Station (m)	Profile	Q Total (m3/s)	Min Ch El (m)	Steady W.S. Elev (m)
Reach1	2036	10 YR	632	159.23	165.02
Reach1	1714	10 YR	632	158.41	163.54
Reach1	1614	10 YR	632	157.43	163.34
Reach1	1394	10 YR	632	157.59	162.51
Reach1	1286	10 YR	632	157.09	162.12
Reach1	1179	10 YR	632	156.87	161.78
Reach1	983	10 YR	632	156.26	161.32
Reach1	980		Bridge		
Reach1	977	10 YR	632	156.26	161.20
Reach1	720	10 YR	632	156.06	160.52
Reach1	486	10 YR	632	154.93	160.16
Reach1	0	10 YR	632	153.50	158.81

The flood levels, estimated flood extent, preliminary flood hazard rating and hydraulic categories for the 1% AEP flood are shown in **Figures 7 to 12** in the report text. Other figures have been prepared to show the calculated flow distribution (**Figure B.1**) and velocities (**Figure B.2**).

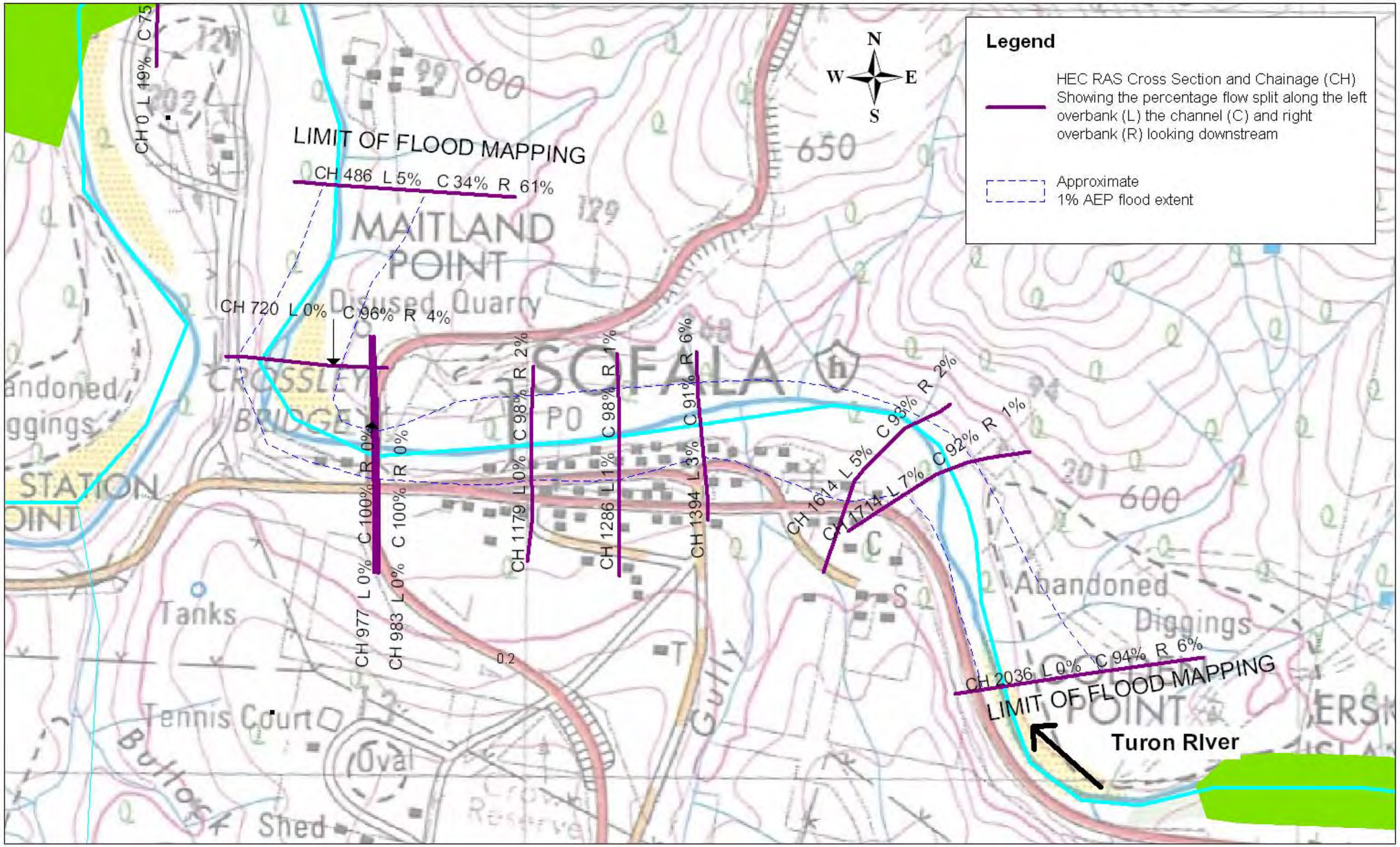


FIGURE B.1 1% AEP Flow Distribution

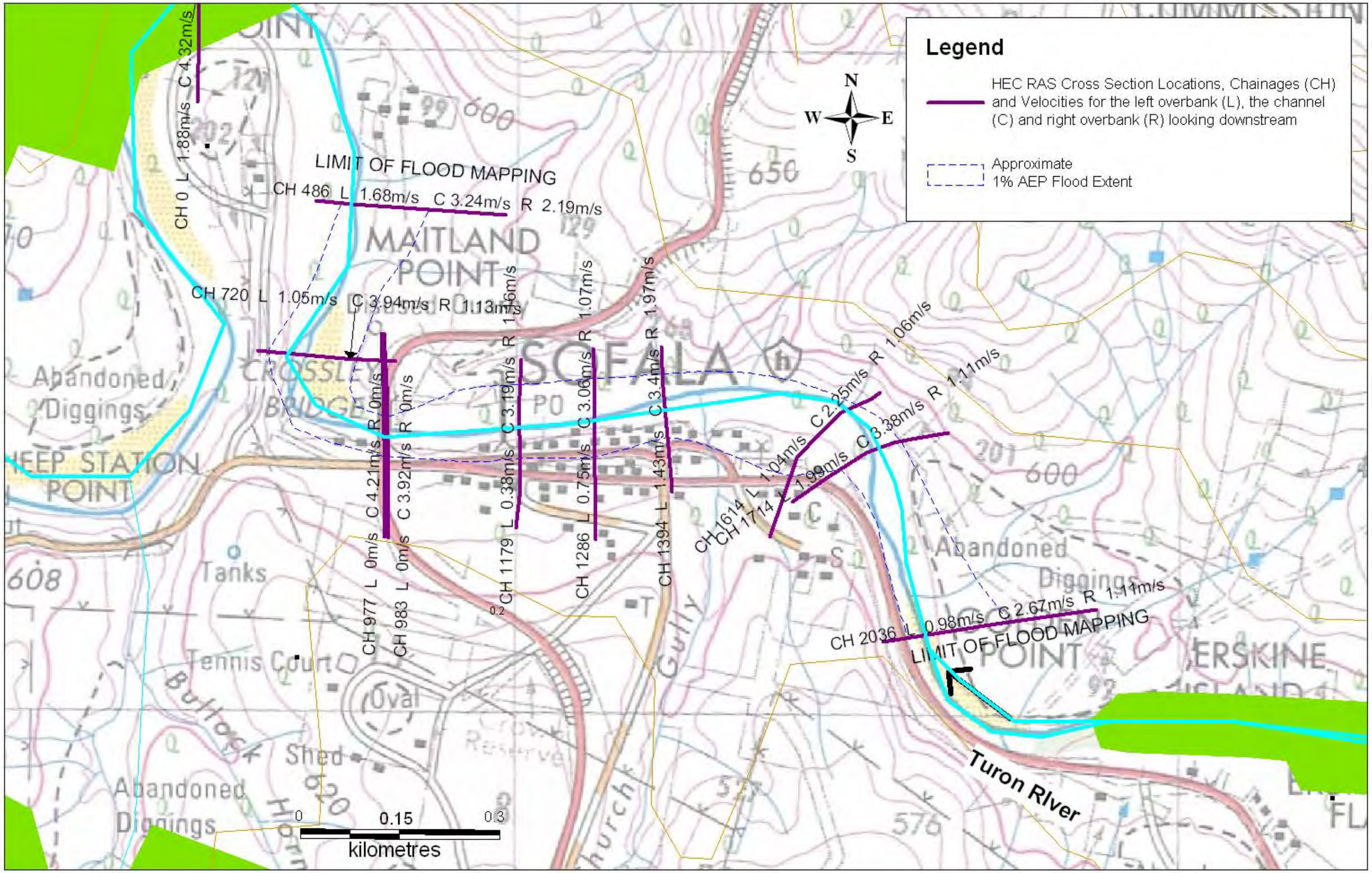


FIGURE B.2 1% AEP VELOCITY DISTRIBUTION

B.6 SENSITIVITY TESTS

A series of sensitivity tests were undertaken using the model.

Steady-State vs. Unsteady modelling

The Hec-RAS model was run in version 3.1.3 software for the November 2005 flood case, using both steady flow analysis and unsteady flow analysis. The unsteady flow values were read from the gauge plot (**Figure A.1**) at 4-hour intervals, and a 30 minute time step was used in the modelling. Results are shown below.

Table B.7 Effect of using Unsteady Analysis Method

	River Station (m)	Profile	Q Total (m3/s)	Min Ch El (m)	Steady W.S. Elev (m)	Unsteady W.S. Elev (m)
Reach1	2036	Nov2005	370.00	159.23	164.072	164.062
Reach1	1714	Nov2005	370.00	158.41	162.556	162.543
Reach1	1614	Nov2005	370.00	157.43	162.293	162.280
Reach1	1394	Nov2005	370.00	157.59	161.452	161.424
Reach1	1286	Nov2005	370.00	157.09	161.046	161.030
Reach1	1179	Nov2005	370.00	156.87	160.700	160.679
Reach1	983	Nov2005	370.00	156.26	160.334	160.330
Reach1	980		Bridge			
Reach1	977	Nov2005	370.00	156.26	160.259	160.211
Reach1	720	Nov2005	370.00	156.06	159.693	159.596
Reach1	486	Nov2005	370.00	154.93	159.230	159.083
Reach1	0	Nov2005	370.00	153.50	157.890	157.825

The resulting flood levels upstream of the bridge differed by only 1 to 2 centimetres, the unsteady analysis results being slightly lower. It is concluded that steady-state modelling is sufficiently accurate the purposes of this study and therefore it has been retained.

Sensitivity to Bed Aggradation

The effects of river bed aggradation have been tested in the Hec-RAS model, by applying an assume dries of 0.3 metre in the bed level between Crossley Bridge (river station 980) and river station 1714 at the upstream end of the town reach.

Results are shown in **Tables B.8 to B.12**.

Table B.8
Sensitivity of 1% AEP Flood Levels to River Bed Aggradation

This table shows the effects of riverbed aggradation within the reach between Crossley Bridge (river station 980) and river station 1714.

	River Station (m)	Profile	Q Total (m3/s)	Min Ch El (m)	Steady W.S. Elev (m)	Diff to Existing (m) †
Reach1	2036	100 YR	1423	159.23	167.11	+ 0.01
Reach1	1714	100 YR	1423	158.41	165.75	+ 0.01
Reach1	1614	100 YR	1423	157.43	165.70	+ 0.01
Reach1	1394	100 YR	1423	157.59	164.80	+ 0.01
Reach1	1286	100 YR	1423	157.09	164.46	0
Reach1	1179	100 YR	1423	156.87	164.16	0
Reach1	983	100 YR	1423	156.26	163.42	0
Reach1	980		Bridge			
Reach1	977	100 YR	1423	156.26	163.02	0
Reach1	720	100 YR	1423	156.06	162.29	0
Reach1	486	100 YR	1423	154.93	162.10	0
Reach1	0	100 YR	1423	153.50	160.66	0

Note: † positive value indicates a rise in flood levels

Table B.9
Sensitivity of 1% AEP Flood Levels to River Bed Aggradation

This table shows the effects of riverbed aggradation on the entire modelled reach.

	River Station (m)	Profile	Q Total (m3/s)	Min Ch El (m)	Steady W.S. Elev (m)	Diff to Existing (m) †
Reach1	2036	100 YR	1423	159.23	167.12	+ 0.02
Reach1	1714	100 YR	1423	158.41	165.76	+ 0.02
Reach1	1614	100 YR	1423	157.43	165.71	+ 0.02
Reach1	1394	100 YR	1423	157.59	164.82	+ 0.03
Reach1	1286	100 YR	1423	157.09	164.49	+ 0.03
Reach1	1179	100 YR	1423	156.87	164.19	+ 0.03
Reach1	983	100 YR	1423	156.26	163.47	+ 0.04
Reach1	980		Bridge			
Reach1	977	100 YR	1423	156.26	163.05	+ 0.03
Reach1	720	100 YR	1423	156.06	162.31	+ 0.02
Reach1	486	100 YR	1423	154.93	162.12	+ 0.02
Reach1	0	100 YR	1423	153.50	160.68	+ 0.02

Note: † positive value indicates a rise in flood levels

Sensitivity to Hydraulic Roughness

Table B.10
Sensitivity of 1% AEP Flood Levels to Hydraulic Roughness

Mannings ‘n’ reduced to 0.035 along the main channel.

	River Station	Profile	Q Total (m3/s)	Min Ch El (m)	Steady W.S. Elev (m)	Diff to Existing (m) †
Reach1	2036	100 YR	1423	159.23	165.93	-1.17
Reach1	1714	100 YR	1423	158.41	164.64	-1.10
Reach1	1614	100 YR	1423	157.43	164.88	-0.81
Reach1	1394	100 YR	1423	157.59	164.06	-0.73
Reach1	1286	100 YR	1423	157.09	164.04	-0.42
Reach1	1179	100 YR	1423	156.87	163.85	-0.31
Reach1	983	100 YR	1423	156.26	163.15	-0.28
Reach1	980		Bridge			
Reach1	977	100 YR	1423	156.26	162.75	-0.27
Reach1	720	100 YR	1423	156.06	162.08	-0.21
Reach1	486	100 YR	1423	154.93	161.93	-0.17
Reach1	0	100 YR	1423	153.50	160.36	-0.30

Note: † positive value indicates a rise in flood levels

Clearing the vegetation in the river indicated that flood levels would reduce up to 1.17m (at chainage 2036).

Table B.11
Sensitivity of 1% AEP Flood Levels to Hydraulic Roughness

Mannings ‘n’ reduced to 0.035 along the main channel and overbank areas.

	River Station	Profile	Q Total (m3/s)	Min Ch El (m)	Steady W.S. Elev (m)	Diff to Existing (m) †
Reach1	2036	100 YR	1423	159.23	165.85	-1.25
Reach1	1714	100 YR	1423	158.41	164.60	-1.14
Reach1	1614	100 YR	1423	157.43	164.82	-0.87
Reach1	1394	100 YR	1423	157.59	164.07	-0.72
Reach1	1286	100 YR	1423	157.09	164.00	-0.46
Reach1	1179	100 YR	1423	156.87	163.81	-0.35
Reach1	983	100 YR	1423	156.26	163.08	-0.35
Reach1	980		Bridge			
Reach1	977	100 YR	1423	156.26	162.62	-0.4
Reach1	720	100 YR	1423	156.06	161.69	-0.6
Reach1	486	100 YR	1423	154.93	161.67	-0.43
Reach1	0	100 YR	1423	153.50	160.20	-0.46

Note: † positive value indicates a rise in flood levels

Table B.12
Sensitivity of 1% AEP Flood Levels to Hydraulic Roughness

Mannings ‘n’ increased to 0.065 along the main channel and overbank areas.

	River Station	Profile	Q Total (m3/s)	Min Ch Elevation (m)	Steady W.S. Elev (m)	Diff to Existing (m) †
Reach1	2036	100 YR	1423	159.23	167.63	+ 0.53
Reach1	1714	100 YR	1423	158.41	166.66	+ 0.92
Reach1	1614	100 YR	1423	157.43	166.63	+ 0.94
Reach1	1394	100 YR	1423	157.59	166.09	+ 1.30
Reach1	1286	100 YR	1423	157.09	165.94	+ 1.48
Reach1	1179	100 YR	1423	156.87	165.76	+ 1.60
Reach1	983	100 YR	1423	156.26	165.17	+ 1.74
Reach1	980		Bridge			
Reach1	977	100 YR	1423	156.26	164.32	+ 1.30
Reach1	720	100 YR	1423	156.06	163.50	+ 1.21
Reach1	486	100 YR	1423	154.93	163.07	+ 0.97
Reach1	0	100 YR	1423	153.50	161.86	+ 1.20

Note: † positive value indicates a rise in flood levels

Sensitivity to Bridge Waterway Blockage

A run was undertaken to test what impact debris blocking the bridge would have on water levels. To represent blockage two alternatives were considered:

- 30% obstruction was applied to the cross sections immediately upstream and downstream of the bridge.
- A debris factor was applied to all the piers at the Crossley Bridge.

The results are presented in **Table B.13** and show that a 30% blockage of the Crossley Bridge results in an increase of flood levels by up to 1.16m upstream of the bridge and a reduction in water levels immediately downstream. A 2m width of debris collecting on the bridge piers was found to increase flood levels by 0.06m immediately upstream of the bridge.

Table B.13 1% AEP flood levels with 30% blockage of the Upstream and Downstream Cross-section and with debris collecting on the bridge.

Chainage (m) (see Figure 4)	1% AEP Flood	1% AEP Flood Level with 30% blockage of upstream and downstream bridge cross sections	Change due to blockage (m)	1% AEP Flood Level with debris collecting on piers of bridge	Change due to blockage (m)
2036	167.10	167.30	0.20	167.11	0.01
1714	165.74	166.25	0.51	165.75	0.01
1614	165.69	166.24	0.55	165.7	0.01
1394	164.79	165.62	0.83	164.81	0.02
1286	164.46	165.45	0.99	164.49	0.03
1179	164.16	165.32	1.16	164.2	0.04
983	163.43	164.19	0.76	163.49	0.06
980 *	Bridge				
977	163.02	162.91	-0.11	163.02	0
720	162.29	162.29	0.00	162.29	0
486	162.10	162.10	0.00	162.1	0
0	160.66	160.66	0.00	160.66	0

* Chainage 980 is the location of Crossley Bridge

APPENDIX C

COMMUNITY CONSULTATION

C.1 CONSULTATION MEETINGS

A meeting was held at the Sofala Community Centre in the evening of 21st November 2005. Residents were invited by means of notices issued by Council and placed in the community.

Attendance at the Sofala Floodplain Management Community Consultation Meeting 21 Nov 05, 7:00 - 9:30pm

Name	Address	On mailing list?
Chris Clark	Clarks Real Estate Pty Ltd 3603 Limekilns Road Whiteflat	Yes
Sandra Tomkinson	Royal Hotel Sofala NSW 2795	Yes
Jane Hawley	4 Denison St Sofala NSW 2795	Yes
Ron Heferen	98 Bowen St Sofala NSW 2795	Yes
Norman Dodds	40 Denison St Sofala NSW 2795	Yes
Marty Tomkinson	Sofala Royal Motel NSW 2795	Yes
Harvey Personage	Roxburgh' Upper Turon Sofala NSW 2795	Yes
Siva Varathan	DECC PO Box 717 Dubbo NSW 2830	Yes
Wayne Sartori	Bathurst Regional Council	
Jillian Reeves	Bathurst Regional Council	
Louise Howells	Cardno Willing	
Robert Spry	Cardno Willing	

Comments and Feedback

	Possible Options	Suggested Location & Comments
Post Office Residence - Denison St, Sofala	Retarding or detention basins	
	Channel widening or deepening	Removal of gravel from river bed in village area
	Levee banks	
	Vegetation management	Removal of trees etc from main channel
	Bridge modifications	
	Planning controls	
	Voluntary house raising or purchase	
	Improvements to emergency management	
Turon Valley, 4419 Sofala Rd, Sofala	Retarding or detention basins	Such earthworks would have to be truly massive to avert the problems of major flood events, and in normal times would then prevent normal flows unless further active engineering was undertaken to ensure such flows. This option seems like overkill for a very rare event.

	Channel widening or deepening	This seems like a short term measure since siltation would eventually return the level to its present level
	Levee banks	In the village I don't believe there would be room to build a levee. They might be possible to protect houses out of town, but would detract from the visual amenity of the district.
	Vegetation management	It's significant that the densest growth of casuarinas is along the river where past clearing by bulldozer was done after the 1986 flood. Proper clearing and poisoning along a narrow width of the centre of the river could help, but clearing of the entire bed would cause greater long term problems from erosion.
	Bridge modifications	The parish map shows a dotted line on the north bank of the river near the bridge which indicates the old river bank. I can only guess that in a cost-saving exercise when the bridge was built the banks were extended in order to eliminate one extra span of the bridge. The river was thus (and remains) artificially choked at the bridge. It would be costly, but returning the banks to their original dimensions and extending/rebuilding the bridge should be considered. Although not part of the flood study, the adequacy of the Crossley Bridge should be considered from a transport perspective. It sits at the bottom of two steep hills on an increasingly busy highway. With tourism rising there is no pedestrian access on the bridge, making it a very hazardous location. Perhaps RTA should be consulted about its capacity.
	Planning controls	There should be restrictions on building or extending residential structures on flood prone land.
	Voluntary house raising or purchase	Not being affected since we do not live on flood prone land I feel unable to comment.
	Improvements to emergency management	Past experience shows that the emergency response was quite satisfactory during flooding.
Royal Hotel, Sofala	Retarding or detention basins	No, not feasible
	Channel widening or deepening	Yes, particularly through the village
	Levee banks	No, would cause extra problems
	Vegetation management	Yes, First crossing to Wallaby Rocks
	Bridge modifications	No
	Planning controls	Not applicable
	Voluntary house raising or purchase	Not feasible
	Improvements to emergency management	Already well taken care of within community

Bathurst Regional Council
Notice of Meeting—Sofala Floodplain Management Study

Engineering Services Department
Cnr Russell & William Streets
Bathurst

Phone: 6333 6100
Fax: 6333 6115

Council advises that a meeting to discuss the Sofala Floodplain Management Study has been arranged and Council invites all interested residents to attend this meeting. Council wants to inform the residents of progress to date, program for completion of the study and formation of Floodplain Management Committee.

Council will meet directly with residents at the meeting and have representatives from Department of Natural Resources and SES in attendance.

Date	Time	Location	Projects to be discussed
21 November 2005	7.00pm	Sofala—Sofala Community Hall	Sofala Flood Study

If you would like to know what is the future of Floodplain Management in Sofala and cannot get to the meeting please feel free to ring or write to Bathurst Regional Council, General Manager and we will send information to you.

Phone 02 6333 6100
Post PMB 17 Bathurst 2795
Fax 02 6333 6115
Email council@bathurst.nsw.gov.au

BATHURST
REGIONAL COUNCIL

Civic Centre
Cnr Russell & William Sts
Private Mail Bag 17
Bathurst NSW 2795

Telephone 02 6333 6111
Facsimile 02 6331 7211
council@bathurst.nsw.gov.au
www.bathurst.nsw.gov.au

15 August 2006

Mr Robert Spry
Cardno Willing
Level 3 910
Pacific Highway
GORDON NSW 2072

Dear Mr Spry

Sofala Floodplain Management Committee Minutes and Comments

Please find **attached** a copy of the minutes, of the Sofala Floodplain Management Committee Meeting held on the 11 August 2006.

Yours faithfully

Neil Allen
DIRECTOR
ENGINEERING SERVICES

Reference: WRS:SN:07.00076
Enquiries: Mr Wayne Sartori 02 6333 6226

SOFALA FLOODPLAIN MANAGEMENT COMMITTEE

MEETING HELD ON FRIDAY 11 AUGUST 2006

Members: Harvey Parsonage (Community Representative)
Marty Tomkinson (Community Representative)
Norm Dodds (Community Representative)
Craig Ronan (NSW State Emergency Service (SES))
Cr P Haysom (Council Representative)

Secretariat: Manager Technical Services (MTS)
Technical Services Assistant

THE COMMITTEE RECOMMENDS

The meeting commenced at 10:40am in the Sofala Panners Inn

1. APOLOGIES Siva Varathan (Department of Natural Resources (DNR))
Cr B Bourke (Council Representative)

2. PREVIOUS MINUTES – Not applicable

3. FLOODPLAIN RISK MANAGEMENT STUDY – Draft Stage 1 Report

MTS tabled comments from Council and DNR **attached** and discussion took place regarding the Draft Stage 1 Report prepared by Cardno Willing. The following points were made;

- Concern was expressed as to the extent of flood damage quantified in section 3.8. Document should clarify damage calculation and damage model used.
- Hydraulic parameters, particularly velocity, should be based on historical / original state of the river not on theoretical values. Theoretical comparisons may mislead or distort assessment.
- Basis on which extreme event is used instead of PMF. How do they compare?
- Concern expressed regarding health of riparian zone including water quality, lack of sunlight, stagnant pools, sedimentation, and tree infestation.

- Strong views expressed regarding vegetation management and the need to maintain, floodways as well as banks. Re-growth and ongoing vegetation maintenance and sediment removal are important issues.

- Page 24 should include environmental impacts eg river health.

- Option assessment generally agreed however, more emphasis required on vegetation management and the inclusion of sediment removal. Poor vegetation control in the past has prevented 'self flushing' and this is required to restore river condition.

- Committee felt final document should provide strong direction for any future vegetation management consultancy. As it would form the basis of a brief, clear precise hydraulic requirements are needed.

4. GENERAL BUSINESS

SES

- SES to provide copy of flood photographs for Cardno Willing consideration.

- Emphasised the need for stream gauging and flood warning systems. Telemetry system similar to or an extension of, that currently in use for Bathurst.

5. NEXT MEETING

To be advised when next submission is received from Cardno Willing.

Meeting closed at 11:25am.

ATTACHMENT 1 – Council Comment

SOFALA FLOODPLAIN RISK MANAGEMENT STUDY
(Draft Stage 1 Report –April 2006)

Note: Bathurst Regional Council comments are in addition to DNR comments attached separately.

General	Requires proof reading as there are numerous spelling, grammatical and format errors
Page 4, Fig 2	Figure incorrectly highlighted.
Page 7, para 3	Should Council provide this additional survey?
Page 8	Sensitivity analysis and 1986 comparison is somewhat confusion. Suggest clarification required to highlight the point.
Page 8,12,20	!986 > 1% 20 houses flooded 1986 yet 2 at 1% ? Confused.
Page 17, fig 7 **Page 18, fig 8**	Would be more useful if high hazard properties shown.
Page 20, para 3	$13,619 differs from value on page S-1. Consider reference to damage of vehicles, appliances and yards better than loss of income.
Page 21	1 property found yet 2 stated. Is this consistent with 20 in 1986.
Page D-1, para 4	Consider reference to damage of vehicles, appliances and yards better than loss of income. Damage assessment methodology should be same DAMAGE Model as was used for Bathurst

ATTACHMENT 2 – Department Natural Resources Comment

Sofala Floodplain Risk Management Study – May 2006 Draft Comments:

General

- Report appears to be a progress report rather than a completed draft Floodplain Risk Management Study report – options have not been assessed.
- Need some discussion on the current planning controls.
- All figures show the flood extents should make it clear that the extents are approximate only and should not be used to determine whether properties are flood affected.
- The Figures showing the town, approx flood extents, hydraulic categories etc should be A3 size. A4 is tooooooooooooo small to be much use. Where they include flood levels there should be a note that the datum is assumed (also Fig 6 & B-1). Extents are approx and should not be used to determine if properties are flood affected.

Specific Comments

Page S-1, para 6	Flood extent maps only show **<u>approximate</u>** extents (global check required) Should mention that the SMEC report identified 20 properties flooded above floor in 1986 and 30 in the extreme event.
Page 1, last para	"Phase **2**" rather than "Phase **11**" may avoid confusion.
Page 4, Fig 2	The FRMStudy column should be highlighted for this report.
Page 7, Fig 3	Can this Fig be improved? It is not of good quality.
Page 8	No reference to "Geomorphology and Hydrology of the Turon River", DLWC, December, 2000 which was mentioned in the Brief.
Page 11	Existing planning controls, LEP, DCP etc.
Page 12, 2nd last para	Need to explain why the 2 yrs of data is "significant" yet the F/F analysis not updated (see also Page A-5)
Page 14, Table 3	For completeness include 1986 levels
Page 14, para 2	Probably worth commenting that upstream of the bridge 1986 flood levels are about 0.8m – 0.9m higher than 1% levels.
Page 16, S3.6	**Provisional** Flood Hazard.
Page 19, Table 4	Top 2 case are the same yet there is an inconsistency in the effects and area affected. What are the impacts on velocities?

Page 20, para 1	"Detailed flood **damage** calculations............"?????
Page 20,	Potential damages or "actual" damages? What damage reduction factor (if any) was used to reflect the flood awareness of the community? Need to check the AAD figure of $10,470. I make the area under the damage/frequency curve $16,000. Should round off the damage figures to the nearest $100. (see also Appendix D)
Page 21, Fig 9	Are you sure the property just downstream of the bridge is not flooded over floor in the 1%? My recall is that in 1986 it was flooded to at least top of the windows and the 1% is about 0.64m lower than 1986.
Page 23, Table 6	Legislative requirements are V/important issues for Veg Management. To be consistent with the Manual, should refer to the **continuing** flood risk.
Page 24, S5.3	Need to consider the ecological impact as well.
Page B-2, 2nd last para	Probably need some discussion about the possible/likely changes to the effective roughness during the rising limb of the flood, particularly for large floods. If you look at the channel vegetation today it looks like the roughness would be much higher than 0.04. However it is possible/likely that once you get to flow depths of 4m or so, the velocities are such that the veg would be flattened or washed out, effectively lowering the apparent roughness.
Page B-2, last para	what about the "Geomorphology and Hydrology of the Turon River", DLWC, December, 2000 report which was mentioned in the Brief? It refers to survey at the gauge site in 1896, 87, 91 and 2000.
Sections B-5 & B-6	Tables should include velocities and flow distributions as the Figures are tooooooooo hard to read easily.
Table D-2	Need a note referring to the generalised nature of the flood damage figure to caution people about comparing the 1986 damage figures for a particular property with the damages that may have actually been incurred. I note that individual properties haven't been specifically identified but identification may be possible in some cases from the chainages.

SOFALA FLOODPLAIN RISK MANAGEMENT STUDY
(Draft Study Report –November 2006)

Page S-1,S-2	- does not show recommendations
	- discussion on Native Vegetation Act and vegetation management should be consistent message, note very different commentary in Georges Plains (GP) Study
Page 3, fig 1	- study area should be Sofala not as shown total sub catchment area
	- stream gauge not shown
Page 5 sec 1.5	- no such statement in Georges Plains Study surely requirement is similar to both
Page 16	- discussion and comment on hydraulic categories presented better than in GP Study
	- no flood storage or intermediate hazard areas shown, is this correct ?
	- figures 7 & 8 clear and logical suggest GP Study could be similar
Page 17, tab 5	- mixed units used are confusing
Page 17, para 5	- suggest comment that no substantial buildings are inundated
Page 18, para 1	- ……probability of 0.007 **(0.7% AEP or >100 year ARI)**
Page 23, fig 9	- report requires explanation on flooded property outside study area
	- given that so many buildings/dwellings seem to be inside 1%AEP, notwithstanding only 2 are above floor flooding, damage value seems very low
Page 25	- clearing of bridge debris and bridge waterway not discussed
Page 29	- clearing bridge debris and channel not listed in recommendations
	- given longer term nature of VMP in preparation, approval and implementation suggest recommendation for some immediate works would be beneficial
	- needs indication of areas requiring planning control

W4.64.1

"With reference to 1986 Turon River" flooding.

22nd January 2007
98 Bowen St
Sofala 2795

Dear Sir or Madam

With reference to The Sofala 1986 Flood, a meeting was held in Sofala late 2005, with your company, which was a public meeting and we where to have another public meeting around Febuary 2006 Twelve Months and no meeting.

Why wait this long it is Wasting time and money, Cardo Willing is the same as the other companys not interested.

As for community consultation this has been done.

To fixe all the problems with the Turon River you must remove all the Trees out of the river flow, this is a river not a forest. 21 years after flood bad what has been done nill.

Yours Faithfully
R Hefferen

W4641

BATHURST
REGIONAL COUNCIL

ADMINISTRATOR'S OFFICE
Civic Centre
Cnr Russell & William Sts
Private Mail Bag 17
Bathurst NSW 2795
Telephone 02 6333 6111
Facsimile 02 6331 7211
council@bathurst.nsw.gov.au
www.bathurst.nsw.gov.au

29 May 2007

Mr Robert Spry
Cardno Willing (NSW) Pty Ltd
Level 3
910 Pacific Highway
GORDON NSW 2072

Dear Mr Spry

Sofala Floodplain Management Committee

Enclosed for your information is a copy of the Minutes of the Sofala Floodplain Committee Meeting held on Monday 21 May 2007.

Yours faithfully

Doug Patterson
ACTING DIRECTOR
ENGINEERING SERVICES

RECEIVED
1 JUN 2007
Cardno (NSW) Pty Ltd

Reference: WS:DR 07.00076
Enquiries: Mr Wayne Sartori 02 6333 6226

image.tif

MINUTES OF MEETING OF

SOFALA FLOODPLAIN MANAGEMENT COMMITTEE

HELD ON MONDAY 21 MAY 2007

Present: Cr P Haysom (Council Representative)
M Tomkinson (Community Representative)
N Dodds (Community Representative)

Secretariat: W Sartori (Manager Technical Services)
D Rodey (Technical Service Assistant)

Apologies: S Varathin (Department of Environment & Climate Change)
Cr B Bourke (Council Representative)
H Parsonage (Community Representative)

The meeting commenced at 10.00 am at the Panners Inn Coffee Shop Sofala.

1. **PREVIOUS MINUTES** – Meeting of 11 August 2006 moved by P Haysom Seconded by M Tomkinson.

2. **FLOODPLAIN RISK MANAGEMENT STUDY** – Draft Final Report March 2007.

- MTS explained briefly the procedure which would follow if the Committee accepted the recommendations in the Report today, being:-

  - Await DECC comments
  - Finalise Report
  - Proposal (Flood Plan) put before next Council Meeting
  - The Sofala Flood Plan will then be placed on public exhibition
  - Subject to any comments received from the public during the exhibition period, the Report will go to Council for adoption
  - Application for funding is then made.

- MTS noted the recommendations in the Report appeared to be in accordance with the Committee's objectives.

- Community representative concerned that the amount of up to $10,000 proposed for the removal of the Casuarinas from the creek would not be enough. Expressed concern that money may be better spent in setting up a communications tower for the village area, to facilitate mobile & other communication in a flood event.

- The order of priorities in the recommendation was discussed and the Committee concluded prioritisation should be as follows:-

First Priority:	Remove Casuarinas
Second Priority:	Clear Debris
Third Priority:	Prepare Vegetation Management Plan

- Community representative believes that cleaning up of the creek will help tourism in the area, and that the removal of the casuarinas would save water, due to the amount of water hydrated out of the river as a result of the vast number of trees. Aim is to try and drought-proof the river, and have the river and banks maintained on an annual basis.

- The approach to the Crossley Bridge was raised. The RTA are to be kept informed.

- A query was raised as to where the local government boundary is situated between Bathurst Regional Council and Mid-Western Regional Council in area around the creek. Council undertook to inform Mid-Western Regional Council.

3. NEXT MEETING

To be advised following the outcome of Council's recommendation.

Meeting finished at 11.00 am.

Sofala Floodplain Risk Management Study
Comments on Draft Final Report (March, 2007)

General Comment

- The Figures showing the town, approx flood extents, hydraulic categories etc should be A3 size. A4 is too small to be much use. This was raised in comments on the May, 2006 draft and is also a requirement of the Brief.
- Need to revisit the FPL and provide justification for its selection, particularly if the 1986 is to be pursued. None of the figures in the Floodplain Risk Management Study show the 1986 event (extents, hydraulic or hazard categories).
- The draft DCP does not appear to provide for more stringent control in floodways or high hazard areas. Its focus seems to be only on the FPL.
-

Page/Section	Comment
Page S-2	Planning controls – 1986 flood recommended as the FPL. As it is **not** proposed to include freeboard in the FPL (flood levels known with reasonable accuracy – see S6.2, page 35) this recommendation is not consistent with the Manual. FPL's consist of a Planning Flood (the magnitude of flood against which protection is sought) plus a suitable freeboard. The freeboard should reflect the circumstances and is necessary to ensure that protection against the Planning Flood is achieved. There is a real danger that the adoption of the 1986 flood as the FPL with zero freeboard may lead to a belief in the community that new development will be protected against a flood equivalent in size to the 1986 event. This is not the case.
Page 7, S2.1	The population of Sofala was 136 in 1997 (see S1.1). Need some consistency.
Page 7, last para of S2.1	"The *bridge*………" spelling
Page 13, S2.7	I think this section needs to be expanded to include some discussion of the policies & planning controls that operated in Sofala under Evans Shire. BRC was created on 26 May 04, only about 6 months before the Interim BRC LEP was put on public exhibition. The amalgamation is just hinted at in the report. BCR's policies are discussed yet I would be surprised if there is much in the way of development in Sofala that has taken place under the BRC banner. It should be noted that the Evans Shire Council, Interim Floodplain Management Policy, 1987 was specifically mentioned in the study brief. This document should also be included in S7. References.
Page 20, last para	I suspect that the reduction in water levels immediately downstream of the bridge is a local effect due to drawdown through the bridge. The cross section is only 3m downstream of the bridge centreline and we are looking at a 1.28m head drop across the bridge (1.28m in

	6m). Unless a 30% blockage of the bridge makes it act like a retarding basin, reducing flows, the blockage will not impact on flood levels downstream except locally.
Page 26, Fig 10	Hazard areas in 1% event or 1986?
S5	There should be some discussion on the selection of the FPL. This should include the selection of the Planning Flood (the flood against which protection is desired) and an appropriate freeboard (see comment re page S-2 above).
Page 32, 3rd dot point	DNR is now Department of Environment and Climate Change (DECC). Global check necessary but you need to be careful as not all of DNR became DECC (water data now belongs to DWE).
Page 34, Table 9	The removal of Casuarinas at the bridge seems to precede the VMP. This appears to be a "cart before the horse" issue.
Page 35, S6.2	Floodplain Management Policy – The last para on page 13 states that this policy only applies to the City of Bathurst. It should also be noted that the definitions of flood prone land apparently adopted by BRC in its 2005 Floodplain Management Policy are not consistent with that in the Manual (although you could argue that the 3rd dot point on page 35 "Land likely to be affected by inundation…….." <u>may</u> be consistent with the Manual even though it doesn't specifically refer to land inundated by the PMF). We need to be very clear about whether we are talking about land subject to flooding (up to PMF/extreme flood – flood prone land) or land subject to flood related building/development controls (the Flood Planning Area – land ≤ the FPL). The expression "designated flood" is no longer used in the Manual. See also my comments re page S-2 above re the use of the 1986 flood (no freeboard) as the FPL for Sofala. If the 1986 event must be a component of the FPL, an alternative approach could be to adopt the 1% as the Planning Flood and the 1986 flood level as the FPL. However the implication of this is that the freeboard between the level of the Planning Flood (1%) and the FPL is between 0.9m and 1m upstream of the bridge (Table 4). This is considerably higher than the 0.5m freeboard recommended as a starting point in the Manual and may be difficult to justify. It is worth noting that an extrapolation of the frequency information in Table 3 suggests that the 1986 flood was in the order of a 300 year ARI event. Of course a conventional approach could be adopted (1% + 0.5m). No matter which approach is adopted it is necessary to provide some discussion and justification.
Page 36, 2nd last para	Section 149 (5) does not "require" the inclusion of advice on other relevant matters. The word used is "may", ie Council has discretion.

Page 36, Table 10	Residential subdivisions – Given that the 1986 flood was about a 300yr event, this may be considered a bit harsh without adequate justification. There is also no reference to the hydraulic or hazard category of the land. Land subject to inundation: a. See earlier comments about 1986 event as FPL. b. A minimum floor level (habitable rooms only??? Commercial as well???) of 0.5m above 1986 puts the floor 1.4 to 1.5m above the 1% level upstream of the bridge! The Manual suggests that min floor levels are based on the FPL on the basis that FPLs are made up of a Planning Flood + freeboard. It should be noted that if you have the 1986 flood level as the FPL (no freeboard) it is difficult to insist on a min floor level of 1986 + 0.5m on land that is just above the 1986 level (controls do not usually apply to land above the FPL!). What does "…except where the damage potential is low." mean? Is this intended to apply to small/minor extensions where insisting on the higher level may require a split level house? If so, it would probably be better to define small/minor extensions (% of existing floor area or "x" m^2) on a once only basis. The use of a % of existing could be a bit unfair to small dwellings Extensions to existing buildings – This should be on a once only basis. What happens if the proposed extension encroaches into the floodway? Development on flood prone land – To be capable of withstanding the water pressure. Flood prone land or land subject to the FPL? May be better to require new development within the FPL to be able to withstand the forces of floodwater, debris (including impact) and buoyancy when inundated to the level of the FPL. Does the draft DCP deal with the placement of fill on the floodplain? This could be a major problem in floodway areas.

C.2 HISTORICAL INFORMATION

The community has provided a number of historical photographs indicating the former condition of the village, and of the Turon River. These are reproduced below, with the photograph reference number and location (where this can be determined).

d1_18956 October 1924 looking upstream at the bend east of Sofala

d1_18957 October 1926 looking downstream, Sofala on left bank

d1_02173 November 1926 looking upstream past the Ilford road crossing

d1_02174 November 1926 Turon River, upstream of Sofala

APPENDIX D

FLOOD DAMAGE ESTIMATE

The standard method of estimating flood damage is to evaluate the depth of flooding, relative to building floor level and/or ground level, and multiply by typical stage-damage curves derived from studies of flood damages. The method was adopted for this study. Survey data on floor levels of all buildings on the Sofala floodplain was provided by Bathurst Regional Council. Note that the survey data includes one house, at river station 2272 which is upstream of the extent of the hydraulic model. Flood levels were extrapolated from the HEC-RAS results to obtain the damage estimate for this house.

A stage-damage relationship was adopted from SKM (2005), who investigated flood damages in the Lower Parramatta River floodplain. That study considered old, low-value houses which are similar in type to the houses on the floodplain at Sofala.

The stage damage relationship used to estimate the direct flood damage caused by overfloor flooding of houses is as follows:

Damage = $ (1000 + D * 11333)
where D = Depth of overfloor flooding.

The detailed calculations are shown in **Table D.1**. External direct damages are estimated to be $ 1,000 per property. The direct damage figures have been multiplied by a factor of 2.0 so as to include indirect damage.

The estimated total flood damage in the 1% AEP flood at Sofala is $ 63,200. Other values are listed in **Table 7** of the main report.

It should be noted that the flood damage calculation method used in this table is generalised, and is not intended to provide details relative to individual properties.

Table D.1
Detailed Estimate of Flood Damages

River Station (m)	Habitable Floor level (m)	Flood Level (m) 1986	Extreme	1% AEP	2% AEP	5% AEP	10% AEP	Depth overfloor 1% AEP	Direct Damage Estimate 1986	Extreme	1% AEP	2% AEP	5% AEP	10% AEP
956	163.17	163.60	167.88	162.96	162.52	161.82	161.14	-0.21	$5,797	$54,365	$0	$0	$0	$0
1098	163.98	164.85	169.35	163.86	163.22	162.37	161.59	-0.12	$10,857	$61,846	$0	$0	$0	$0
1132	165.15	165.00	169.45	163.98	163.34	162.46	161.67	-1.16	$0	$49,797	$0	$0	$0	$0
1132	164.16	165.00	169.45	163.98	163.34	162.46	161.67	-0.18	$10,454	$60,971	$0	$0	$0	$0
1151	164.23	165.08	169.51	164.06	163.40	162.51	161.71	-0.17	$10,662	$60,916	$0	$0	$0	$0
1162	165.04	165.13	169.55	164.10	163.44	162.54	161.74	-0.95	$1,932	$52,034	$0	$0	$0	$0
1176	164.74	165.19	169.59	164.15	163.49	162.58	161.77	-0.59	$6,032	$55,939	$0	$0	$0	$0
1187	164.09	165.22	169.62	164.18	163.52	162.62	161.81	0.09	$13,789	$63,645	$2,036	$0	$0	$0
1188	164.55	165.22	169.62	164.19	163.53	162.62	161.81	-0.36	$8,626	$58,481	$0	$0	$0	$0
1205	165.43	165.26	169.66	164.23	163.58	162.67	161.86	-1.20	$0	$48,902	$0	$0	$0	$0
1213	164.80	165.28	169.68	164.26	163.60	162.70	161.89	-0.54	$6,515	$56,344	$0	$0	$0	$0
1232	165.06	165.33	169.72	164.31	163.65	162.76	161.95	-0.75	$4,046	$53,855	$0	$0	$0	$0
1232	165.02	165.33	169.72	164.31	163.65	162.76	161.95	-0.71	$4,488	$54,297	$0	$0	$0	$0
1256	165.02	165.39	169.78	164.38	163.72	162.83	162.02	-0.64	$5,194	$54,978	$0	$0	$0	$0
1268	164.82	165.42	169.81	164.41	163.76	162.87	162.06	-0.41	$7,780	$57,551	$0	$0	$0	$0
1274	165.07	165.43	169.82	164.43	163.78	162.89	162.08	-0.64	$5,135	$54,899	$0	$0	$0	$0
1297	166.21	165.49	169.87	164.49	163.85	162.97	162.16	-1.71	$0	$42,540	$0	$0	$0	$0
1301	165.31	165.50	169.88	164.51	163.86	162.98	162.17	-0.81	$3,107	$52,780	$0	$0	$0	$0
1309	165.13	165.52	169.90	164.53	163.89	163.01	162.20	-0.60	$5,370	$55,002	$0	$0	$0	$0
1331	165.28	165.58	169.95	164.60	163.96	163.08	162.28	-0.68	$4,351	$53,867	$0	$0	$0	$0
1346	165.78	165.62	169.98	164.64	164.02	163.14	162.34	-1.14	$0	$48,551	$0	$0	$0	$0
1350	165.21	165.63	169.99	164.66	164.03	163.15	162.35	-0.55	$5,748	$55,164	$0	$0	$0	$0
1356	165.78	165.64	170.00	164.67	164.05	163.17	162.37	-1.11	$0	$48,826	$0	$0	$0	$0
1403	166.65	165.78	170.13	164.83	164.22	163.34	162.54	-1.82	$0	$40,513	$0	$0	$0	$0
1409	169.27	165.80	170.17	164.85	164.24	163.36	162.57	-4.41	$0	$11,199	$0	$0	$0	$0
1423	166.94	165.87	170.25	164.91	164.30	163.41	162.62	-2.03	$0	$38,491	$0	$0	$0	$0
1476	165.96	166.09	170.55	165.13	164.51	163.62	162.82	-0.84	$2,508	$53,003	$0	$0	$0	$0
1495	165.83	166.18	170.66	165.20	164.59	163.69	162.89	-0.63	$4,889	$55,687	$0	$0	$0	$0
1588	170.21	166.58	171.19	165.58	164.96	164.06	163.24	-4.63	$0	$12,119	$0	$0	$0	$0
1692	172.19	166.68	171.11	165.73	165.14	164.28	163.50	-6.46	$0	$0	$0	$0	$0	$0
2272	167.16	168.98	174.56	168.10	167.57	166.79	166.10	0.93	$21,646	$84,806	$11,582	$5,598	$0	$0
								Total	$148,925	$1,551,365	$13,619	$5,598	$0	$0

NOTE: the flood damage calculation method used in this table is generalised, and is not intended to provide details relative to individual properties.

The Average Annual Damage (AAD) is estimated to be $ 13,840. This value is derived by calculating the area under the damage-probability curve, **Figure D.1**.

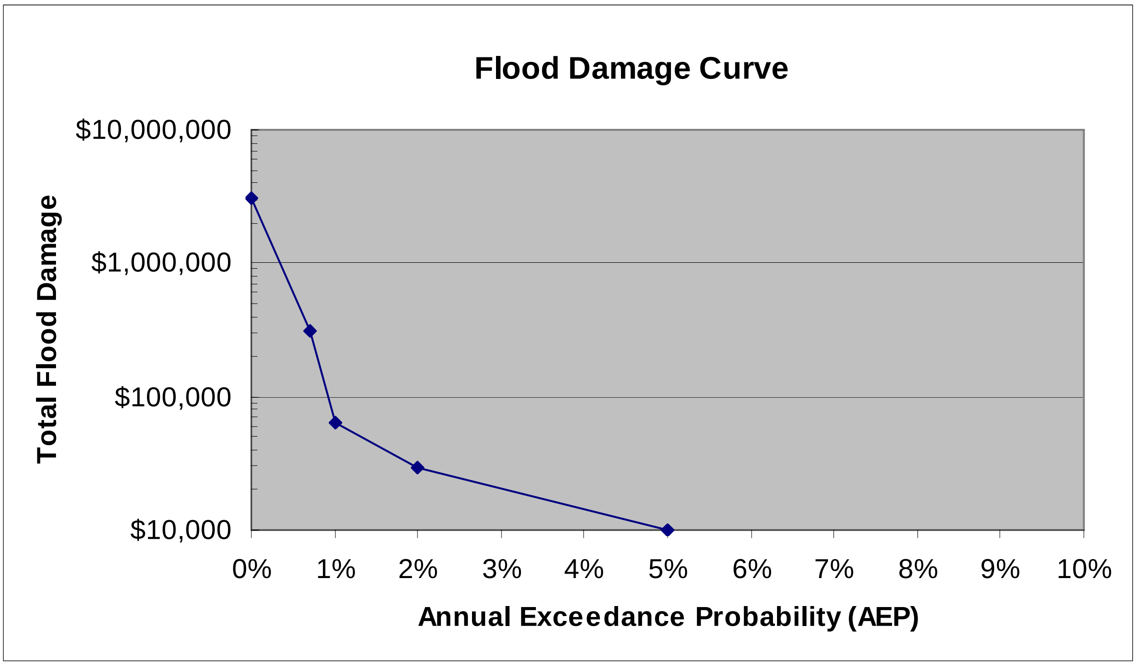


FIGURE D.1
Damage- Probability Curve

APPENDIX E

DRAFT BRIEF FOR VEGETATION MANAGEMENT PLAN

1. INTRODUCTION

Bathurst Regional Council, through the Sofala Floodplain Management Committee, is developing a Floodplain Risk Management Strategy for the Turon River at Sofala. The Sofala Floodplain Management Committee comprises representatives of Council, the Department of Natural Resources, State Emergency Service and representatives of the local Sofala Community.

The Sofala Floodplain Risk Management Study (FRMS) has been completed, including hydraulic modelling to determine the nature of the flood behaviour at Sofala. The Floodplain Risk Management Study presented the results of the modelling of several alternative flood mitigation options. These options included structural works and Planning measures. The final report recommended Option 1 – Vegetation Management as the preferred option for flood mitigation works within the Turon River Floodplain which was adopted by Council at its meeting of *[insert date]*.

The Vegetation Management Plan and Floodplain Risk Management Plan forms the next step in the process of developing and implementing the option recommended within the Floodplain Risk Management Study.

Implementation of the Vegetation Management Plan will form a key component of the final Floodplain Risk Management Plan for Sofala.

2. STUDY AREA

The Turon River Catchment lies to the east of Sofala and extends to the Great Dividing Range between Running Stream, Capertee and Portland. In total the catchment area covers approximately 883 square kilometres. The River is subject to variable flows including large floods.

The study area for this Brief is the reach of the Turon River from Golden Point, about 1.5 kilometres upstream of Crossley Bridge at Sofala, to 500 metres downstream of the bridge. The study area is identified on [*provide Figure]*.

3. SOFALA VEGETATION MANAGEMENT PLAN

3.1 Objectives

a) To map the vegetation in the study area to provide a baseline for future vegetation management.
b) To assess current vegetation conditions and flora values.
c) To provide broad and specific management actions and strategies for vegetation that will create a valuable corridor of vegetation while reducing flooding.
d) To comply with the principles of the Native Vegetation Act, Bathurst Vegetation Management Plan, and other applicable legislation and regulations.

3.2 Approach to the Preparation of the Vegetation Management Plan

The suggested approach includes:

(i) Assess in detail (and list species) all existing vegetation (native and exotic and location) in the study area.
(ii) Estimate by interpolation, extrapolation, documentation or by comparison with similar rivers and creeks nearby, the range of species that once may have grown in the study area; and
(iii) Involve the community in the preparation of the Vegetation Management Plan.

3.3 Report Components of the Vegetation Management Plan

- Removal of exotics - strategy for a phased removal of exotics so as to minimise impact on displaced fauna.
- Native plant corridor - strategy for establishment of a sustainable native plant corridor along the river. Existing/ proposed plant density is to be consistent with the recommendations of the Sofala Floodplain Risk Management Plan. Species should be based on results of the study and should aim for structural diversity (trees, shrubs, grasses, groundcover, natives from local seed source). Seed sources are to be identified. The native plant corridor is to ideally be sustainable to provide habitat for fauna.
- Identify strategies for community participation in the implementation stages.

3.4 Pollution Control

- Develop a strategy for vegetation interception of runoff from urban areas, ie. to protect the native plants from gaining nutrients over time.

3.5 Strategy for Ongoing Management

- Identify management actions, such as periodic thinning, to prevent adverse effects of flooding.
- Identify a weed control strategy.

3.6 Strategy for Recreation

- prepare a concept plan of a linear park along the river. The linear park may also include a concept for a foot crossing and/or a cycleway/ pedestrian path.

3.7 Flood Behaviour

- The proposed vegetation corridor to be decided upon after full consultation with flood models identifying any potential impact on flood behaviour.

3.8 Economic Appraisal

- Prepare an economic appraisal to NSW Treasury guidelines of the works proposed under the Vegetation Management Plan.

4. FORMAT OF FINAL REPORT

At the completion of the Plan, a final report is to be prepared containing sections generally as detailed below:

1. Executive Summary

   Explaining the function of the Sofala Vegetation Management Plan as part of a series of activities associated with the vegetation management measures recommended by the Sofala Floodplain Risk Management Study.

2. Introduction

   Setting the scene for the reader regarding the nature of the Plan, the need for it and the elements comprising the Plan.

3. Background

   Detail the persons and organisations involved, previous studies and data bases.

4. Existing Habitat

   Detail the existing Turon River habitat in relation to species of flora in supporting, fauna, and aquatic life.

5. Strategy for Removal and Revegetation of Flora Species

   Detail a strategy for the removal of flora species and re-vegetation of appropriate species of vegetation.

6. Ongoing Management Strategy

   Detail a sustainable strategy for the ongoing management of vegetation along the river within the study area, to limit plant densities to those proposed in the FRMS.

7. Economic Evaluation of Implementation

   The cost of removal and replanting is to be estimated and the benefits assessed.

8. Environmental Impacts

   An assessment of the riparian habitat in respect of the carrying out of stream clearing and replanting.