Flood Intelligence and Warning

Teesdale Flood Risk Identification Study

Golden Plains Shire

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CONTENTS

APPENDICES

LIST OF FIGURES

LIST OF TABLES

GLOSSARY OF TERMS

Afflux	Refers to the difference in water level (or depth) between two modelling scenarios, usually measured in metres and a change in extent (e.g. "was wet now dry")
Annual Exceedance Probability (AEP)	Refers to the probability or risk of a flood of a given size occurring or being exceeded in any given year. A 90% AEP flood has a high probability of occurring or being exceeded; it would occur quite often and would be relatively small. A 1% AEP flood has a low probability of occurrence or being exceeded; it would be fairly rare but it would be of extreme magnitude.
Australian Height Datum (AHD)	A common national surface level datum approximately corresponding to mean sea level. Introduced in 1971 to eventually supersede all earlier datums.
Average Recurrence Interval (ARI)	Refers to the average time interval between a given flood magnitude occurring or being exceeded. A 10 year ARI flood is expected to be exceeded on average once every 10 years. A 100 year ARI flood is expected to be exceeded on average once every 100 years. The AEP is the ARI expressed as a percentage.
Cadastre, cadastral base	Information in map or digital form showing the extent and usage of land, including streets, lot boundaries, water courses etc.
Catchment	The area draining to a site. It always relates to a particular location and may include the catchments of tributary streams as well as the main stream.
Design flood	A design flood is a probabilistic or statistical estimate, being generally based on some form of probability analysis of flood or rainfall data. An average recurrence interval or exceedance probability is attributed to the estimate.
Discharge	The rate of flow of water measured in terms of volume over time. It is to be distinguished from the speed or velocity of flow, which is a measure of how fast the water is moving rather than how much is moving.
Flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or overland runoff before entering a watercourse and/or coastal inundation resulting from elevated sea levels and/or waves overtopping coastline defences.
Flood frequency analysis	A statistical analysis of observed flood magnitudes to determine the probability of a given flood magnitude.
Flood hazard	Potential risk to life and limb caused by flooding. Flood hazard combines the flood depth and velocity.

Floodplain	Area of land which is subject to inundation by floods up to the probable maximum flood event, i.e. flood prone land.
Flood storages	Those parts of the floodplain that are important for the temporary storage, of floodwaters during the passage of a flood.
Geographical information systems (GIS)	A system of software and procedures designed to support the management, manipulation, analysis and display of spatially referenced data.
Hydraulics	The term given to the study of water flow in a river, channel or pipe, in particular, the evaluation of flow parameters such as stage and velocity.
Hydrograph	A graph that shows how the discharge changes with time at any particular location.
Hydrology	The term given to the study of the rainfall and runoff process as it relates to the derivation of hydrographs for given floods.
Intensity frequency duration (IFD) analysis	Statistical analysis of rainfall, describing the rainfall intensity (mm/hr), frequency (probability measured by the AEP), duration (hrs). This analysis is used to generate design rainfall estimates.
LiDAR	Spot land surface heights collected via aerial light detection and ranging (LiDAR) survey. The spot heights are converted to a gridded digital elevation model dataset for use in modelling and mapping.
Peak flow	The maximum discharge occurring during a flood event.
Probability	A statistical measure of the expected frequency or occurrence of flooding. For a fuller explanation see Average Recurrence Interval.
Probable Maximum Flood	The flood that may be expected from the most severe combination of critical meteorological and hydrologic conditions that are reasonably possible in a particular drainage area.
RORB	A hydrological modelling tool used in this study to calculate the runoff generated from historic and design rainfall events.
Runoff	The amount of rainfall that actually ends up as stream or pipe flow, also known as rainfall excess.
Stage	Equivalent to 'water level'. Both are measured with reference to a specified datum.
Stage hydrograph	A graph that shows how the water level changes with time. It must be referenced to a particular location and datum.
Topography	A surface which defines the ground level of a chosen area.

1 INTRODUCTION

1.1 Overview

Water Technology has been commissioned by Golden Plains Shire Council (Council) to undertake the Teesdale Flood Risk Identification Study. The investigation area covers the Native Hut Creek and tributaries in the township of Teesdale. Teesdale is identified as a Priority Flood Risk Area in the Corangamite Regional Floodplain Management Strategy (2018), which identifies both riverine and flash flood risks for the town and states that "*flooding associated with Native Hut Creek has damaged several residential properties"*.

Previous flood investigations covering Teesdale include CCMA investigations undertaken in 2008 and 2019. The 2008 study utilised RORB hydrologic modelling and HEC-RAS one-dimensional hydraulic modelling, while the 2019 study utilised HEC-RAS two-dimensional hydraulic modelling. A regional flood study of the Barwon River catchment which covers the study area was also completed in 2016 (GHD, 2016).

The CCMA modelling completed in 2019 indicates that the current flood mapping which is the basis for the current Floodway Overlay (FO) and Land Subject to Inundation Overlay (LSIO) in the Golden Plains Planning Scheme understates the flood hazard in Teesdale. The Flood Risk Identification Study is being carried out to ensure that the planning scheme mapping accurately reflects flood hazard to ensure that growth in Teesdale is managed appropriately into the future. As such, updated flood mapping suitable for inclusion in the Golden Plains Planning Scheme is a key output required from the study.

In addition, the study will produce flood intelligence information for use in emergency management situations, assess the current flood impact/exposure in terms of annual average damages caused by flooding in Teesdale, investigate structural and non-structural mitigation options to reduce damages, investigate and make recommendations for establishing a flood warning system for the town.

This report is one of a series documenting the outcomes of the Teesdale Flood Risk Identification Study. Each reporting stage is shown below:

- R01 - Data Review and Validation
- R02 – Joint Validation Modelling Report
- R03 – Design Hydrology and Hydraulic Modelling Report
- **R04 – Flood Intelligence and Flood Warning Report – This Report**
- R05 – Flood Damages and Mitigation Assessment Report
- R06 – MFEP Documentation
- R07 – Final Summary Report

1.2 Study Area

Teesdale is located approximately 8.5 km north of Inverleigh and is situated on the banks of Native Hut Creek. The Native Hut Creek catchment begins approximately 22.5 km north of Teesdale near the town of Meredith. The creek meanders south across agricultural land, the vast majority of which has been historically cleared of large vegetation in line with its agricultural use.

The catchment within and upstream of the study area is mostly cleared agricultural land, and the main waterway (Native Hut Creek) has several onstream dams of varying size along its alignment. The Native Hut Creek catchment, draining to Teesdale is approximately 110 km^2. The entire catchment is located within the Golden Plains municipal area. The study area is focussed on the township of Teesdale and includes the following waterway structures:

- Two large on-stream dams approximately 3km upstream of the township.
  - An indicative assessment of the impact of the upstream dams was completed in R01 – Data Collation and Validation. The assessment found the dams would have minimal impact on peak flow rate or flood levels in a significant storm event.
- Road crossings, formal and informal, at the following roads:
  - Tolson Road/Stones Road
  - Sutherland Street
  - Bannockburn-Shelford Road
  - Barkers Road
- Several off-stream dams throughout the town.

1.3 Previous Reporting

This report follows report R03 – Design Modelling Report. R03 detailed the design event modelling for the range of modelled events (50% AEP to PMF). The previous report also detailed climate change modelling under a range of scenarios in addition to model sensitivity testing.

This report discusses the Flood Intelligence products developed as part of the study. It also provides an assessment of the Total Flood Warning System components currently in place for Teesdale, with recommendations for further improvement to the flood warning system.

2 BACKGROUND: TOTAL FLOOD WARNING SYSTEM

The Total Flood Warning System (TFWS) is intended to encompass all of the elements required to produce an appropriate timely response to flooding. The elements of the core TFWS are shown in Figure 2-1 below.

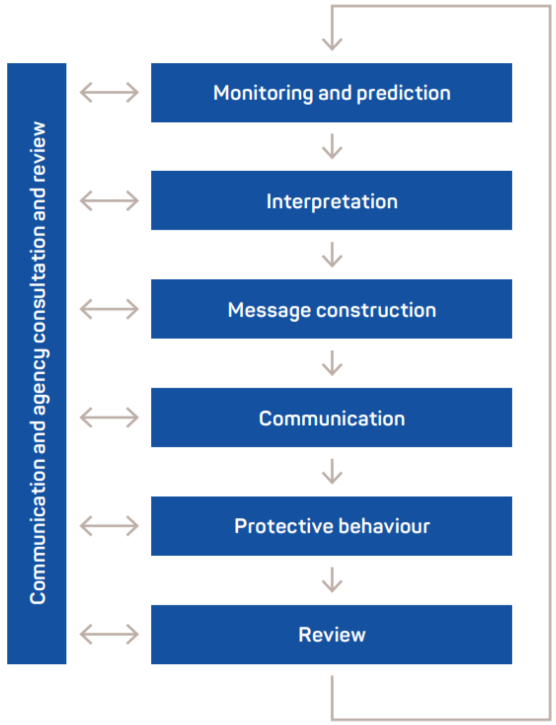

Figure 2-1 Total Flood Warning System elements[1]

The information produced by a flood investigation generally relates to the "monitoring and prediction" and "interpretation" elements. Flood mapping, damages and intelligence produced by the study will be valuable in interpreting incoming data. Some of the elements of the study (for example the "Flood/No Flood" tool produced in the Municipal Flood Emergency Plan) can aid with prediction.

Message construction, communication, and protective behaviour are outside the scope of a flood investigation however would generally be completed from within an Incident Control Centre (if one has been set up) and the applicable Incident Management Team controlling the incident. Formal flood warning messages in Victoria fall within the remit of the Bureau of Meteorology and fall within two classes: Flood Watches and Flood Warnings.

Flood Watches are general warnings covering a large area and are not specific to particular waterways or townships. They can be delivered well before flooding is expected to arise and are often based on forecast rainfalls.

Flood Warnings, on the other hand, are specific to a location and will predict how high the water will peak at that location. Flood Warnings are often related to Flood Class Levels (see Section 8 below).

Review of the available information should take place after any event, or any other discovery of new flood information as appropriate. Historic events should be added to the available information, particularly the MFEP, as they occur.

Monitoring, in the context of flooding, generally refers to monitoring rainfall and stream levels but may include other aspects such as storage levels and catchment conditions to name a few. Locations to monitor will depend on the available data sources and the catchment of interest.

The following sections will discuss the current and ideal monitoring capability for Native Hut Creek; a draft rating curve of Native Hut Creek at Teesdale to assist in future data collection and prediction where possible; flood behaviour and impacts at the modelled AEPs; flood travel times; and flood classification levels for Teesdale.

3 RATING CURVE DEVELOPMENT

A rating curve has been extracted from the TUFLOW hydraulic model at the Bannockburn-Shelford Road bridge. This location represents the most appropriate location for a gauge on Native Hut Creek due to the confined nature of the waterway corridor at this location, with flow contained in most events. In events larger than around a 2% AEP event, flows will overtop the road. Gauge boards on the upstream side of the road placed at the low point where overtopping commences along with a location further from the bridge would ensure gauge readings could be undertaken during large events, however the model indicates readings at this location may be slightly higher than those taken upstream of the bridge opening. Manual gauge readings may therefore overestimate the flow in Native Hut Creek at high flow rates.

The rating curve has been developed utilising a least squares polynomial fit across the model results for flow and height at the upstream side of the bridge. Model results for the 10%, 5%, and 0.5% AEP events informed the curve. A clear inflexion point can be seen just above 30 m^3/s, where the floodplain upstream of the bridge is engaged and small increases in water level correspond to significant increases in flow.

The curve is shown in Figure 3-1 and Figure 3-2 below. Also plotted are the flows and heights extracted from the model for all modelled events except the PMF. An example rating table, in the same format as that currently used by the Department of Energy, Environment and Climate Action, is provided in Appendix A. The example table is based on a gauge zero of 99.037 mAHD, which was taken from the TUFLOW model. Should the gauge site be developed, a gauge zero will be required and the stage heights can be linked using mAHD as a datum.

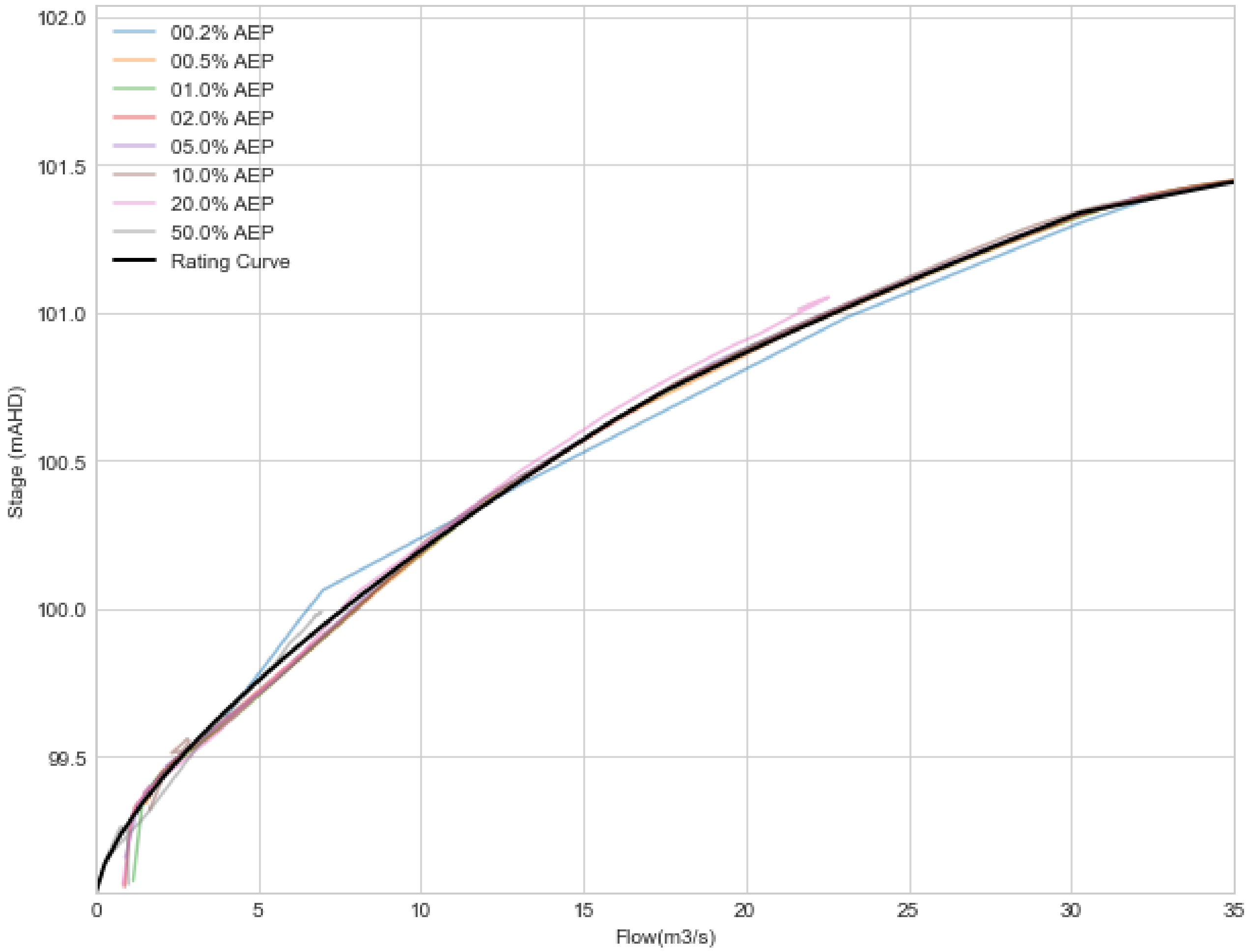

Figure 3-1 Native Hut Creek at Bannockburn-Shelford Road bridge, low flows

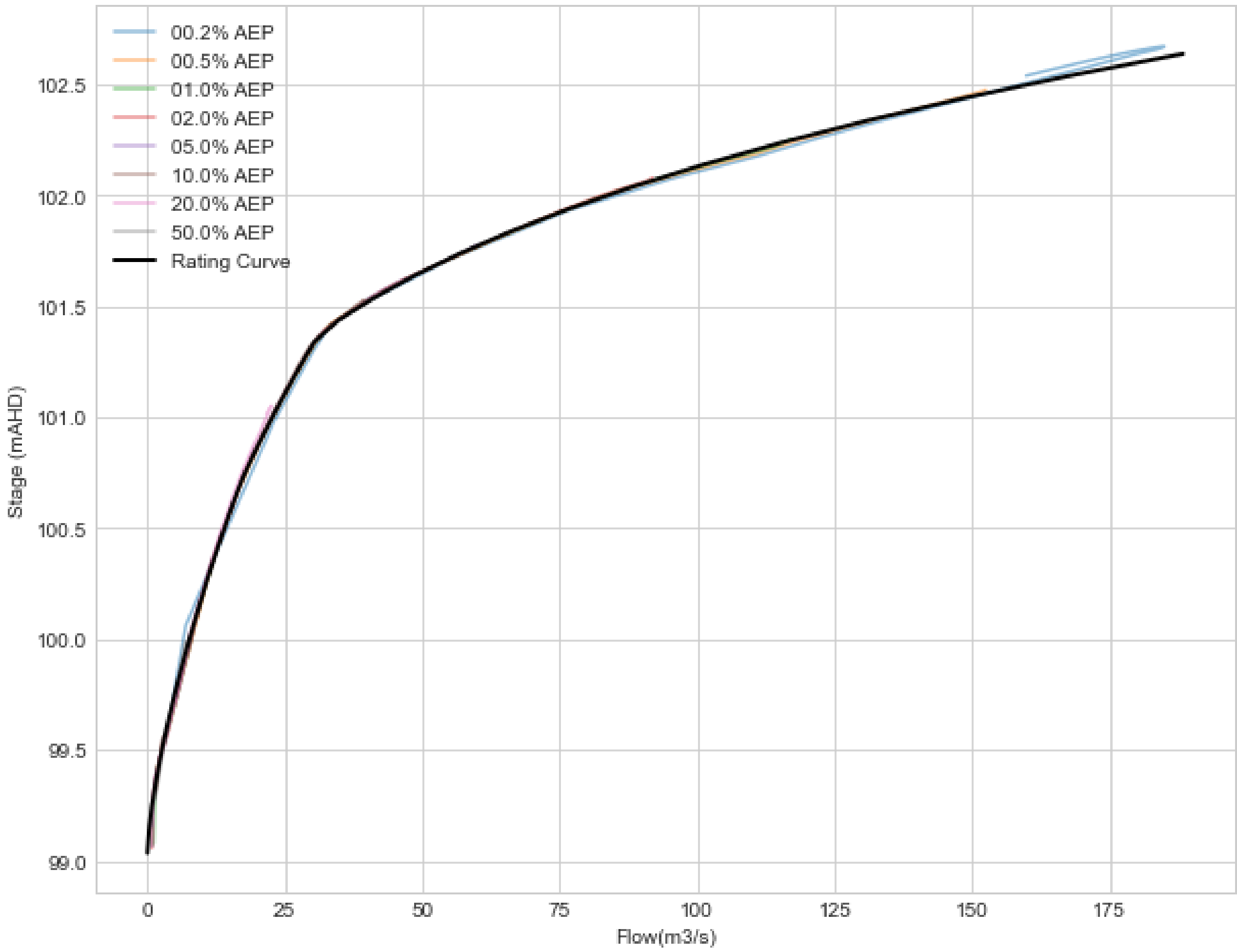

Figure 3-2 Native Hut Creek at Bannockburn-Shelford Road bridge, high flows

4 FLOOD BEHAVIOUR AND IMPACTS

4.1 Overview

When Native Hut Creek flows, water first breaks the banks at 4 Stones Road, flowing towards the west and over Stones Road before re-joining the creek upstream of Squires Road/Sutherland Street. Model results indicate this occurs at relatively low flow rates in the creek of around $10m^3/s$ (~50% AEP). Barker Street overtops shortly after, with the minor culvert's capacity overcome in minor events. At higher flowrates of around $40m^3/s$ (10% AEP), flows break out near the Stones Road/Tolsons Road bridge on the south side of the creek, flowing through residential properties and over Sutherland Street, re-joining the waterway approximately 200m north of the Bannockburn-Shelford Road bridge.

The elevated Bannockburn-Shelford Road overtops at around $90m^3/s$ (~2% AEP), with overtopping commencing at a low point on the road 90 metres east of the bridge. As flows increase, another low point approximately 90 metres to the west begins to overtop. The depression on the west side of Teesdale-Inverleigh Road fills and the road is overtopped. The floodplain downstream of the bridge narrows towards Barker Street and remains relatively confined until the confluence with the Learmonth Street tributary, downstream of which numerous breakouts occur as the creek flows away from Teesdale.

4.2 Flood Impacts Summary

Table 4-1 provides a summary of key flood behaviour and impacts with a summary of roads inundated. Behaviours and impacts are shown in the likely order of inundation, i.e. from more frequent, lower magnitude events to less frequent larger flood events.

Note the table below refers to Stones Road, however it should be noted that this is also Tolsons Road. The inundation of Stones Road joins Tolsons Road at approximately 10% AEP and there are no properties or otherwise between the two inundation points, thus they have been combined.

Table 4-1 Flood Impacts Summary

Flood Event	Characteristics – Flood Behaviour	Roadways Inundated
50% AEP ~600 ML/d ~7.4 m^3/s 99.99 m AHD at Bannockburn-Shelford Road bridge	Breakout occurs upstream of Stones Road, flowing along the north side of Native Hut Creek and filling local depressions. The breakout rejoins Native Hut Creek at Pantics Road.	▪ Learmonth St (<0.1m) ▪ Stones Road (<0.3m) ▪ Barker Street (<0.3m) ▪ Russel St (<0.1m)
20% AEP ~1,950 ML/d ~23 m^3/s 101.05 m AHD at Bannockburn-Shelford Road bridge	Breakout upstream of Stones Road becomes more significant with deep flows on the north side of Native Hut Creek. Breakout from dam at 95 Tolson Road flows over paddocks south of Native Hut Creek, rejoining before Sutherland Street. Stones Road and Barker Street flooded to hazardous depths. Minor breakouts on west side of Native Hut Creek, north and south of Bannockburn-Shelford Road. Significant breakouts around and downstream of Barker Street and around Native Hut Drive.	▪ Learmonth St (<0.1m) ▪ Stones Road (>0.5m) ▪ Pantics Road (<0.1m) ▪ Barker Street (>0.5m) ▪ Russel St (~0.1m)

Flood Event	Characteristics – Flood Behaviour	Roadways Inundated
10% AEP ~3,400 ML/d ~40.5 m³/s 101.53 m AHD at Bannockburn-Shelford Road bridge	Floodplain fully engaged with breakout flows on both sides of Native Hut Creek throughout the town. Turtle Bend inundated with isolated islands. **Teesdale Kindergarten driveway and carpark inundated.** Access via community hall possible. **87 Pantics Road inundated above floor.**	▪ Learmonth St (<0.1m) ▪ Stones Road (>0.5m) ▪ Mercer Tce (~0.5m) ▪ Pantics Road (<0.3m) ▪ Barker Street (>1m) ▪ Sutherland Street (~0.3m) ▪ Russel St (<0.3m)
5% AEP ~5,200 ML/d ~60.5 m³/s 101.78 m AHD at Bannockburn-Shelford Road bridge	Generally as above with deeper, faster flowing water. Hazardous depths across floodplain. **Teesdale Kindergarten driveway and carpark inundated to hazardous depths. Access via community hall possible.**	▪ Learmonth St (<0.1m) ▪ Stones Road (~1m) ▪ Pantics Road (>0.3m) ▪ Mercer Tce (~0.9m) ▪ Barker Street (>1.0m) ▪ Sutherland Street (~0.5m) ▪ Teesdale-Inverleigh Road (<0.3m) ▪ Russel St (<0.3m)
2% AEP ~7,950 ML/d ~92 m³/s 102.08 m AHD at Bannockburn-Shelford Road bridge	Generally as above with deeper, faster flowing water. Hazardous depths across floodplain. Bannockburn-Shelford Road overtopped. **844 Teesdale-Inverleigh Road inundated above floor.**	▪ Learmonth St (~0.1m) ▪ Bannockburn-Shelford Road (<0.1m) ▪ Jollys Road (<0.1m) ▪ Stones Road (>1m) ▪ Pantics Road (>0.5m, ~750m length) ▪ Mercer Tce (>1m) ▪ Barker Street (>1.0m) ▪ Sutherland Street (~0.8m) ▪ Teesdale-Inverleigh Road (~0.4m) ▪ Russel St (<0.3m)
1% AEP ~10,150 ML/d ~118 m³/s 102.25 m AHD at Bannockburn-Shelford Road bridge	Generally as above with deeper, faster flowing water. Hazardous depths across floodplain.	▪ Learmonth St (~0.1m) ▪ Bannockburn-Shelford Road (<0.3m) ▪ Jollys Road (<0.1m) ▪ Stones Road (>1m) ▪ Pantics Road (>0.5m, ~750m length) ▪ Mercer Tce (>1m) ▪ Barker Street (>1.0m) ▪ Sutherland Street (>1m) ▪ Teesdale-Inverleigh Road (~0.6m) ▪ Russel St (<0.3m)

Flood Event	Characteristics – Flood Behaviour	Roadways Inundated
0.5% AEP ~13,100 ML/d ~ 52 m^3/s 102.48 m AHD at Bannockburn-Shelford Road bridge	Bannockburn-Shelford Road overtopped to depths greater than 0.3 metres. Generally as above with deeper, faster flowing water. Hazardous depths across floodplain.	▪ Learmonth St (~0.1m) ▪ Bannockburn-Shelford Road (>0.3m) ▪ Jollys Road (<0.1m) ▪ Stones Road (>1m) ▪ Pantics Road (>0.5m, ~750m length) ▪ Mercer Tce (>1m) ▪ Barker Street (>1.0m) ▪ Sutherland Street (>1m) ▪ Teesdale-Inverleigh Road (~0.9m) ▪ Russel St (<0.3m) ▪ Teesdale-Lethbridge Road (<0.1m)
0.2% AEP ~16,000 ML/d ~185 m^3/s 102.67 m AHD at Bannockburn-Shelford Road bridge	Generally as above with deeper, faster flowing water. Hazardous depths across floodplain.	▪ Learmonth St (~0.1m) ▪ Bannockburn-Shelford Road (<0.5m) ▪ Jollys Road (<0.1m) ▪ Stones Road (>1m) ▪ Pantics Road (>0.5m, ~750m length) ▪ Mercer Tce (>1m) ▪ Barker Street (>1.0m) ▪ Sutherland Street (>1m) ▪ Teesdale-Inverleigh Road (>1m) ▪ Teesdale-Lethbridge Road (<0.1m)

5 FLOOD PEAK TRAVEL TIME

With no active or historic gauges on Native Hut Creek, flood peak travel times have been extracted from the RORB model built for the study. The model is sensitive to selection of the K_c routing parameter with respect to flood timing. Flood timing is also expected to be influenced by antecedent catchment conditions. Given no gauge monitoring is possible, flood peak timing at Teesdale has been estimated from the start of significant rainfall.

The modelled hydrographs for the 10% AEP and 1% AEP rainfall events are shown in Figure 5-1 and Figure 5-2. The below graphs show all modelled events for the AEP between 3 hours and 72 hours in duration for all ten temporal patterns. A total of 100 hydrographs were produced for each AEP. Also shown on the graphs is the critical peak flow, selected in accordance with the recommendations of ARR.

The graphs show the significant range in peak flows and timing produced by rainfall depths of a certain AEP when that rain falls over different durations and patterns within the duration. This illustrates the difficulty in accurately predicting flood peaks and timing from rainfall alone.

The graphs show that flood peaks can manifest around 7 hours from the start of intense rainfall, with the majority of events peaking between 7 hours and ~30 hours from the start of the rainfall burst. Some events peak beyond 30 hours from the start of rainfall however these become rarer and may contain “embedded bursts” where rainfall intensity within the burst increases for a period of time.

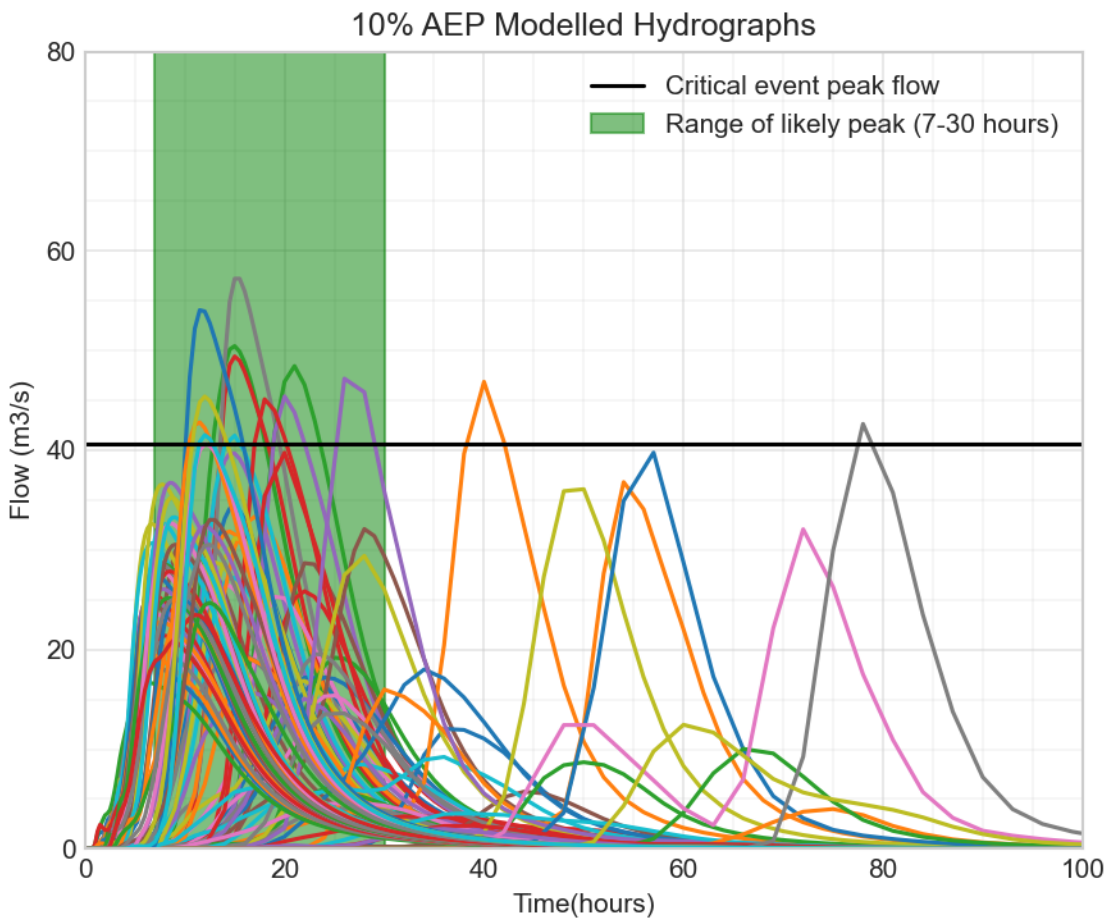

Figure 5-1 10% AEP hydrographs from all 100 modelled rainfall events

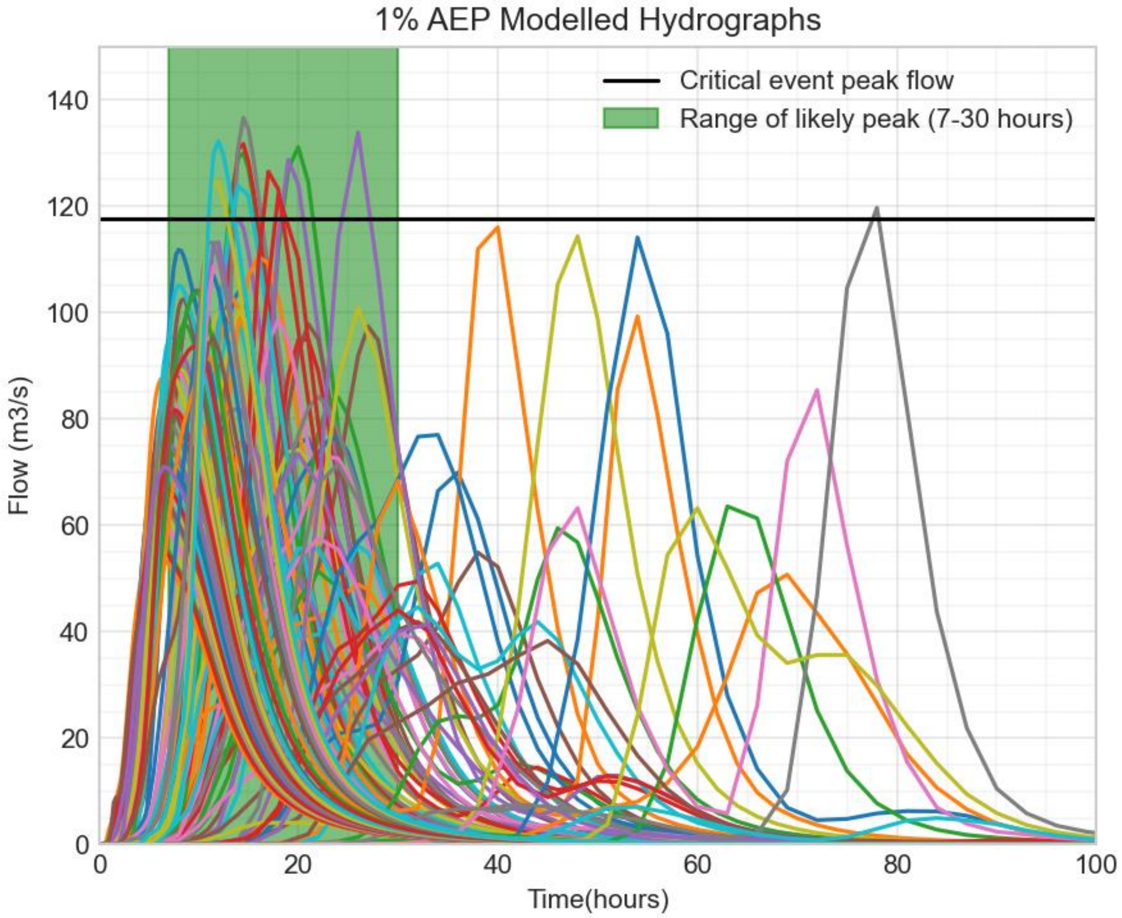

Figure 5-2 1% AEP hydrographs from all 100 modelled rainfall events

Similar graphs for the remaining AEPs modelled were used to develop Table 5-1 below of expected rises and peak times in the Native Hut Creek at Teesdale from the start of rainfall.

Table 5-1 Flood peak timing for Teesdale

Location From	Location To	Typical Travel Time	Comments	Duration
Teesdale (Native Hut Creek)				
Start of rainfall (catchment)	Teesdale	2 - 5 hours	Begin to rise from normal levels	Generally <24 hours
Start of rainfall (catchment)	Teesdale	7 - 30 hours	To peak – may be longer dependent on rainfall temporal pattern	

6 FLOOD/NO FLOOD TOOL

In the absence of a warning system, an estimate of the magnitude of flooding in Native Hut Creek at Teesdale may be obtained by monitoring the depth of rainfall in a given event, taken from the start of the event.

The Flood/No Flood tool in Figure 6-1 below provides a graphical representation of the Intensity-Frequency-Duration relationships for various AEP events as presented in R03 – Design Modelling.

To use the table, plot the total rainfall depth obtained against elapsed time since the start of the event. Exclude very light rain or drizzle when determining the event start point. Plotting of rainfall data should occur periodically as the event progresses. The likelihood and potential severity of flooding can be estimated by checking the rainfall and adopting the nearest curve AEP event as being likely.

It may be appropriate to step up or down a level depending on catchment antecedent conditions, for example if the rainfall for a 12 hour duration indicates a 5% AEP event will occur, but the catchment is dry with most farm dams empty, it may be appropriate to “step down” to a 10% AEP event or even lower. Similarly a very wet catchment will produce a greater response and may justify a “step up” in estimated AEP for response purposes.

The tool can provide a quick estimate as to whether there will be a flood and how severe that flood may be, however it must be stressed that the tool cannot provide accurate flood predictions and should not be relied upon entirely. Should life or property be in danger a cautious approach should be taken.

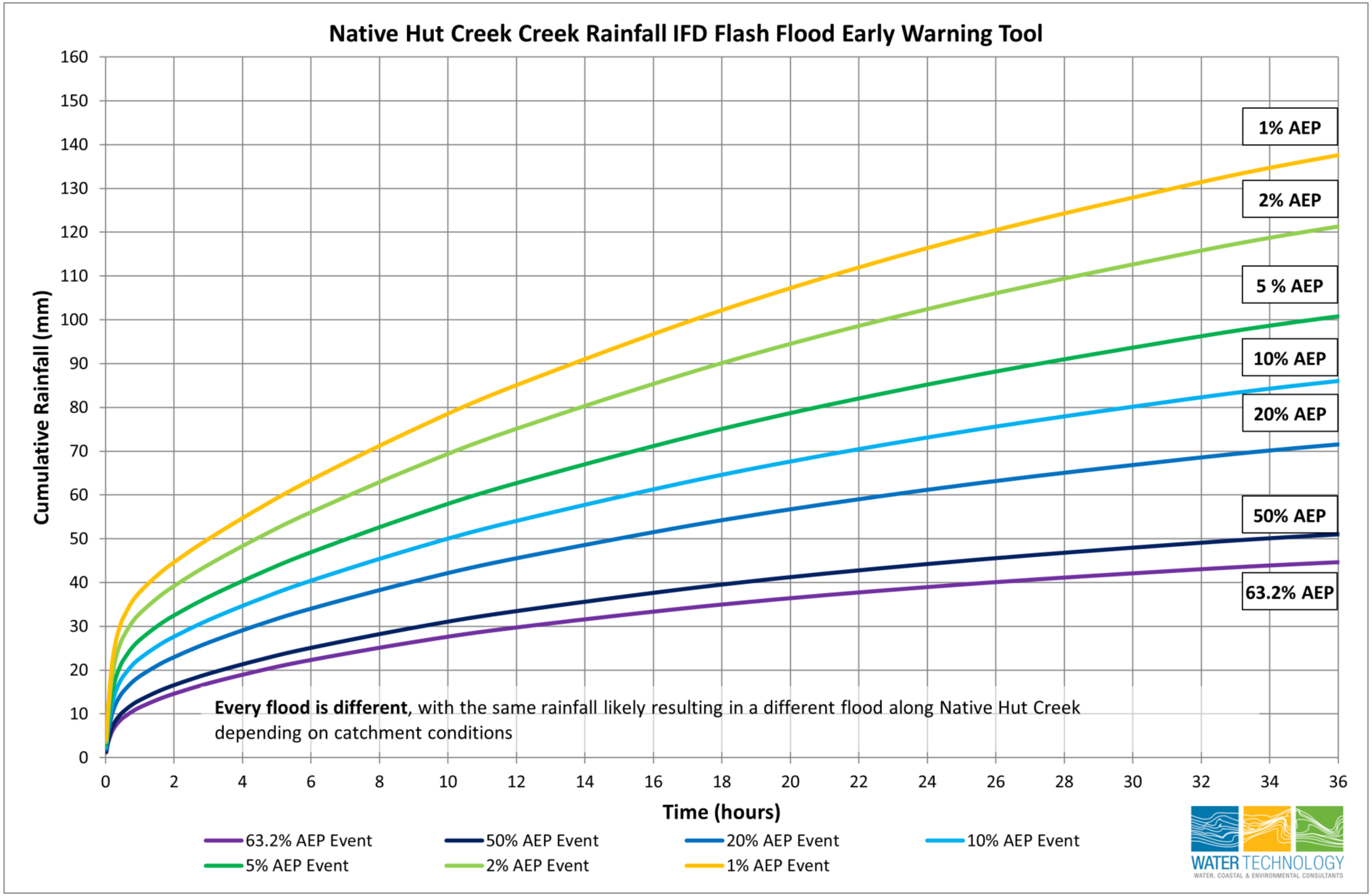

Figure 6-1 Teesdale Flood/No Flood Tool

7 FLOOD CLASSIFICATION LEVELS

While no gauge exists at Teesdale, recommended Flood Classification Levels (FCLs) have been developed utilising the theoretical gauging site and rating curve developed for the Bannockburn-Shelford Road bridge and the Bureau of Meteorology's definitions of FCLs. The bureau defines FCLs as per the below[1]:

Minor flooding

If the water level reaches the minor flood level, it causes inconvenience. Low-lying areas next to water courses are inundated. Minor roads may be closed and low-level bridges submerged. In urban areas flooding may affect some backyards and buildings below floor level as well as bicycle and pedestrian paths. In rural areas removal of livestock and equipment may be required.

Moderate flooding

If the water level reaches the moderate flood level, the area of inundation is larger. Main traffic routes may be affected. Some buildings may be affected above floor level. Evacuation may be required. In rural areas removal of livestock is necessary.

Major flooding

If the water level reaches the major flood level large areas are inundated. Many buildings may be affected above floor level. Properties and towns are likely to be isolated and major rail and traffic routes closed. Evacuation may be required. Utility services may be affected.

The results of the modelling have been assessed against the above criteria and flood class levels have been set for the proposed gauge location at the Bannockburn-Shelford Road bridge. The proposed flood class levels are detailed in Table 7-1 below.

Table 7-1 Proposed Flood Class Levels for Teesdale

Flood Class	Level at Bridge	Description
Minor	101.05 mAHD	The 20% AEP event matches the above minor flooding definition quite well, as Stones Road requires closure and low-lying areas next to Native Hut Creek are inundated.
Moderate	101.53 m AHD	The 10% AEP event floods Pantics Road to potentially hazardous levels and may require evacuation of vulnerable residents on that road. The area of inundation is significant. No buildings are flooded above floor level in this event.
Major	102.25 mAHD	The 1% AEP flood level is likely to require closure of the Bannockburn-Shelford Road bridge, potentially isolating parts of the town. Detours are likely to require careful management. Flooding of this magnitude is likely to be accompanied by flooding in neighbouring catchments.

[1] http://www.bom.gov.au/australia/flood/knowledge-centre/about-warning-service.shtml

8 MONITORING CAPABILITY FOR NATIVE HUT CREEK

8.1 Existing Capability

Currently, there is no formal flood warning system in place for the Native Hut Creek catchment. Additionally, there are no streamflow or rainfall gauges within the catchment. Due to this, official flood warning capability for the catchment and township is limited to the issue of a Flood Watch for the Barwon, Leigh and Moorabool Rivers area. Note a flood watch is not necessarily guaranteed to be issued prior to flooding.

The closest rain gauges that record sub-daily rainfalls and report to the Bureau of Meteorology's website are detailed in Table 8-1 below, with the distance measured from the Bannockburn-Shelford Road bridge.

Table 8-1 Nearby hourly rain gauges (Bureau of Meteorology)

Site Number	Name	Distance from Teesdale
87168	She Oaks AWS	15.2 km North-East
89104	Mt Mercer	25.6 km North
90167	Winchelsea	24.4 km South

8.2 Ideal (Potential) Capability

Flood data monitoring for Native Hut Creek would benefit from the placement of a rain gauge and stream gauge within the catchment. Rainfall in the north of the catchment is expected to be captured quite well by the Sheoaks gauge, however Teesdale itself lies between a number of gauges which may not reflect rainfall in the immediate vicinity of the township.

A sub-daily rain gauge within Teesdale would therefore improve the monitoring capability for the township and lower areas of the catchment. A Teesdale rain gauge would provide the additional benefit of allowing for monitoring of flash flooding conditions within the township, which is known to have caused issues recently, based on feedback received during community consultation sessions for this project.

In addition to a rain gauge within the township, a stream gauge on Native Hut Creek immediately upstream of the Bannockburn-Shelford Road bridge would greatly improve monitoring and data gathering for the township. Outputs from this Flood Risk Identification Study have been linked, where possible, to a gauge height at this proposed location. A stream gauge here would also gather stream height data in future flood events, allowing more detailed catchment analysis and calibration of models to improve confidence in the flood intelligence products.

Stream gauging in the catchment upstream is not expected to provide significant benefit to Teesdale. This is due to the following factors:

- The catchment shape and size already produce fast response times. Upper or mid catchment gauging may not provide sufficient lead time in an event to enable suitable response actions to be implemented.
- There is a significant tributary which enters Native Hut Creek immediately upstream of the Stones Road/Tolsons Road bridge. Any mid/upper catchment gauging would not be able to take account of this tributary and could therefore underestimate peak flows at Teesdale should the tributary influence flooding in a particular event.

In summary, a rain gauge at Teesdale and a stream gauge at the Bannockburn-Shelford Road bridge would improve flood monitoring and data gathering capabilities in Teesdale significantly. The rain gauge would play a direct role in warning of impending floods while the stream gauge would provide invaluable data to benchmark other monitoring information against.

In heavy rainfall events where Native Hut Creek rises quickly, a stream gauge may only provide warning time sufficient to enact response actions other than evacuation. A more cost effective option may therefore be to install a gauge without telemetry, or to have the site ready for deployment of a Portable Automatic Logging System (PALS) to monitor levels in Native Hut Creek during expected flow events. One potential issue with the PALS option is the demand for PALS units during events for which heavy rainfall is forecast. PALS ownership and deployment arrangements should therefore be confirmed prior to pursuing this option.

9 SUMMARY

Preferred monitoring capability and infrastructure to support a Total Flood Warning System for Teesdale has been discussed, with a sub-daily rain gauge and stream gauge suggested. Both the rain gauge and stream gauge are proposed within Teesdale itself and would improve the monitoring and data gathering capability for flood conditions in the town. A rating curve has been developed for Native Hut Creek at the Bannockburn-Shelford Road bridge, which can act as a starting rating table should the site be adopted until gauging can occur.

A number of flood intelligence products have been developed to improve flood response capability for the town, including a flood impact summary table, flood peak timing estimates and the development of a quick “flood/no flood” tool designed to estimate the magnitude of flooding based on observed rainfall.

Flood Class Levels have been recommended based off the Bureau of Meteorology’s definitions and flood mapping completed for Teesdale. The Flood Class Levels utilise the proposed stream gauge site as their basis.

Much of the flood intelligence information contained in this report will be included in a draft revision of the Golden Plains Municipal Flood Emergency Plan (MFEP) for SES and Council approval.

APPENDIX A
RATING TABLE

Table A-1 Rating Table for Native Hut Creek at Bannockburn-Shelford Road bridge in ML/d

mLGH	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0	0.00	0.89	2.43	4.36	6.62	9.14	11.9	14.9	18.0	21.4
0.1	24.9	28.6	32.5	36.4	40.6	44.8	49.2	53.7	58.4	63.1
0.2	68.0	72.9	78.0	83.2	88.5	93.9	99.4	105	111	116
0.3	122	128	134	134	140	153	159	166	172	179
0.4	185	192	199	206	213	220	227	234	241	249
0.5	256	263	271	279	286	294	302	310	317	325
0.6	333	341	350	358	366	374	374	383	391	408
0.7	417	425	434	443	452	460	469	478	478	487
0.8	506	515	524	533	543	552	561	571	580	590
0.9	599	609	619	629	638	648	658	668	678	688
1	698	708	719	729	739	749	760	770	781	791
1.1	802	812	823	833	844	855	866	876	887	898
1.2	909	920	931	942	953	964	976	987	998	1010
1.3	1020	1030	1040	1060	1070	1080	1090	1100	1110	1120
1.4	1140	1150	1160	1170	1180	1200	1210	1220	1230	1240
1.5	1260	1270	1280	1290	1300	1320	1330	1340	1350	1370
1.6	1380	1390	1400	1420	1430	1440	1450	1470	1480	1500
1.7	1520	1530	1550	1560	1580	1600	1610	1630	1650	1660
1.8	1680	1700	1710	1730	1750	1770	1780	1800	1820	1840
1.9	1850	1870	1890	1910	1920	1940	1960	1980	2000	2010
2	2030	2050	2070	2090	2110	2130	2140	2160	2180	2200
2.1	2220	2240	2260	2280	2300	2320	2340	2360	2380	2390
2.2	2410	2430	2450	2470	2490	2510	2530	2560	2580	2600
2.3	2620	2620	2660	2660	2700	2700	2800	2800	2900	2900
2.4	3010	3010	3110	3110	3220	3220	3330	3330	3450	3450
2.5	3560	3620	3680	3740	3810	3870	3930	4000	4060	4130
2.6	4190	4260	4330	4400	4470	4540	4610	4690	4760	4830
2.7	4910	4980	5060	5140	5220	5300	5380	5460	5540	5630
2.8	5710	5710	5880	5880	6060	6060	6240	6240	6420	6420
2.9	6610	6610	6800	6800	7000	7000	7200	7200	7400	7400
3	7610	7720	7830	7940	8050	8160	8270	8380	8500	8610
3.1	8730	8850	8960	9090	9210	9330	9450	9580	9710	9830
3.2	9960	10100	10200	10400	10500	10600	10800	10900	11000	11200
3.3	11300	11300	11600	11600	11900	11900	12200	12200	12500	12500
3.4	12800	12800	13100	13100	13500	13500	13800	13800	14100	14100
3.5	14500	14600	14800	15000	15200	15400	15500	15700	15900	16100
3.6	16300	16500	16700	16800	17000	17200	17400	17600	17800	18000

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