I4 — Flood Assessment Report

REPORT

Flood Assessment

Prepared for

BHP Billiton Mitsubishi Alliance

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1.1 Introduction

A one-dimensional hydraulic model was developed for the major creeks within the study area, namely Cherwell Creek, Caval Creek, Nine Mile Creek, Harrow Creek and Horse Creek. The purpose of the hydraulic modelling was to describe the flood extents for a range of design probability events.

The hydraulic modelling was undertaken utilising the mathematical HEC-RAS software which accounts for steady-state, one-dimensional, gradually varied flow. HEC-RAS is produced and supported by the US Army Corp of Engineers, and widely accepted in Australia and internationally for this type of hydraulic analysis.

1.2 Cross-Section Data

Topographic data to define the existing river waterway geometry in the HEC-RAS model was based on aerial photogrammetric survey (2007) of the study area, provided by BMA.

1.3 Roughness Values

Manning's roughness coefficients were assigned to the left overbank, right overbank and main channel for each cross-section. The roughness values were estimated from field inspections and aerial photographs. Floodplain and channel roughness values were compared to values tabulated in Chow (1959). The adopted roughness values are shown in Table 1-1.

Table 1-1 Roughness Values

Drainage Feature	Manning's 'n' Values		
	Left Overbank	Channel	Right Overbank
Cherwell Creek	0.1	0.035	0.1
Caval Creek	0.1	0.035	0.1
Nine Mile Creek	0.1	0.035	0.1
Harrow Creek	0.1	0.035	0.1
Horse Creek	0.07	0.04	0.07

Existing vegetation along the river banks has a substantial influence on hydraulic roughness and the influence varies according to depth and magnitude of flow. Different hydraulic roughness factors were therefore determined for the main channel of flow and the left and right overbanks.

Channel roughness values were generally low over the extent of the hydraulic model. Cherwell, Caval, Nine Mile and Harrow Creeks generally have no rifts or deep pools with some cover of stones and weeds. Horse Creek has a greater presence of pooling and shoals, which equated to a slightly higher roughness value. The roughness values used in the model reflect this.

Overbank roughness values used for Cherwell, Caval, Nine Mile and Harrow Creeks are classified as heavy stand of timber, a few down trees, little undergrowth and flood stage below branches (Chow, 1959). Harrow Creek has a lesser cover with medium to dense brush and was assigned a lower roughness coefficient.

1.4 Boundary Conditions

When the HEC-RAS model is used for the subcritical flow simulations, the user is required to specify the boundary conditions at the downstream end of the model. This provides the starting conditions for the model and for this study; the downstream boundary condition was set at normal depth for all model runs.

Section 1 HEC-RAS

Peak flows from the Rational Method calculations were entered into the HEC-RAS model. Flood extents were then calculated for the critical duration storm event for the 5, 10, 20, 50 and 100 ARI Years events. The peak flows used are shown in Table 3-1.

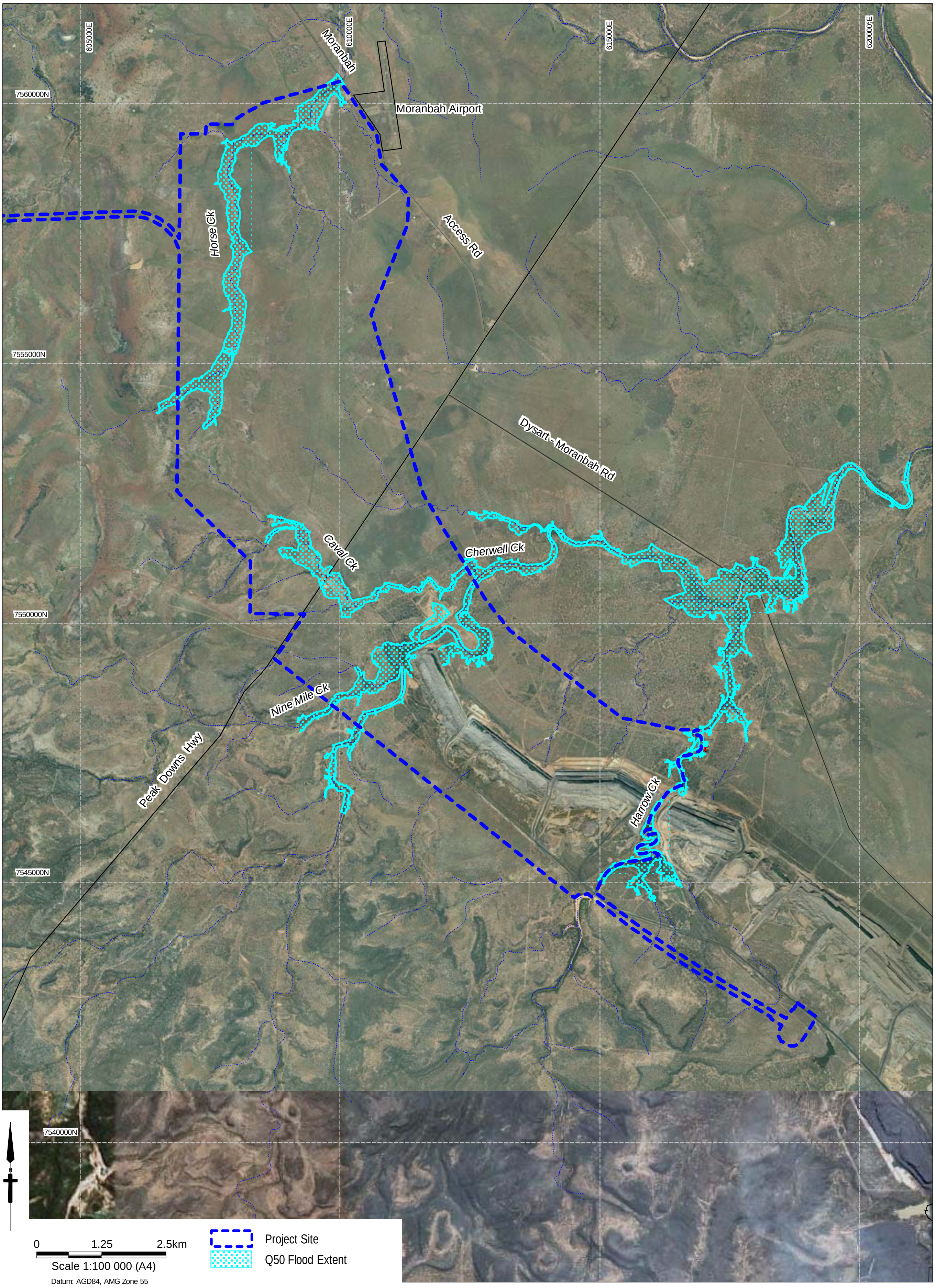
1.5 Peak Flow Methodology Adoption

The peak flows adopted for the HEC-RAS model were chosen from the Rational Method over the XP-RAFTS peak flows. The XP-RAFTS and Rational Method results were compared and contrasted, however with the limited gauged data available the XP-RAFTS model parameters (storage coefficient) could not be calibrated with any degree of certainty. The peak outflows from the XP-RAFTS model proved to be much greater than expected compared to the much more conservative results from the Rational Method. This data was also compared against some anecdotal information regarding the overtopping of the Dysart Road by Cherwell Creek. This information indicated that the bridge is overtopped about once per year and the HEC-RAS model using the Rational Method flows modelled this within some reasonable bounds of expectation.

The HEC-RAS hydraulic model, when using the derived Rational Method 6 hour peak flows, showed a reasonable correlation in catchment area and peak flow to the FFA (FLIKE LPIII). Since this gauge data is the only available source of calibration it was decided that the Rational Method, 6 hour storm duration, would be used as the peak flows for the HEC-RAS hydraulic model.

1.6 Results

The resulting flood inundation levels from the HEC-RAS modelling software were plotted and are shown in Figure 1.1 and Figure 1.2 for the ARI 50 and 100 Year flood events respectively.



Source: BMA Supplied Data

Client

BMA
BHP Billiton Mitsubishi Alliance

URS

Project

CAVAL RIDGE PROJECT
FLOOD ASSESSMENT

Title

Q 50 FLOOD EXTENT - CHERWELL AND GROSVENOR CREEKS

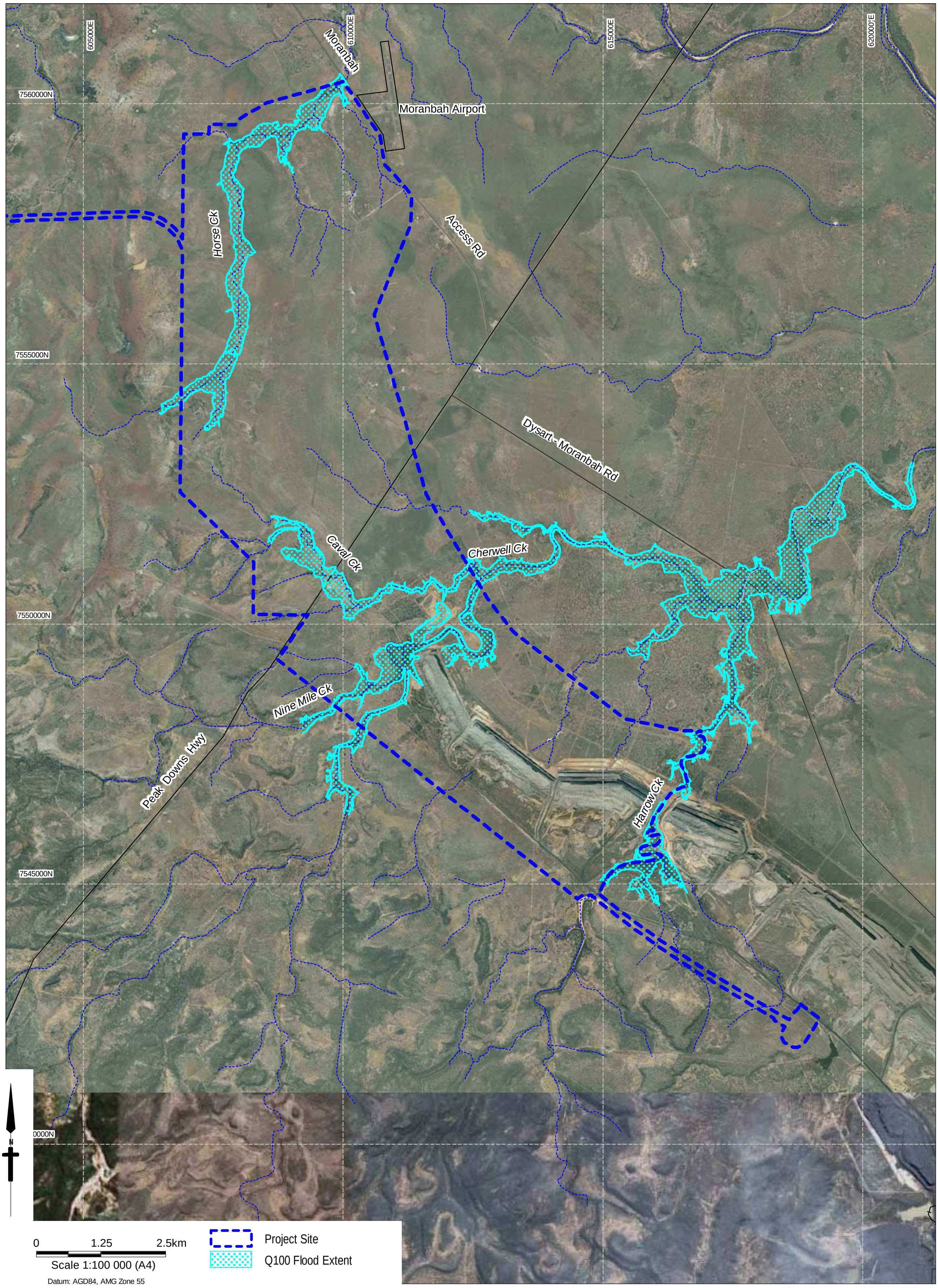
Drawn: VH | Approved: RS | Date: 28-05-2009

Job No: **4262 6163** | File No: 42626158-g-181.wor

Figure: **1.1**

Rev:A

A4



0 1.25 2.5km

Scale 1:100 000 (A4)

Datum: AGD84, AMG Zone 55

Project Site

Q100 Flood Extent

Source: BMA Supplied Data

Client	Project	Title
BMA BHP Billiton Mitsubishi Alliance	CAVAL RIDGE PROJECT FLOOD ASSESSMENT	**Q 100 FLOOD EXTENT - CHERWELL AND GROSVENOR CREEKS**
URS	Drawn: VH · Approved: RS · Date: 28-05-2009	Figure: **1.2** · Rev:A
	Job No: **4262 6163** · File No: 42626158-g-182.wor	A4

2.1 Introduction

XP-RAFTS can be used to estimate the flood discharges for observed and design storms. Parameters such as catchment area, vectored slope, storage coefficient, percent impervious area, surface roughness and rainfall loss are used to simulate the catchment response to a specific storm and to generate design hydrographs where required. Channel routing effects can be specifically modelled with the Muskingum-Cunge channel routing method.

2.2 Input Data

2.2.1 Sub-Catchment Data

The basic model structure consists of nodes which represent each sub-catchment area. Links provide a connection between nodes and simulate channel routing effects.

For computational purposes the catchment is sub-divided into a series of sub-catchments which are differentiated by drainage sub-division, topography and land use or soil type. Discharges are computed at the outlet of each sub-catchment.

1 in 100,000 scale topographic maps were used to identify the catchment boundaries and major flow paths. The catchment was then sub-divided into twenty sub-catchments (with an additional connector node to represent the confluence of Cherwell Creek and Grosvenor Creek with Isaac River) to provide flows at key locations and to adequately describe major changes in landuse and topography.

Sub-catchment areas were calculated using the topographic maps and along with contour data of the site slope and surface roughness of each sub-catchment was estimated.

2.2.2 Loss Model

XP-RAFTS include an option to account for rainfall losses, which is a simple approach that allows an initial loss followed by a continuing loss. The continuing loss may be a constant rate or a ration of the incremental rainfall. The values adopted are summarised in Table 2-1.

Table 2-1 XP-RAFTS rainfall losses

ARI (Years)	Initial Loss (mm)	Continuing Loss (mm/hr)
5	22	2.5
10	19	2.5
20	16	2.5
50	13	2.5
100	10	2.5

The rainfall loss parameter values are derived from AR&R (1987) Volume 1 – Table 6.6 Design Loss Rates for Queensland. The median continual loss value (2.5 mm/hr) was adopted for all ARI events. The initial loss limits were set for the 5 Year ARI and 100 Year ARI events and loss values between interpolated as shown in Table 2-1.

2.2.3 Link Data

In the hydrologic model, nodes representing sub-catchments are joined by links. Links define the channel or travel time between an upstream and downstream node. In XP-RAFTS, links can be described using a simple link lagging procedure or the Muskingum-Cunge routing procedure.

In link lagging, the hydrograph is shifted in time by the lag specified in the model with no attenuation. The channel routing method allows physical parameters such as the channel shape, roughness and slope to be used to calculate hydrograph attenuation and lag.

The run-off routing procedure is used for this study rather than the simple link lagging procedure.

2.3 Calibration

Rainfall run-off models should be calibrated with data from historical storms if they are to predict flows accurately. This requires details of rainfall patterns in both time and space, along with recorded stream flows. Ideally, stream flows would be available at several locations in the catchment so that areas with different characteristics can be equally well calibrated.

For this study, the only available stream flow data available was approximately 35km upstream of the Grosvenor Creek and Isaac River confluence and 22km downstream of the Cherwell Creek and Isaac River confluence. A summary of the gauging stations is listed in Table 2-2.

Table 2-2 Stream flow gauge stations

Station Name	Station Number	Catchment Area (km^2)	Data Range	Number of Zero Flow Years
Goonyella	130414A	1214	1983 – 2004 (19 years)	2
Deverill	130410A	4092	1968 – 2005 (37 years)	0

The first stage of the calibration of the hydrology model was to estimate the recurrence interval of recorded flood events. This was undertaken using a flood frequency analysis (FFA).

2.3.1 Flood Frequency Analysis

A flood frequency analysis was developed for the Deverill and Goonyella gauging stations on Isaac River. A Flike Log Pearson Type III distribution was applied to the recorded peak flood flow data for the two gauging stations. As the period of recorded data is limited, the flood frequency analysis was limited to the 1, 2, 5, and 10 Year ARI peak flows for Isaac River at these locations. Results of the flood frequency analysis are shown in Table 2-3.

Table 2-3 Flood frequency analysis

ARI (Years)	Goonyella (m^3/s)	Deverill (m^3/s)
10	1221	1705
5	604	1080
2	133	368
1	1	4

Peak flood flows for the flooding assessment of Grosvenor Creek, Cherwell Creek, Nine Mile Creek, Harrow Creek and Horse Creek, were originally proposed to be estimated using a flood frequency analysis of the Deverill gauging station flow data. This methodology was deemed unsuitable for the following reasons:

- Deverill gauging station data is only available for a period of 39 years. Extrapolation of this data to estimate the 50 and 100 year flows was therefore not used, especially considering a large proportion are low flow years.
- Peak flows from Deverill gauging station do not correlate will in comparison to Gooneylla gauge (located upstream) and Yatton gauge (located downstream). Further investigation revealed that the Deverill gauge rating curve (relationship between water level (m) and discharge (m^3/s)) has changed 27 times during the period of record, highlighting the variability of the Isaac River in this location.

2.3.2 XP-RAFTS Calibration

Due to the limited data set available for the relevant gauging stations, the XP-RAFTS model could not be reasonably calibrated with the flood frequency analysis peak flows.

2.4 Results

Due to the limited availability of data to calibrate the XP-RAFTS model, the hydrologic model was only used to generate the critical storm duration of 6 hours.

Section 3 Rational Method

The Rational method is a probabilistic or statistical method for use in estimating design floods. It is used to estimate a peak flow of selected ARI from an average rainfall intensity (AR&R 1987). The Rational Method is used in three general situations, but most relevant for this situation, can be used when no data is available for the site.

3.1 The Formula

As used in design, the formula of the Rational Method is:

$$Q_Y = 0.278 \cdot C_Y I_{t_c,Y} A \qquad \text{(AR\&R 1987)}$$

Where Q_Y = peak flow rate (m^3/s) of average recurrence interval (ARI) of Y years

C_Y = runoff coefficient (dimensionless) for ARI of Y years

A = area of catchment (km^2)

$I_{tc,\,Y}$ = average rainfall intensity (mm/hr) for design duration of t_c hours and ARI of Y years.

The runoff coefficients used for the Rational Method calculations is:

$$C_Y = (0.54 \cdot Log(Y) + 0.46) \cdot C_{10} \qquad \text{(AR\&R 1987)}$$

3.2 Results

Based upon the catchment delineation for the XP-RAFTS hydrologic model, peak outflows could be calculated for each catchment using the Rational Method. The results are summarised in Table 3-1.

Table 3-1 Rational Method Peak Outflow

Catchment	Catchment Area (km^2)	Peak Outflow (m^3/s)				
		Q5	Q10	Q20	Q50	Q100
Cherwell Ck @ Isaac Confluence	689	1475	1781	2188	2788	3369
Harrow Ck @ Cherwell Confluence	223	477	576	708	902	1090
Nine Mile Ck @ Cherwell Confluence	72	154	186	229	291	352
Grosvenor Ck @ Isaac Confluence	764	1635	1974	2426	3092	3735
Horse Ck @ Grosvenor	57	122	147	181	231	279

The peak outflows calculated are used as the input into the hydraulic model (HEC-RAS).

References

Section 4

Chow (1959) *Open Channel Hydraulics*, McGraw-Gill Book Co., New York, N.Y.

Institution of Engineers, Australia (1987) *Australian Rainfall and Runoff: A Guide to Flood Estimation*, Vol. 1, Editor-in-chief D.H. Pilgram, Revised Edition 1987 (Reprinted edition 1998), Barton, ACT