Narrabri Flood Study

Namoi River, Mulgate Creek and Long Gully

Narrabri Shire Council

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Acknowledgements and limitations

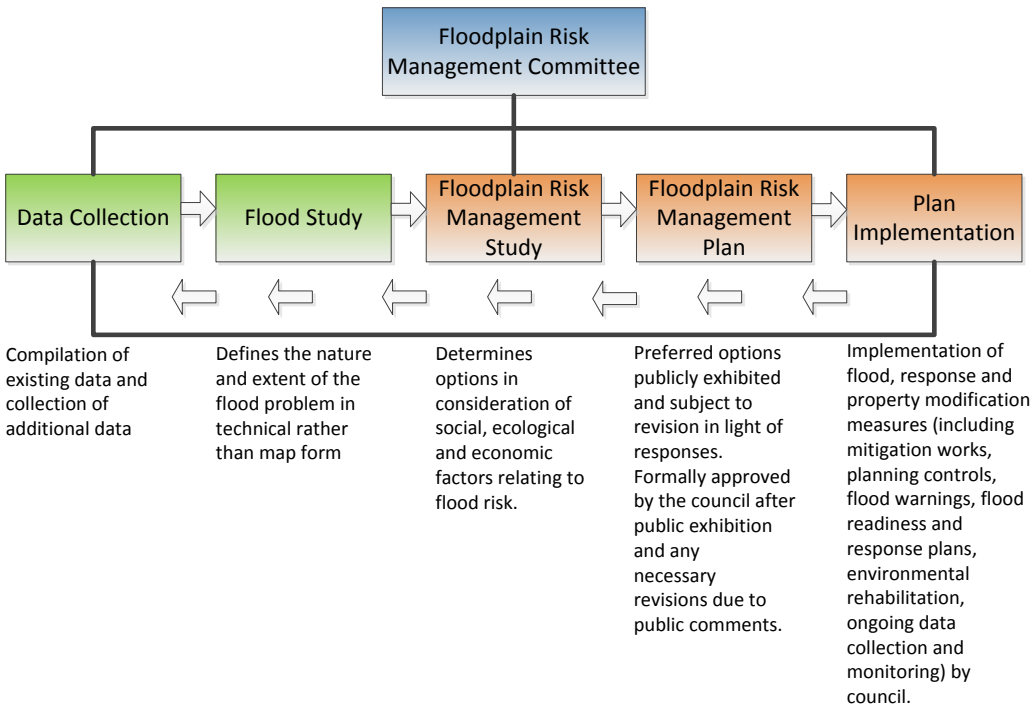
This project was prepared with financial assistance from the NSW Government's Floodplain Management Program. This document does not necessarily represent the opinions of the NSW Government or the Office of Environment and Heritage.

While all due effort has been made to ensure the reliability of flood model results, all models have limitations (Ball et al, 2016). The accuracy of any model is a function of the quality of the data used in the model development including topographical data, drainage structure data and calibration data. Modelling is by nature a simplification of very complex systems and results of flood model simulations should be considered as a best estimate only. There is, therefore, an unknown level of uncertainty associated with all model results that should be considered when utilising the outputs from this study.

Foreword

The NSW Government's Flood Prone Land Policy provides a framework for managing development on the floodplain. The primary objective of the policy is to develop sustainable strategies for managing human occupation and use of the floodplain using risk management principles. Under the Policy, the management of flood liable land remains the responsibility of local government. The State Government subsidises flood mitigation works to alleviate existing problems and provides specialist technical advice to assist Councils in the discharge of their floodplain management responsibilities.

The NSW Government's Floodplain Development Manual (2005) (the Manual) has been prepared to support the NSW Government's Flood Prone Land Policy. The Manual provides council's with a framework for implementing the policy to achieve the policies primary objective. The framework is shown below.



The Narrabri Flood Study constitutes the first stage of the Floodplain Risk Management process and assesses the risk of regional flooding from the Namoi River and local flooding from its tributaries, Mulgate Creek and Long Gully. It has been prepared by consultants WRM Water & Environment Pty Ltd and the Narrabri Shire Floodplain Risk Management Committee for Narrabri Shire Council.

Contents

List of Figures

List of Tables

1 Introduction

1.1 OVERVIEW

The township of Narrabri is located on the Namoi River floodplain and is drained by a number of smaller tributaries including Mulgate Creek, Horsearm Creek and Long Gully. Narrabri has experienced above floor flooding from each of these sources on a regular basis in the past posing a significant risk to property and life. The location of Narrabri and the drainage characteristics of the area of interest are shown in Figure 1.1.

There have been several studies prepared to define the flood risk from the Namoi River but minimal investigations have been undertaken to define the flood risk from its minor tributaries Mulgate Creek and Long Gully. Recently completed ground survey of the study area provides an opportunity to update the Namoi River flood studies and assess the flood risk from the local tributaries.

This study has been commissioned by Narrabri Shire Council, with funding assistance administered by the NSW Office of Environment and Heritage (OEH), to define the flood behaviour at Narrabri from each of the above sources.

The primary objectives of the study are to:

- determine the flood behaviour including design flood levels over the full range of flooding up to and including the Probable Maximum Flood (PMF) from both the Namoi River and the local tributaries;
- provide a model that can establish the effects on flood behaviour of future development;
- assess the sensitivity of flood behaviour to potential climate change effects such as increases in rainfall intensities; and
- assess the provisional hydraulic categories and undertake mapping of provisional hazard, preliminary emergency response planning classifications, and preliminary flood planning extent areas.

1.2 ADOPTED APPROACH

Given the relative size of the Namoi River catchment compared to the local catchments (see Figure 1.1), flooding from the two sources have been assessed separately with flood maps prepared from each source. The approach adopted for the study involved:

- a review of previous investigations;
- a review of available recorded flow data at stream gauges in and around Narrabri;
- estimate design flood discharges for the Namoi River from an annual series flood frequency analysis of the recorded peak flows;
- develop and calibrate a computer based hydrological model (XP-RAFTS) to estimate local catchment design flood design discharges throughout the study area;
- develop and calibrate a computer based hydraulic model (MIKE-FLOOD FM-flexible mesh) to simulate the movement of floodwaters across the floodplain;
- prepare peak flood depth, extent and level maps for a range of design events from the Namoi River;
- prepare peak flood depth, extent and level maps for a range of design events from the local catchments of Mulgate Creek and Long Gully; and

- assess the provisional hydraulic categories and undertake mapping of provisional hazard, preliminary emergency response planning classifications, and preliminary flood planning extent areas for Narrabri.

The hydraulic model was calibrated to the recorded water level data for three Namoi River flood events including the 1955, 1971 and 1998 floods. For the local catchments, there is no recorded stream flow data within the study area to calibrate the XP-RAFTS and MIKE-FLOOD models. For these catchments, anecdotal information on flood behaviour was obtained through a community survey in 2016 for the December 2004 and February 2012 historical flood events. Both of these events caused significant damage and disruption to the community. A total of 33 responses were received from the community survey.

1.3 REPORT STRUCTURE

The report is structured as follows:

- Section 2 describes the previous flood studies conducted for Narrabri. The drainage characteristics in and around Narrabri and the available stream flow gauging data are also described;
- Section 3 describes the configuration of the XP-RAFTS hydrological model;
- Section 4 describes the configuration of the MIKE-FLOOD hydraulic model;
- Section 5 outlines the model calibration against five historical flood events;
- Section 6 presents the design discharge estimates from an annual series flood frequency analysis;
- Section 7 presents the results from the design flood model run and sensitivity analysis undertaken as well as, a description of the flooding behaviour from the two tributaries;
- Section 8 describes the hydraulic hazard category analysis and provides the provisional flood hazard categories proposed for the study areas;
- Section 9 provides a summary of the findings for the study;
- Section 10 is a list of references; and
- Section 11 is a glossary of technical terms used in this report.

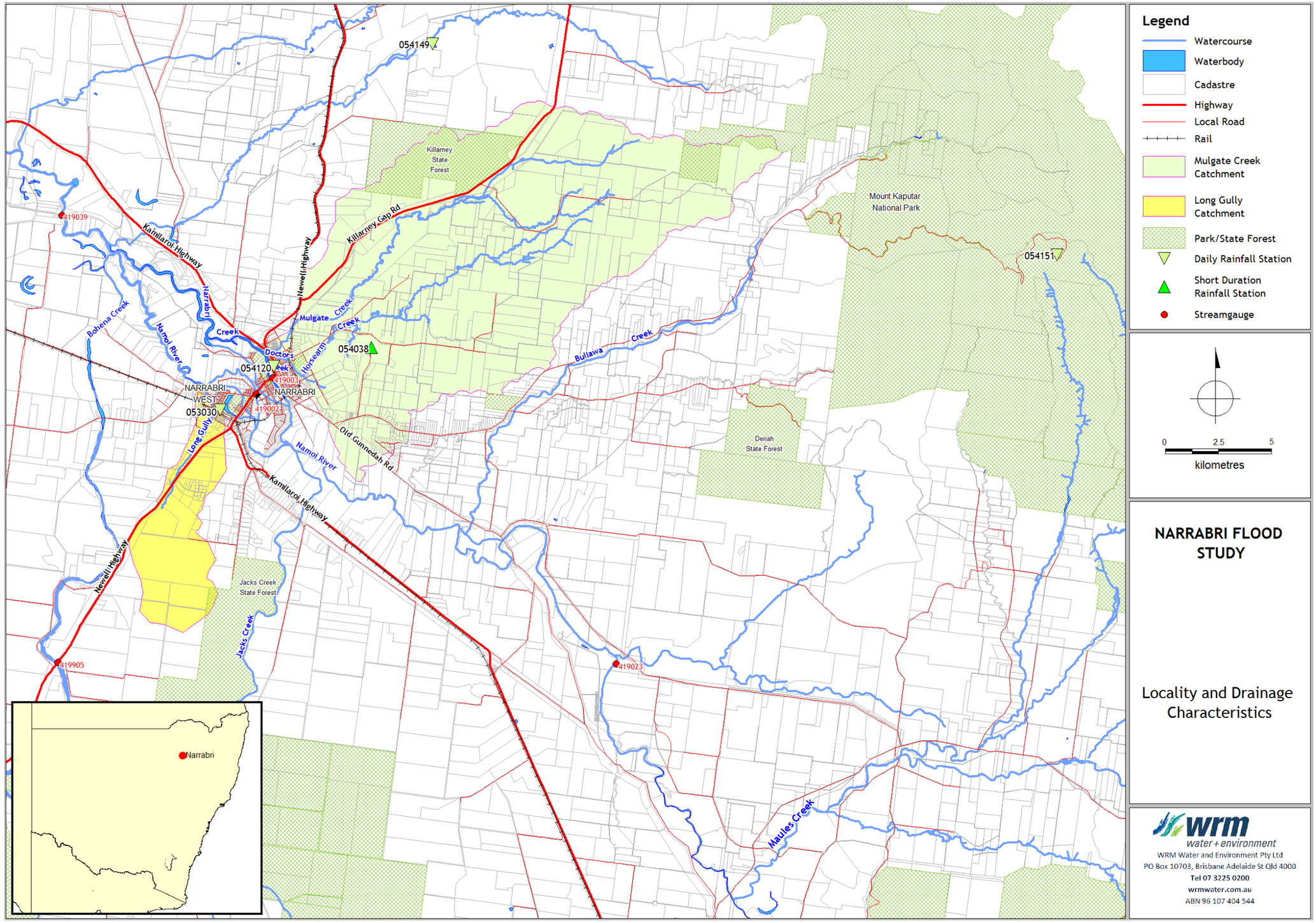


Figure 1.1 – Narrabri locality and drainage characteristics

2 Background

2.1 PREVIOUS STUDIES

A number of studies relating to flooding and drainage in and around Narrabri have been undertaken since the 1960's. A brief description of these studies is given below.

2.1.1 Mitigation of Flood Damage Caused by Mulgate Creek, University of New South Wales Water Research Laboratory (1967)

This report details the flooding issues experienced around Mulgate Creek up to the mid-1960's. The report goes on to propose a number of mitigation measures to reduce the impact Mulgate Creek flooding has on the surrounding areas. It would appear that the current alignment and large embankment of the Killarney Gap Road was first suggested in this report.

2.1.2 Namoi Valley Flood Mitigation Study, Laurie, Montgomerie & Pettit (1980)

This study primarily describes the wide scale flooding along the Namoi River, including flooding in Narrabri. Important flow paths through the town were mapped in this study. The study concluded that "Narrabri would be among the worst two or three towns in the State as far as flood problems are concerned". Options for the rail, major highways, airport access as well as town levees were investigated. The study found that flood protection levees would not be suitable for the town due to the large number of flow paths that drain through the town. No flood modelling was undertaken for this study.

2.1.3 NSW Inland Rivers Floodplain Management Studies: Summary Report – Namoi Valley, Laurie, Montgomerie & Pettit (1982)

The Namoi Valley Floodplain Management Study describes a potential levee scheme to protect the three major urban areas of Narrabri. The scheme includes a series of new levees used in conjunction with the existing highway and railway embankments to effectively shield the town from regional flooding. No flood modelling was undertaken for this study.

2.1.4 Narrabri Flood Study, Kinhill (1991)

Kinhill (1991) prepared the first technical flood study of Narrabri that included a quasi-two-dimensional MIKE-11 model of the Namoi River and Narrabri Creek based on detailed survey captured during 1989. The model was calibrated to the 1971 flood and then verified against the 1955, 1974, 1976 and 1984 floods. The study showed that there was a wide scatter of observed historical flood levels and that some of the flood levels were inconsistent. Accordingly only general trends of flood levels for the historical flood profiles through Narrabri could be assumed. Design discharges were estimated for the Namoi River and Bohena Creek using an annual series flood frequency analysis. The study did not investigate flooding along Mulgate Creek, Horsearm Creek or Long Gully.

The design discharges and hydraulic model developed for this study have been used as the basis (albeit modified) for the vast majority of flooding investigations conducted at Narrabri over the next 25 years.

2.1.5 Narrabri Floodplain Management Study, Bewsher Consulting (1996)

The Narrabri Floodplain Management Study is a comprehensive four volume report describing the existing flooding characteristics in and around Narrabri from both the Namoi River and local catchments including Mulgate Creek. A number of flood mitigation options were identified through a detailed community consultation program. The options were assessed using the MIKE-11 computer flood model developed for the Kinhill (1991) study.

Flood damage modelling was undertaken to determine the economic benefits of the various mitigation options. The outcome of the study was a detailed floodplain management plan for Narrabri.

2.1.6 Narrabri Supplementary Floodplain Management Study, Max Winders & Associates (2002)

The Narrabri Supplementary Floodplain Management Study was commissioned to determine appropriate floodplain management strategies for four key development areas within Narrabri. To complete this study the MIKE-11 model (developed in the 1991 study and updated in the 1996 study) was updated to give more definition in the areas being investigated. A number of flood-runners between the Namoi River and Narrabri Creek were incorporated into the model to improve the definition of flow distribution across the town during large events. The addition of Mulgate Creek to the model allowed local catchment flooding to be simulated for the first time. The regional Namoi River and Narrabri Creek flood model was calibrated to the 1971 flood event and verified using the 1955, 1974, 1976 and 1984 floods. Based on the results of the verified model a number of development and mitigation measures were recommended.

The study found that local flooding in the industrial area of Narrabri was up to 0.6 m lower than regional river flooding of the same probability.

2.1.7 Narrabri – Wee Waa Floodplain Management Plan, NSW Department of Natural Resources (2005b)

The Narrabri – Wee Waa Floodplain Management Plan focusses on floodplain management downstream of Narrabri (west-northwest of Mollee Weir).

2.1.8 Narrabri Bypass Flood Study, Aquatech Consulting (2012)

Two stages of the Narrabri Bypass Flood Study were conducted. The first stage was a feasibility study investigating a complete flood bypass around the east of Narrabri. This bypass was found to not be financially feasible. The second stage of the study concentrated on bypassing Mulgate Creek flows to the north of the Francis Street industrial area. After Council approved further extension of the industrial area, the proposal was no longer considered. The Narrabri Bypass Flood Study reveals a number of mitigation options that have previously been investigated for both regional and local catchment flooding.

2.1.9 Narrabri Flood Study Review, URS (2014)

The Narrabri Flood Study Review investigated regional flooding (with coincident local Mulgate Creek flooding) affecting the town of Narrabri. The existing MIKE-11 model of Narrabri Creek, the Namoi River and Mulgate Creek was updated for the study. A number of bridge structures were added and some additional survey incorporated into the model. The model was then verified by comparing the computed 1% annual exceedance probability (AEP) levels against recorded 1955 flood levels.

2.2 STUDY AREA DRAINAGE

2.2.1 Namoi River

Figure 2.1 shows the drainage characteristics in and around Narrabri. The main drainage feature is the Namoi River, which is a major tributary of the Murray Darling River system. The Namoi River has a catchment area of 25,400 km^2 to Narrabri. About 2.5 km upstream of the town centre, the Namoi River divides into two branches; Narrabri Creek and the Namoi River. Narrabri Creek carries the low flows through the town with the Namoi River channel carrying flood flows (and local catchment runoff) only. Bewsher (1996) suggest that the Narrabri Creek did not always carry the low flows through town but it is not known when the change occurred. The two branches join up about 10 km downstream of the town.

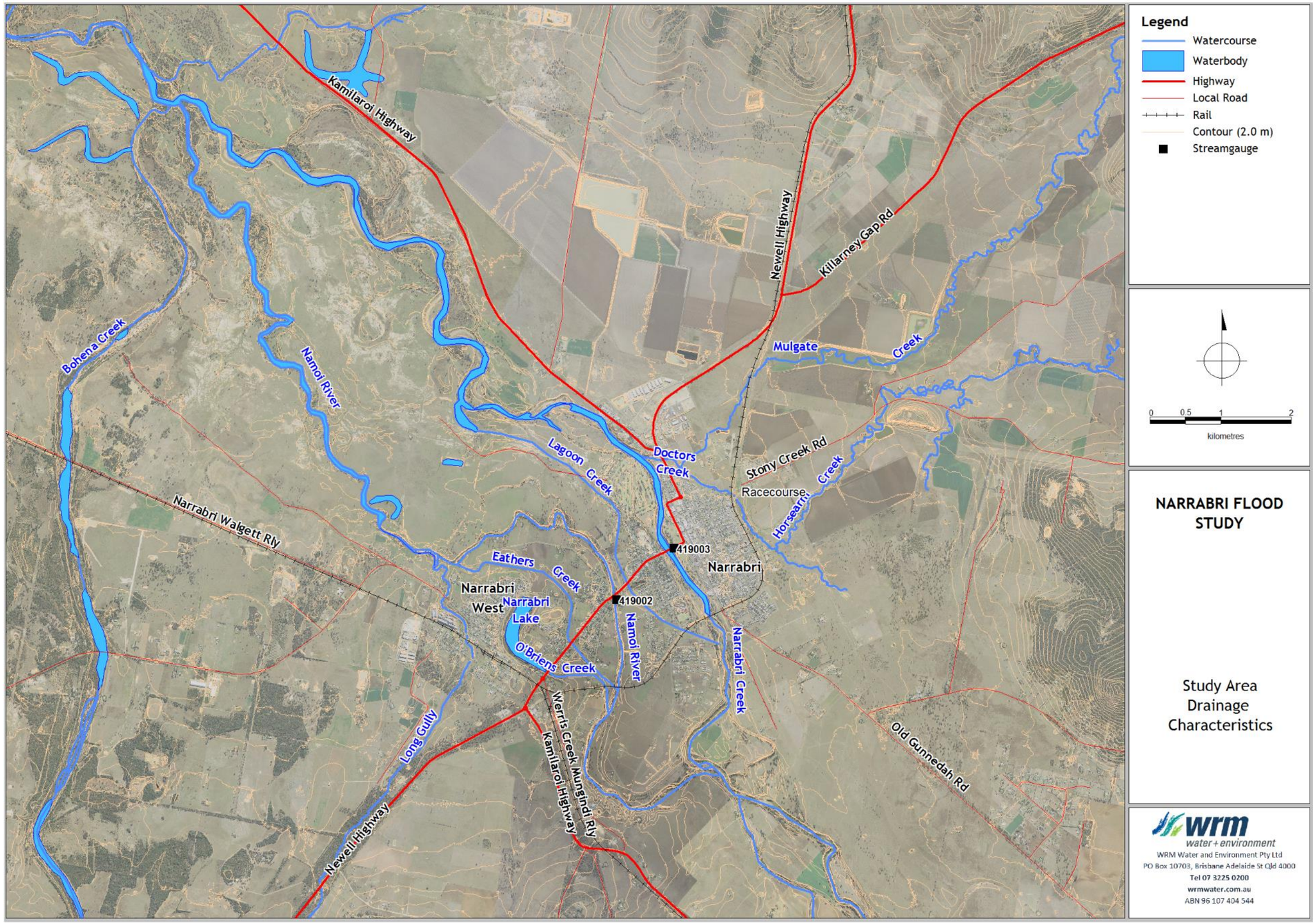


Figure 2.1 – Study area drainage characteristics

There are a number of other high level flood channels or flood runners that drain through the town:

- Eathers Creek and O'Briens Creek (which contains Narrabri Lake) are flood channels of the Namoi River branch; and
- Lagoon Creek and Horsearm/Doctors Creek are flood channels of the Narrabri Creek branch.

Significant water storages within the Namoi River catchment include:

- Keepit Dam (426,000 ML);
- Split Rock Dam (397,000 ML);
- Chaffey Dam (62,000 ML); and
- Lake Goran.

Historic flood studies of Narrabri have analysed the effects of these water storages on Namoi River flooding at Narrabri and generally concluded that minimal to negligible flood mitigation is felt at Narrabri due to these storages.

2.2.2 Mulgate Creek catchment

The Mulgate Creek catchment is located to the northeast of Narrabri (see Figure 2.1). It commences within the Mount Kaputar National Park at a peak elevation of around 700 mAHD before draining into very flat agricultural land as it gets closer to Narrabri, a fall of some 500 m. The majority of this fall occurs in the upper 2 to 3 km of the catchment within or adjacent to the National Park. The total catchment area to Narrabri Creek is 201 km^2.

Figure 2.1 shows that there are two distinct tributaries in the catchment; Mulgate Creek and Horsearm Creek. Mulgate Creek is the most northern tributary that generally drains along Killarney Gap Road towards Narrabri. Horsearm Creek drains generally parallel to but to the south of Mulgate Creek. Horsearm Creek drains around the southern side of the racecourse before it turns northward and drains between Narrabri and the racecourse towards Mulgate Creek. The creek has been named Doctors Creek downstream of the confluence of Mulgate and Horsearm creeks. Doctors Creek travels some 500 m into Narrabri Creek.

Both Mulgate Creek and Horsearm Creek drain along small ill-defined main channels across a broad flat floodplain. The channels appear to lose definition in places, particularly closer to Narrabri. The Doctors Creek channel is much more defined and deeper as it drains into Narrabri Creek.

Given the flat nature of the floodplain, significant flood events in Mulgate Creek and Horsearm Creek overflow their channels and combine to form one flow path and drain towards Narrabri. There are also a number of small levee banks that have the potential to impact on the distribution of flow draining towards Narrabri. Road infrastructure, such as the Newell Highway and Killarney Gap Road, also has the potential to change the distribution of flow.

2.2.3 Long Gully catchment

Long Gully drains into Narrabri West from the south (see Figure 2.1). It commences about 10 km to the south of Narrabri within the Jacks Creek State Forest. It flows as a broad overland flow path adjacent to the Newell Highway for most of its length. The catchment has mostly been cleared for agriculture and has a catchment area of 28 km^2 to its confluence with the Namoi River.

Long Gully drains through the urban areas of Narrabri West draining into the Namoi River about 1.2 km to the northwest of its crossing of the Narrabri Walgett Railway. During large floods, additional local catchment flows may overflow their catchments and drain towards Long Gully to impact on properties in Narrabri West.

2.2.4 Bohena Creek catchment

Bohena Creek drains into the Namoi River about 10 km downstream of Narrabri and has a catchment area of 2,180 km^2 to the Newell Highway. Investigations of the calibration events for this study have found that Bohena Creek flood flows have little if any impact on peak flood levels in Narrabri. However the size of the catchment would suggest that there is potential for Bohena Creek to impact on flood levels to the immediate west of Narrabri West. Flooding from Bohena Creek is not included in the scope of this study. However it is recommended to include an assessment of Bohena Creek as part of the flood study review phase of any future Floodplain Risk Management Study.

2.3 STREAM FLOW DATA

2.3.1 Available data

Stream flows have been recorded in the study area at various locations by the NSW Department of Primary Industries Office of Water (DPIWater) since 1891. Data at these stations were used for hydraulic model calibration and discharge estimation. The data available at the various stream gauges is summarised in Table 2.1. The locations of the gauges are shown in Figure 1.1.

A review of the available stream flow rating curves, which is the relationship used to convert recorded water level to a discharge, for these key gauging stations is given in the following sections.

Table 2.1 – Stream gauges within the study area

Station name	Station number	Period of record	Maximum gauged level (mRL)	Date of maximum gauging	Maximum recorded level (mRL)	Date of maximum level
Namoi River at Narrabri	419002	Jan 1892 - Present	7.6	Nov 2000	8.56	Feb 1955
Narrabri Creek at Narrabri	419003	Aug 1891 - Present	7.75	Nov 2000	9.44	Jan 1910
Namoi River at Mollee	419039	Oct 1972 - Present	7.84	Feb 2012	8.16	Jan 1974

2.3.2 Namoi River at Narrabri

Figure 2.2 shows the DPI Water rating curve (Table 183.01) and historical stream flow measurements (gaugings) for the Namoi River at Narrabri stream gauge. The historical gaugings are physical measurements of the stream flow, which are used to derive the rating curve when sufficient gaugings have been undertaken across a range of water levels. The Namoi River gauge at Narrabri had its flow first gauged in 1908 and has been gauged approximately 402 times since then. The gauge has not recorded water levels since September 1995 and the rating curve is no longer updated by DPI Water but the gauge is manually read during medium to high flows.

Figure 2.2 also shows the rating curve derived by the MIKE-FLOOD model (described in Section 4). The MIKE-FLOOD curve assumes that the Namoi River gauge measures all floodplain flows from the left (western) bank of Narrabri Creek. Hence the MIKE-FLOOD rating curve for the Namoi River includes flows from Lagoon Creek, Namoi River, Eathers Creek and O'Briens Creek. The MIKE-FLOOD model rating curve is reasonably close the DPI Water rating curve and the historical gaugings up to a gauge height of 8 mRL. The two curves significantly deviate for larger events above the highest recorded stream gaugings. As the DPI Water rating has been extrapolated above this water level the level of confidence in this curve in this region is decreased. Further discussion on the differences between the two curves is given in Section 5.2.1.

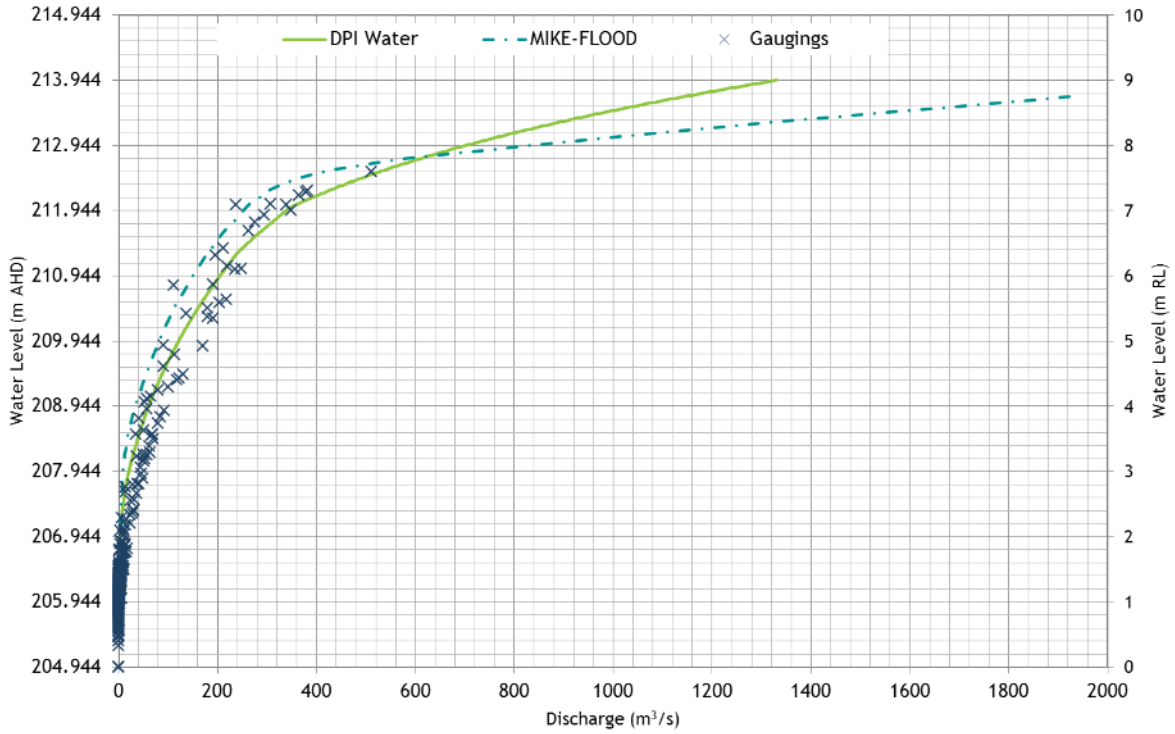


Figure 2.2 – Rating curve and gauging history for Namoi River at Narrabri (GS419002)

2.3.3 Narrabri Creek at Narrabri

Figure 2.3 shows the DPI Water rating curve (Table 170.2) and historical gaugings for the Narrabri Creek at Narrabri stream gauge. The Narrabri Creek at Narrabri station was first gauged in 1908 and has been gauged 599 times since then.

Figure 2.3 also shows the rating curve derived from the MIKE-FLOOD model (described in Section 4). The MIKE-FLOOD curve assumes that the Narrabri Creek gauge measures all flows from the left (western) bank of Narrabri Creek including Narrabri Creek, and Horsearm Creek to the east. That is, the combined Namoi River and Narrabri Creek gauges represent the total flood flow past Narrabri. The MIKE-FLOOD model and the DPI Water curves are in excellent agreement up to about 9 mRL gauge height. The curves start to separate above this level where there are no stream gaugings to define the DPI Water curve. There are three very early historical gaugings that do not follow the adopted rating curve. It is likely that these gaugings relate to a different datum and do not reflect a significant change in the channel and floodplain characteristics.

2.3.4 Namoi River at Mollee

Figure 2.4 shows the DPI Water rating curve and historical gaugings for the Namoi River at Mollee gauge. The Namoi River gauge at Mollee was first gauged in 1965 and has had approximately 422 gaugings since that time.

The figure also shows the rating curve adopted for the MIKE-FLOOD model (described in Section 4). The Mollee gauge is located at the downstream boundary of the hydraulic model and as such the MIKE-FLOOD curve has been adopted as the downstream boundary condition. The MIKE-FLOOD curve has been developed to replicate the DPI Water gauge at this location with adjustments made to the high flow rating to ensure mass is conserved between the upstream and downstream gauges, as discussed further in Section 5.2.1. Although the two curves appear similar, there is a significant departure between the two curves at high flows with the hydraulic model predicting higher flows than the DPI Water rating curve at the same water level.

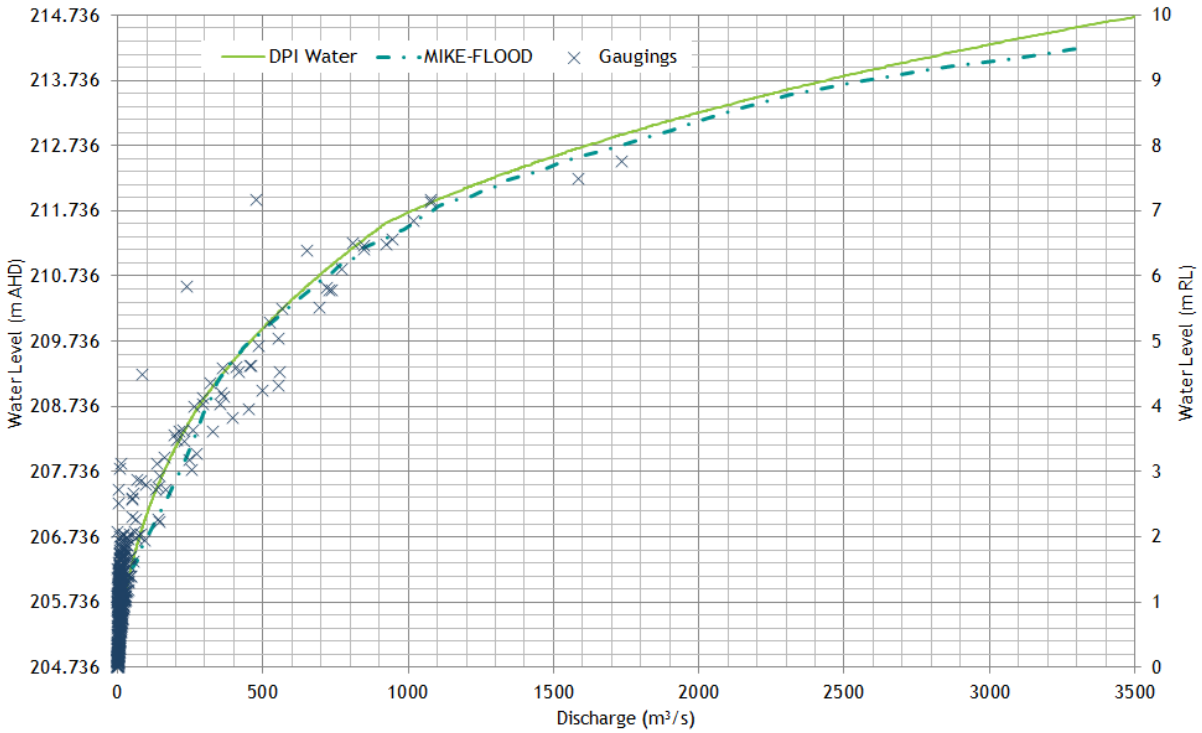


Figure 2.3 – Rating curve and gauging history for Narrabri Creek at Narrabri (GS419003)

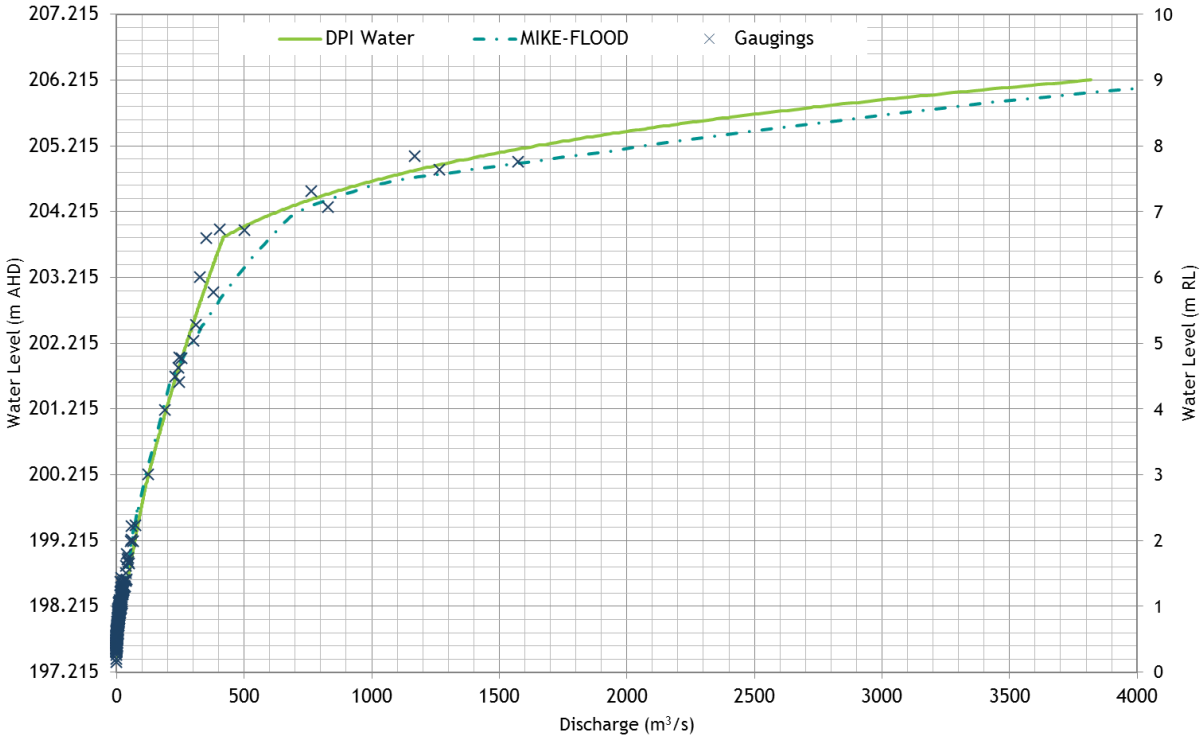


Figure 2.4 – Rating curve and gauging history for Namoi River at Mollee (GS419039)

3 Hydrological modelling (local catchments)

3.1 MODEL DESCRIPTION

The XP-RAFTS runoff-routing model (XP Software, 2013) was used to estimate historic flood discharges and design flood discharges for the study area including the:

- Mulgate Creek catchment;
- Long Gully catchment; and
- the residual area between the two study catchments (Narrabri Township).

The XP-RAFTS model uses a network of nodes to represent subcatchments and links to represent the drainage systems between subcatchments. Subcatchments are defined at each node based on total area, impervious area, average catchment slope and roughness.

The XP-RAFTS model uses initial and continuing losses to estimate the volume of runoff for a particular rainfall event. The net rainfall is then routed through the drainage network after appropriate losses are deducted and the result is a surface runoff hydrograph at the catchment outlet and nominated nodes.

3.2 MODEL CONFIGURATION

Figure 3.1 shows the subcatchments and routing link configuration of the XP-RAFTS model for Mulgate Creek and Long Gully. A total of 69 subcatchments were used ranging in size from 1.40 km^2 to 8.44 km^2. Details of the adopted XP-RAFTS subcatchment areas and links are given in Table 3.1 and Table 3.2 respectively. These parameters were determined through model calibration, as described in Section 5.3.

The following is of note:

- 38 subcatchments were used to represent the Mulgate Creek catchment;
- 13 subcatchments were used to represent the Long Gully catchment;
- 18 subcatchments were used to represent the remaining area of Narrabri;
- Catchment slope was derived from the project DEM, which is based on LiDAR survey. Where required this data was supplemented with 1 arc second satellite data (SRTM) from Geoscience Australia;
- Catchment roughness (PERN) 'n' parameters were defined based on land use using:
  - 0.08 for forest areas;
  - 0.05 used for cropped areas; and
  - 0.035 used for grassed areas and urban areas.
- All subcatchments were assumed to be 0% impervious with the exception of urban subcatchments, which were set at 25% impervious. Aerial photography was used to determine that 25% impervious was representative of these catchments;
- Channel routing was determined using the Muskingum Cunge method with 'K' values calculated based on link length and channel flow velocity. Representative flow velocities were extracted from the hydraulic model with:
  - 1.0 m/s adopted for all links with slope greater than 1%; and
  - 0.5 m/s adopted for all others.
- Channel storage exponent 'x' of 0.25 was adopted for all links.