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Tamworth Regional Council

Report for Manilla Flood Study

April 2012

FINAL

INFRASTRUCTURE | MINING & INDUSTRY | DEFENCE | PROPERTY & BUILDINGS | ENVIRONMENT

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Contents

Table Index

Figure Index

Appendices

Glossary

Annual Exceedance Probability (AEP) - AEP (measured as a percentage) is a term used to describe flood size. AEP is the long-term probability between floods of a certain magnitude. For example, a 1% AEP flood is a flood that occurs on average once every 100 years. It is also referred to as the ‘100 year flood’ or 1 in 100 year flood’. The terms 100-year flood, 50-year flood, 20-year flood etc, have been used in this study. See also average recurrence interval (ARI);

1e-4% (approx) AEP sometimes referred to as the PMF Event

0.2% AEP sometimes referred to as the 1 in 500 year ARI Event

1% AEP sometimes referred to as the 1 in 100 year ARI Event

2% AEP sometimes referred to as the 1 in 50 year ARI Event

5% AEP sometimes referred to as the 1 in 20 year ARI Event

10% AEP sometimes referred to as the 1 in 10 year ARI Event

20% AEP sometimes referred to as the 1 in 5 year ARI Event

Afflux - The increase in flood level upstream of a constriction of flood flows. A road culvert, a pipe or a narrowing of the stream channel could cause the constriction.

Australian Height Datum (AHD) - A common national plane of level approximately equivalent to the height above sea level. All flood levels; floor levels and ground levels in this study have been provided in meters AHD.

Average annual damage (AAD) - Average annual damage is the average flood damage per year that would occur in a nominated development situation over a long period of time.

Average recurrence interval (ARI) - ARI (measured in years) is a term used to describe flood size. It is a means of describing how likely a flood is to occur in a given year. For example, a 100-year ARI flood is a flood that occurs or is exceeded on average once every 100 years. The terms 100-year flood, 50-year flood, 20-year flood etc., have been used in this study. See also annual exceedance probability (AEP).

Catchment - The land draining through the main stream, as well as tributary streams.

Development Control Plan (DCP) - A DCP is a plan prepared in accordance with Section 72 of the *Environmental Planning and Assessment Act, 1979* that provides detailed guidelines for the assessment of development applications.

Design flood level - A flood with a nominated probability or average recurrence interval, for example the 1% AEP flood is commonly use throughout NSW.

OEH (formerly DECCW, DECC, DNR, DLWC, DIPNR) - Office of Environment and Heritage. Covers a range of conservation and natural resources science and programs, including native vegetation, biodiversity and environmental water recovery to provide an integrated approach to natural resource management. This department was formed in April 2007.

Discharge - The rate of flow of water measured in terms of volume per unit time, for example, cubic metres per second (m3/s). Discharge is different from the speed or velocity of flow, which is a measure of how fast the water is moving.

Ecologically sustainable development (ESD) - Using, conserving and enhancing natural resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be maintained or increased. A more detailed definition is included in the Local Government Act 1993.

Effective warning time - The time available after receiving advice of an impending flood and before the floodwaters prevent appropriate flood response actions being undertaken. The effective warning time is typically used to move farm equipment, move stock, raise furniture, evacuate people and transport their possessions.

Emergency management - A range of measures to manage risks to communities and the environment. In the flood context it may include measures to prevent, prepare for, respond to and recover from flooding.

EP&A Act - Act Environmental Planning and Assessment Act, 1979

Extreme flood - An estimate of the probable maximum flood (PMF), which is the largest flood likely to occur.

Flood - A relatively high stream flow that overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami.

Flood awareness - An appreciation of the likely effects of flooding and knowledge of the relevant flood warning, response and evacuation procedures.

Flood hazard - The potential for damage to property or risk to persons during a flood. Flood hazard is a key tool used to determine flood severity and is used for assessing the suitability of future types of land use.

Flood level - The height of the flood described either as a depth of water above a particular location (e.g. 1m above a floor, yard or road) or as a depth of water related to a standard level such as Australian Height Datum (e.g. the flood level was 7.8m AHD). Terms also used include flood stage and water level.

Flood liable land - Land susceptible to flooding up to the Probable Maximum Flood (PMF). Also called flood prone land. Note that the term flood liable land now covers the whole of the floodplain, not just that part below the flood planning level, as indicated in the superseded Floodplain Development Manual (NSW Government, 2005).

Flood Planning Levels (FPLs) - The combination of flood levels and freeboards selected for planning purposes, as determined in floodplain management studies and incorporated in floodplain management plans. The concept of flood planning levels supersedes the designated flood or the flood standard used in earlier studies.

Flood Prone Land - Land susceptible to flooding up to the Probable Maximum Flood (PMF). Also called flood liable land.

Flood Proofing - A combination of measures incorporated in the design, construction and alteration of individual buildings or structures subject to flooding, to reduce or eliminate damages during a flood.

Flood stage see flood level.

Flood Study - A study that investigates flood behaviour, including identification of flood extents, flood levels and flood velocities for a range of flood sizes.

Floodplain - The area of land that is subject to inundation by floods up to and including the Probable Maximum Flood event, that is, flood prone land or flood liable land.

Floodplain Risk Management Study – Studies carried out in accordance with the Floodplain Development Manual and assess options for minimising the danger to life and property during floods.

Floodplain Risk Management Plan - The outcome of a Floodplain Management Risk Study.

Floodway - Those areas of the floodplain where a significant discharge of water occurs during floods. Floodways are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in flood levels.

Freeboard - A factor of safety expressed as the height above the design flood level. Freeboard provides a factor of safety to compensate for uncertainties in the estimation of flood levels across the floodplain, such as wave action, localised hydraulic behaviour and impacts that are specific event related, such as levee and embankment settlement, and other effects such as “greenhouse” and climate change.

High Flood Hazard - For a particular size flood, there would be a possible danger to personal safety, able-bodied adults would have difficulty wading to safety, evacuation by trucks would be difficult and there would be a potential for significant structural damage to buildings.

Hydraulics Term - given to the study of water flow in waterways, in particular, the evaluation of flow parameters such as water level and velocity.

Hydrology Term - given to the study of the rainfall and runoff process; in particular, the evaluation of peak discharges, flow volumes and the derivation of hydrographs (graphs that show how the discharge or stage/flood level at any particular location varies with time during a flood).

LGA - Local Government Area, or Council boundary.

Local catchments - Local catchments are river sub-catchments that feed river tributaries, creeks, and watercourses and channelised or piped drainage systems.

Local Environmental Plan (LEP) – A Local Environmental Plan is a plan prepared in accordance with the *Environmental Planning and Assessment Act*, 1979, that defines zones, permissible uses within those zones and specifies development standards and other special matters for consideration with regard to the use or development of land.

Local overland flooding - Local overland flooding is inundation by local runoff within the local catchment.

Local runoff - local runoff from the local catchment is categorised as either major drainage or local drainage in the NSW Floodplain Development Manual, 2005.

Low flood hazard - For a particular size flood, able-bodied adults would generally have little difficulty wading and trucks could be used to evacuate people and their possessions should it be necessary.

Flows or discharges - It is the rate of flow of water measured in terms of volume per unit time.

Merit approach- The principles of the merit approach are embodied in the *Floodplain Development Manual* (NSW Government, 2005) and weigh up social, economic, ecological and cultural impacts of land use options for different flood prone areas together with flood damage, hazard and behaviour implications, and environmental protection and well being of the State’s rivers and floodplains.

Overland flow path - The path that floodwaters can follow if they leave the confines of the main flow channel. Overland flow paths can occur through private property or along roads. Floodwaters travelling along overland flow paths, often referred to as ‘overland flows’, may or may not re-enter the main channel from which they left — they may be diverted to another watercourse.

Peak discharge - The maximum flow or discharge during a flood.

Present value - In relation to flood damage, is the sum of all future flood damages that can be expected over a fixed period (usually 20 years) expressed as a cost in today’s value.

Probable Maximum Flood (PMF) - The largest flood likely to ever occur. The PMF defines the extent of flood prone land or flood liable land, that is, the floodplain.

Reliable access - During a flood, reliable access means the ability for people to safely evacuate an area subject to imminent flooding within effective warning time, having regard to the depth and velocity of floodwaters, the suitability of the evacuation route, and other relevant factors.

REP - Regional Environmental Plan. A plan prepared in accordance with the EPA Act that provides objectives and controls for a region, or part of a region. For example, the Georges River REP.

Risk - Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of this study, it is the likelihood of consequences arising from the interaction of floods, communities and the environment.

RORB/RAFTS - The software programs used to develop a computer model that analyses the hydrology (rainfall–runoff processes) of the catchment and calculates hydrographs and peak discharges. Known as a hydrological models.

Runoff - the amount of rainfall that ends up as flow in a stream, also known as rainfall excess.

SES - State Emergency Service of New South Wales

Stage–damage curve - A relationship between different water depths and the predicted flood damage at that depth.

Velocity - the term used to describe the speed of floodwaters, usually in m/s (metres per second). 10km/h = 2.7m/s.

Water surface profile - A graph showing the height of the flood (flood stage, water level or flood level) at any given location along a watercourse at a particular time.

1. Introduction

1.1 NSW Flood Prone Land Policy

The primary objective of the New South Wales Government's Flood Prone Land Policy is to reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone property, and to reduce private and public losses resulting from floods, utilising ecologically positive methods wherever possible.

Through the Office of Environment and Heritage (OEH) previously the Department of Environment, Climate Change and Water (DECCW) the Department of Planning (DoP) and the State Emergency Service (SES), the NSW Government provides technical assistance to local government on all flooding and land use planning matters. The Floodplain Development Manual (NSW Government, 2005) is provided to assist Councils to meet their obligations through the preparation of floodplain risk management plans. Figure 1-1 from the Manual documents the process for plan preparation, implementation and review. Tamworth Regional Council is responsible for local land use planning in Manilla. Through its Floodplain Risk Management Committee, Tamworth Regional Council proposes to prepare a comprehensive floodplain risk management plan for the study area in accordance with the NSW Government's "Floodplain Development Manual: the management of flood liable land", April 2005.

1.2 Key Issue

Manilla town is located at the confluence of the Manilla and Namoi Rivers (Appendix A) which drain to Keepit Dam in the New England region of NSW. Manilla is located 43 km to the northwest of Tamworth and has population of approximately 2100 (Australian Bureau of Statistics Census Data, 2006). The two rivers draining through Manilla command a considerable catchment area of some 5150 km^2. The catchments are primarily rural, with a number of towns located in the catchment.

Floodwaters in both catchments tend to rise quickly and isolate communities and properties for several days. Many houses can be inundated in flood events necessitating evacuations. Some rainfall and river gauging data in the catchment is available, and significant events have been recorded in Manilla. Significant events noted in the literature and mentioned by residents, are the 1955 event and the 1964 flood. The 1964 flood was considered the worst in 100 years at the time.

1.3 Study Objectives

The primary objective of this study was to define the main-stem flood behaviour under historical conditions and design flood behaviour under existing and future climate conditions in the study area. The study produced information on flood levels, depths, velocities, flows, hydraulic categories, and provisional hazard categories for a full range of design and historical flood events. In addition, the study produced estimates of flood damage.

To achieve this objective, the study collected, compiled and reviewed all available relevant data (including survey, aerial photography and satellite imagery). The design events included the 0.5%, 1%, 2%, 10% and 20% AEP events together with the Probable Maximum Flood (PMF). In addition, the potential impacts of climate change on flooding were assessed together with a number of other sensitivity analysis.

Hydrologic and hydraulic modelling was undertaken to satisfy the study objectives. The models and results produced in this study are intended to form the basis for a subsequent floodplain risk management studies by Tamworth Regional Council, where detailed assessment of flood mitigation options and floodplain risk management measures will be undertaken.

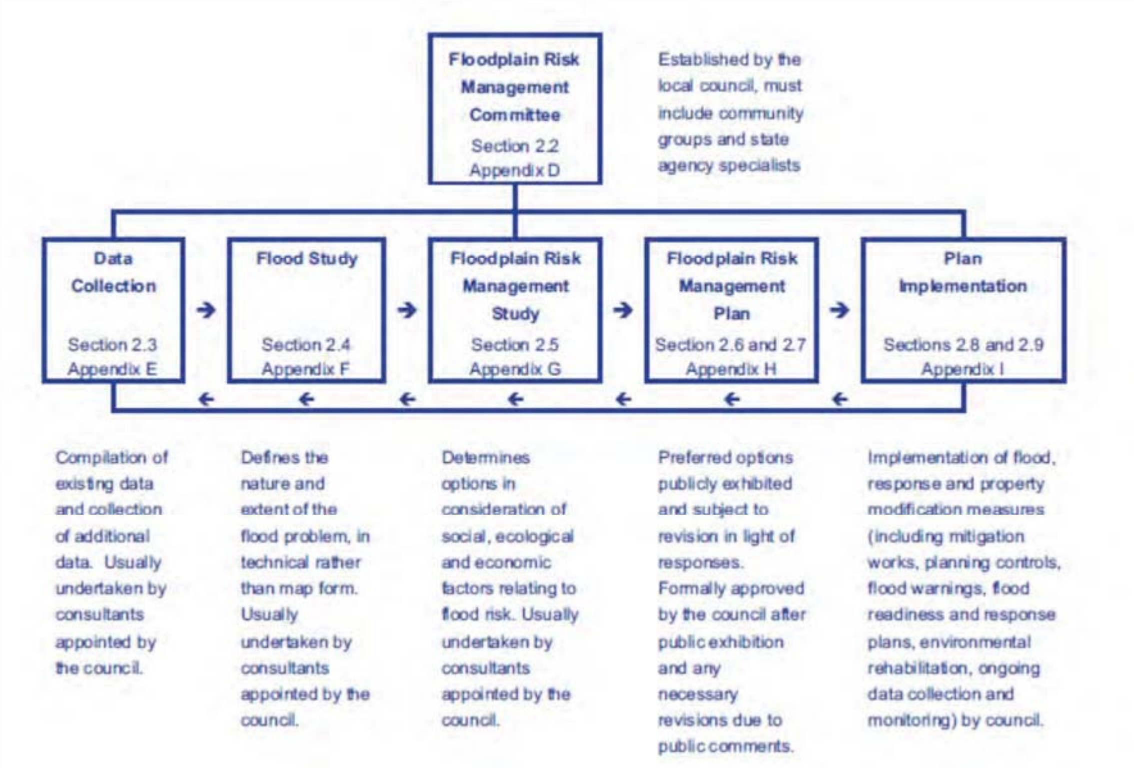


Figure 1-1 Flood Plain Risk Management Process (NSW Government, 2005)

2. Background

2.1 Catchment Description

The upper catchments of the Manilla and Namoi River catchments are located to the northwest of Tamworth in the New England region of NSW (Appendix A). Both rivers drain large catchments (2075 km^2 and 3075 km^2 respectively) before they confluence at Manilla, approximately 25 km upstream of Keepit Dam on the Namoi River.

The Manilla River headwaters are located near Split Yard Mountain in the Nandewar Range and drains in a north easterly direction to the Plumthorpe area, before turning south-east towards the town of Barraba. Approximately 20km south of Barraba, the Manilla River discharges into Split Rock Dam (storage volume 400 GL). From Split Rock Dam, the Manilla River drains southwards for a further 25km before it confluences with the Namoi River within the town of Manilla.

The Namoi River headwaters are located in the Warrahbah National Park and drains in a south westerly direction to the confluence with the Manilla River. Near the headwaters, the Namoi River has it's confluences with the Macdonald River, which drains a large (3075 km^2) catchment. The Macdonald River headwaters are located in the Dividing Range approximately 70km west of Tamworth. It discharges through the towns of Woolbrooke and Bendemeer along upstream of the confluence with the Namoi River.

A number of significant tributaries discharge to the Manilla, Namoi and Macdonald River as follows:

- Barraba Creek at Barraba;
- Bohra Creek at Upper Manilla;
- Yarramanbully and Halls Creek near Manilla; and
- A number of tributaries along the length of the MacDonald River.

The catchments in the upstream reaches of these creeks are generally steep and heavily forested. Lower reaches are mostly rural in nature. In many areas, particularly towards Manilla, the river generally has a deep, well defined, channel with a wide floodplain. River slopes vary from 1% to 2%.

A number of significant floods have occurred in Manilla as follows:

- A significant event in 1840;
- A significant event in February 1864 in which 4 out of the 12 residents were drowned;
- A significant event in 1910;
- Since 1941 when gauging started there have been 16 minor, 3 moderate and 2 major floods;
- The February 1955 flood was a major event and this was noted to be the highest since the 1910 event;
- The January 1964 was also a major event and is enshrined in many residents' memories. It was noted as the worst in 100 years; and
- More recent flood events occurred in 1971, 1984, 1998 and 2004.

Floodwaters in both catchments tend to rise quickly and isolate communities and properties for several days. Many houses can be inundated in flood events necessitating evacuations. The nature of flooding varies considerably from in-stream flood ways to areas where the floodwaters inundate floodplains at bends in the river and where floodwaters backup into the lower reaches of tributary creeks. There are a number of rainfall and river gauging data in the catchment, with records dating back as far as 1916. While this data is available, its usefulness to inform the flood study is discussed in ensuing sections of this report.

2.2 Previous Studies

The 2007 study, Assessment of Flood Risk in Various Towns and Villages (Bewsher 2007), provides a comprehensive synopsis of the historical flooding at Manilla and was undertaken with the following scope:

Tamworth Regional Council commissioned Bewsher Consulting Pty Ltd to conduct a preliminary assessment of the flood problem at 11 towns and villages throughout the Local Government Area (LGA). The principle aim of the assessment was to identify flood problems, prioritise the towns and villages according to the general scope of the problem, and to develop a strategic plan for the preparation of detailed flood studies and floodplain management studies and plans, as stipulated in the New South Wales Government's Floodplain Development Manual (April 2005).

A prioritised plan for future flood studies and floodplain management studies and plans within the Tamworth Regional Council LGA was presented. The principal factor for allocating priorities was the number of buildings located within the historic flood extent. The typical flood velocities and available warning times at each location were also been considered. Another important consideration is the frequency of the historical event under consideration.

By this method, the town of Manilla was given a high priority for future studies. The 1964 flood inundated many homes, with significant flood depths and velocities. While the construction of Split Rock Dam on the Manilla River in 1988 may have lessened the frequency of flooding from the Manilla River, the location of relatively large number of houses on the floodplain is noted as a cause for concern. (Bewsher 2007),

The 2007 study, Assessment of Flood Risk in Various Towns and Villages provided the following synopsis of flooding at Manilla:

With a population of about 2,000 people, Manilla is the largest of 11 towns and villages covered in this study. The town is located at the junction of the Manilla River and Namoi River (combined catchment area 5,130 km^2) (Figure 3.2).

Manilla had just been surveyed when on 12-13 February 1864 a flood drowned four of the 12 inhabitants and destroyed houses and Veness' store (built in 1853 near the foot of Market Street). Appendix A contains an article about the flood originally published in 1949 and reprinted in the Manilla Express in 1964. Surveyor Arthur Dewhurst estimated that the flood peak was ten feet (about 3m) higher than the previous record flood in 1840. Mr Macleod, author of the article in 1949, put it "at least 5 feet higher" than the big 1840 and 1910 floods. Significantly he adds:

"What made it more dangerous was the fact that it rose suddenly at night when the inhabitants were asleep".

Since 1941, flows in the Namoi River at Manilla Railway Bridge have been gauged. During this time, 21 floods have exceeded the "minor" flood designation at Manilla (16 minor, 3 moderate, 2 major) (Manilla Local Flood Plan, p.A-4). The major floods occurred on 25 February 1955 and 14 January 1964.

The February 1955 flood was the highest since January 1910 and is said to have affected three homes, with the little damage to property. The January 1964 flood is said to have affected about 60 properties, which compares to 137 buildings estimated to be located within the flood footprint by using the mapped flood extent and SPOT image. Possibly many of these properties experienced only shallow ground flooding and so were not considered "affected".

The Manilla Express described the 1964 flood as the worst for 100 years. The following details are gleaned from the newspapers of the day:

- *About one-third of the town had to be evacuated as floodwaters rose and entered low lying areas of the town shortly after 2pm (on Tuesday 14 January);*
- *All the families in North Manilla, Namoi Street, River Street, the lower ends of Rowan and Market Streets, and the low-lying areas of West Manilla were evacuated;*
- *At one stage the rate of rise was estimated at 18 inches (0.45m) every ten minutes;*
- *The flood peaked at about 6pm and receded quickly;*
- *Homes in the worst hit areas were almost complete covered by floodwaters;*
- *Some houses were lifted off their foundations while others were partially demolished;*
- *A small house near the corner of Court and River Streets was swept away;*
- *In River Street the PMG line staff offices and store rooms were completely swept away leaving only the foundations to indicate that a building had once stood there, and the showground was devastated;*
- *A large tree broke its way through the front double windows of Mr Ridley's home, and a television and piano were destroyed and a bedroom suite floated through the window;*
- *An elderly couple in West Manilla had to spend the night in the ceiling of their house when floodwaters prevented a rescue boat from reaching them;*
- *Manilla's loss was expected to exceed £250,000;*
- *One poultry farmer at West Manilla lost 2,000 fowls valued at £1,500-£2,000.*

Mr Toby Grant, long-time resident at North Manilla, was interviewed to gain an appreciation of the behaviour of the 1964 flood. At 25 River Street, the flood reached a depth of about 1.5m over the floor which is raised about 0.3m above the ground. The flood reached a level of 1ft below the top of the petrol bowsers at the North Manilla store. About 20 houses were inundated above flood level in North Manilla, When a log hit the door to 25 River Street, the force of water broke the wall on the opposite side. The torrent was such that a neighbour's house was "washed away", another house was washed off its foundations, and a cement booth with 6 inch thick walls was washed into the middle of the arena at the showground.

Photographs of the 1964 flood confirm the severe depths of flooding. Only the roofs remained above water at some houses.

Newspaper reports of people forced to climb onto roofs and be rescued by boat suggests little prior warning of the flood. However, it is noted that the Manilla Shire Clerk was notified of the rising floodwater upstream at Barraba at 9am on the day of the flood, and a radio announcement was made (Barraba Chronicle, Wednesday January 22, 1964, p.2). The timing of the 1964 flood was fortunate, in contrast to the 1864 flood. It appears that this was a key to the different consequences in terms of loss of life:

"Perhaps the one thing we have to be thankful for is the fact that this disaster for our town struck when it did – in the daylight. Had it come in darkness we shudder to think what the consequences could have been" (Manilla Express, Wednesday January 22, 1964, p.8, editorial).

"Had the flood occurred at night, there must have been enormous loss of life". (Bignall, 1980, p.36).

The frequency of the 1964 flood was estimated as a 50-100 year ARI event by LM&P (1982, p3-31). The construction of Split Rock Dam in 1988 on the Manilla River about 30km upstream from Manilla might mitigate floods at Manilla – LM&P (1982, p3-32) offer the following judgement:

"It is conceivable that if Split Rock storage was operating it could have effected a significant reduction in the record 1964 flood and in the 1974 flood. On the other hand, the volumes involved in the 1955 and 1971 flood were so great that Split Rock storage may not have achieved much mitigation of peak flow rates".

Split Rock Dam may be useful in mitigated floods even if full due to the routing of the flood through the storage, especially if as suggested in the Manilla Local Flood Plan (pB-1) the synchronisation of flows between the Manilla and Namoi Rivers exert an important influence on flood behaviour at Manilla.

"The most severe flooding in Manilla has occurred when high flows in the Namoi River were backed up or held up by a major flood in the Manilla River"

However, Toby Grant insists that the Namoi River was not in (major) flood in the 1964 event. Historical flood levels at the North Ceurindi gauge on the Namoi River about 16km upstream from its junction with the Manilla River lend some support to this view (see Table 2.3).

Today, adequate warning of floods should be available in Manilla. According the NSW State Flood Plan, the Bureau of Meteorology is required to provide seven hours' notice of flooding. The lessons of the 1864 and 1964 floods indicate that a flood warning system that reaches every household, combined with updated emergency plans and a flood-aware community, are vital tools to reduce the threat of life at Manilla. (Bewsher 2007).

3. Data

3.1 Introduction

For the purposes of undertaking the flood study, and to calibrate models, it was necessary to source the following key data:

- Concurrent rainfall and runoff data for significant flood events that can be used for calibration of the hydrological model parameters;
- Pluviographic rainfall data at 6 minute intervals to provide information on historic storm temporal patterns;
- Daily rainfall data to provide spatial distribution of rainfall events;
- Runoff gauge data, including gauge history and rating curves, to determine hydrographs of flood events; and
- Topographic survey data for the compilation of flood models and for the purposes of flood modelling.

3.2 River Data

3.2.1 Runoff Gauges

A number of river gauges are located along the Manilla, Namoi and Macdonald Rivers (Refer to Appendix B). A number of these gauges were suitable for calibration, as tabulated below, as they:

- Are located at appropriate positions along the river channels for the purposes of the study;
- Had captured significant flood events;
- Had reasonable gauging data and rating tables to provide information on reported hydrographs during flood events. It is important to note, that while operational dates may span a number of years, for some of the gauges earlier measurements were only captured as daily totals; and
- Had data periods that were concurrent with pluviographic rainfall data in the catchment.

Table 3-1 Runoff Gauge Data

Gauge Number	Gauge Name	River	Operational Dates	Comments
419005	Namoi River At North Cuerindi	Namoi	01/01/1916 – 01/01/2009	Namoi River 16 km Upstream Of Manilla Confluence
419020	Manilla River At Brabri	Manilla	01/01/1948 – 01/01/2010	Manilla River 6 km Upstream Of Manilla Confluence
419022	Namoi River At Manilla Railway Bridge	Namoi	01/01/1952 – 01/01/2010	Namoi River 0.7 km Downstream Of Manilla Confluence
419053	Manilla River At Black Springs	Manilla	01/01/1972 – 01/01/2010	Manilla River 0.9 km Upstream Of Split Rock Dam

3.2.2 Flood Frequency Analysis

Flood frequency analysis was undertaken using the data provided by the Pinneena (Version 9.3) software, for the Namoi River at Manilla Railway Bridge gauge (419022). While the Pinneena software provides the ability to undertake flood frequency analysis, this has no ability to screen data and assess impacts of data outliers. To this end the flood frequency analysis was undertaken manually. In respect to the flood frequency, the following was noted referring to Appendix B:

- Daily flow measurements were undertaken for the full record from approximately 1953 onwards. From 1974 onwards automatic stage recordings were available, providing a better measurement of the instantaneous flood peak. For Manilla, which experiences rapidly rising water levels in a flood, the instantaneous flood peak could be larger than the average daily measurement;
- Of the gaugings undertaken from 19/03/1941 to 14/10/2009 to calculate the rating curves, a large number of measurements are noted as being “doubtful” and in the range of flow, less than approximately 500 m^3/s. Thus the rating curve for larger flows needs to be treated with circumspection; and
- The more extreme gaugings were measured during the 1955 event, with a maximum measured discharge of less than approximately 2000 m^3/s. The maximum stage measured was 9.335m. This is significantly less than the extrapolated rating curve which extends to 14.29m. Thus, again, the rating curve for extreme events needs to be treated with circumspection;

The manual flood frequency was undertaken for two data periods as follows:

- Pre-construction of Split Rock Dam - Use was made of the daily flow measurements. Although instantaneous measurements were available for part of this period (namely 1974 to 1987), these were not included to ensure the same data type was used; and
- Pre-construction of Split Rock Dam - Use was made of the instantaneous flow measurements;

The results of the flood frequency analysis are shown in the figures and tables below. Further supporting information is provided in Appendix B. From the results, the 1% AEP event could be expected to be approximately 5100 m^3/s at the Manilla Railway Bridge before construction of Split Rock Dam. Under current conditions, after construction of Split Rock Dam, the 1% AEP event could be expected to be approximately 3600 m^3/s at the Manilla Railway Bridge, however this will be heavily dependent of the storage status of the Split Rock Dam at the time of the event.

For the purposes of model calibration, flood volumes were estimated for particular events by using measured gauging of water level and flow at various gauges to develop a stage-flow relationship. From this relationship flow hydrographs at 15-minute increments for the Manilla and Namoi rivers were developed.

Figure 3-1 Flood frequency analysis - pre-construction of Split Rock Dam

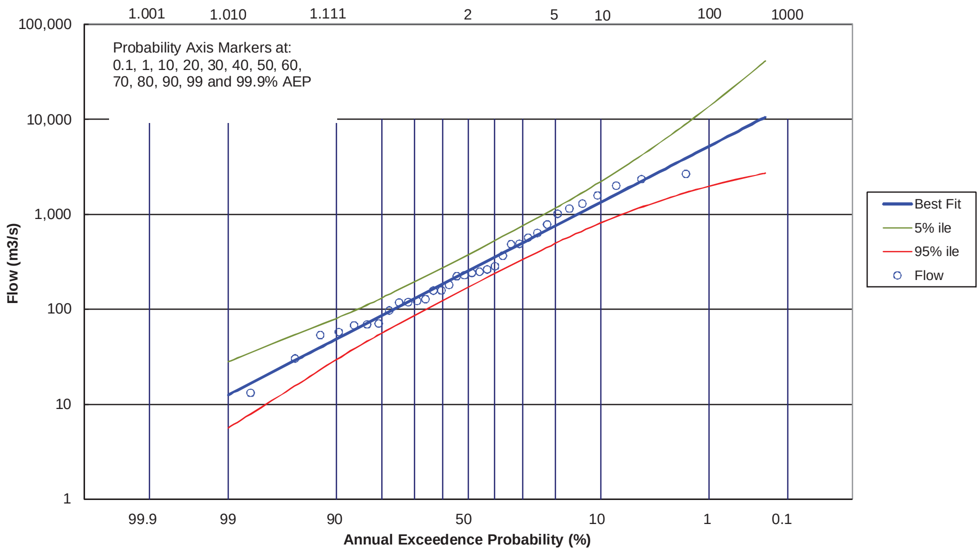
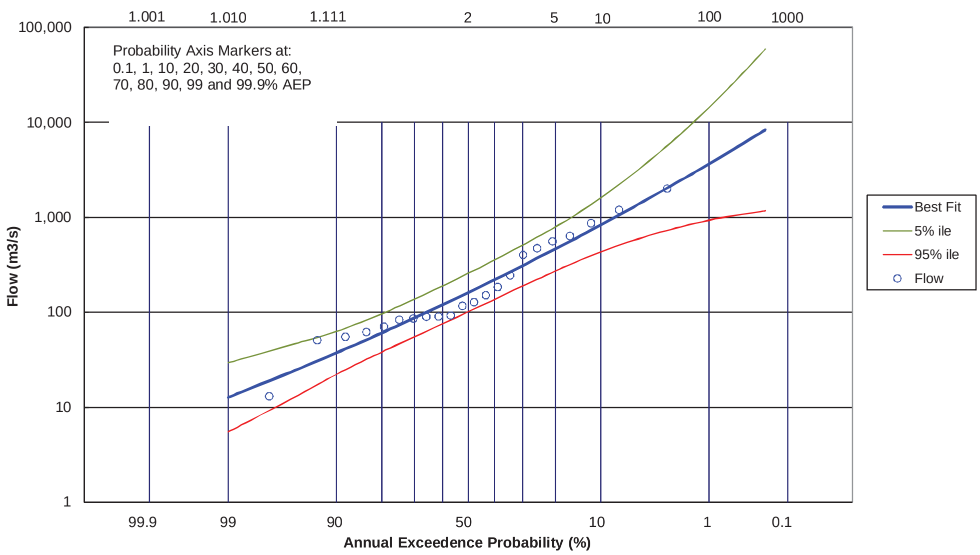


Table 3-2 Flood frequency analysis results

AEP	Pre-Split Rock Dam Flood Peak (m^3/s) (based on daily data)	Post-Split Rock Dam Flood Peak (m^3/s) (based on instantaneous data)
20%	752	461
10%	1329	826
2%	3613	2427
1%	5140	3610
0.5 %	7107	5232

Figure 3-2   Flood Frequency Analysis - Post-Construction Of Split Rock Dam



3.3 Rainfall Data

A number of rainfall gauges (Refer to Appendix B) are located within the Manilla, Namoi and Macdonald river catchments as tabulated below. While the daily rainfall data gauges are numerous, there are only a few pluviograph gauges in the catchment that provide temporal information on historic storms. The daily rainfall gauges are useful to determine any spatial distributions of rainfall that may have occurred during a significant storm event. The pluviographic rainfall stations 54102 (Barraba) and 55136 (Woolbrook) were primarily used for the purposes of calibration, as they:

- Had the longest period of record, coincidental with the runoff gauge data;
- Provided 6 minute rainfall data for a number of significant storm events;
- Are located at appropriate positions along the river channels for the purposes of the study; and
- Are located within the catchment.

Where possible, calibration was undertaken for events using the Barraba gauge pluviographic rainfall temporal patterns to represent rainfall in sub-catchments draining to the Manilla River and the Woolbrook gauge pluviographic rainfall temporal patterns to represent rainfall in sub-catchments draining to the Namoi and Macdonald rivers. In the event that data for any particular calibration event was missing from either gauge the pattern from the other was applied to all sub-catchments and weighted according to daily rainfall totals in the catchments for the event period.

Table 3-3 A selection of available Rainfall Data

Gauge Number	Type	Operational Dates	Comments
Barraba - 54102	Pluviograph	1971 – Present	Calibration With Manilla River
Woolbrook - 55136	Pluviograph	1972 – Present	Calibration With Namoi And Macdonald Rivers
Manilla Post Office - 055031	Daily	1883 – Present	Confirmation of rainfall distribution with Woolbrook and Barraba Gauges
Barraba Post Office - 054003	Daily	1964 – Present	Confirmation of rainfall distribution with Woolbrook and Barraba Gauges
Bendemeer - 55109	Daily	1958 – Present	Confirmation of rainfall distribution with Woolbrook and Barraba Gauges

3.4 Calibration Event Data

The flow gaugings in Table 3-1 were interrogated to abstract significant events for calibration purposes, for which concurrent pluviographic rainfall data was available. Events that were considered appropriate for calibration are listed in Table 3-4 below, with concurrent pluviographic rainfall data provided in Appendix B.

Table 3-4 Calibration Event Data (at Manilla Railway)

Event	Flood Peak Date	Flood Peak Level (m)	Flow (m^3/s)
1971	30/01/1971	10.285 m	2565
1984	30/01/1974	8.293 m	1650
1998	07/09/1998	9.219 m	2050
2004	18/01/2004	6.315 m	940
1964*	14/01/1964	14 m	5800

*approximate data only

3.5 Topographic Survey

As part of the study, survey data was compiled as follows:

- DTM data to describe the topography and floodplains of the Manilla and Namoi Rivers through the town of Manilla;
- Terrestrial survey of key features such as bridges and areas where the methodology used to produce the DTM were limited; and
- Survey of floor levels, for the purposes of flood damage assessments.

The survey was undertaken by Aerometrex and Baxter Geo Consulting, using Tamworth Regional Council's orthorectified photography for both towns. A survey QA report is provided in Appendix I. The photography was surveyed at 20cm pixel resolution (GSD) in March 2008 and had the following specifications:

- Flying Height: 7670 ft;
- Horizontal Accuracy (Ortho): +/- 0.40m RMSE;
- Horizontal Accuracy (Feature): +/- 0.20m RMSE;
- Vertical Accuracy of 0.17m (to 68% or 1 Sigma confidence); and
- Vertical accuracy of 0.34m (to 95% or 2 Sigma confidence).

Aerometrex processed the data and:

- Provided coded breaklines in dxf (for input into Civil 3D & 12D);
- Spot heights at an interval of 10m in a digital format which will be suitable for input into Civil 3D & 12D;
- Provided four spot heights adjacent to houses or buildings in the expected flood area approximately 350 per site; and
- Provide a georeferenced image in ECW format.

Thereafter Baxter Geo Consulting:

- Undertook additional survey control under instruction from Aerometrex;
- Provided survey control to Aerometrex;
- Received processed data from Aerometrex and loaded it into Civil 3D for validation;
- Undertook field validation of selected points;
- Located features, such as bridges, weirs and extra points along the river banks; and
- Established floor levels within the PMF when it has been determined by modelling.

3.6 Split Rock Dam

Split Rock Dam was constructed in 1987 to provide irrigation water to the Namoi valley, to protect the river environment and to supply additional water for towns along the Namoi River. Split Rock Dam has a height of 66m and holds a volume of 397.37GL of water at full capacity.

Parameters for configuration of Split Rock Dam as part of the Manilla RORB hydrological model were obtained from NSW State Water. The reservoir was configured with 2 spillways (spillway level and dam crest level), a height-storage relationship and a "weir only" outlet to simulate storage in the reservoir.

It is important to note that Split Rock Dam is currently being upgraded, with a 2m high concrete parapet wall as part of the Dam Safety Upgrade Program, however the capacity of the dam is not intended to be increased with this upgrade. This upgrade is aimed at ensuring compliance with ANCOLD and DSC safety guidelines. Table 3-5 below shows the key dimensions used in the configuration of the Split Rock Dam Reservoir in the RORB hydrological model.

In the environmental assessment for the Keepit Dam Upgrade (State Water excerpt), State Water commissioned the Department of Natural Resources to synthesise the past 100-years of rainfall and river flow data in the Namoi River catchment using the Integrated Water Quality and Quantity Model (IQQM) software model (DIPNR 2005). This model was used to predict storage levels in the reservoir (CSIRO, 2007). The study indicated that in the 5 largest flood events in the Namoi River, the dam would be at greater than 98% capacity prior to the event occurring. The Keepit Dam Upgrade Environmental Assessment therefore concluded that it would be reasonable to assume that in events greater than the 1% AEP event, the dam would be at full supply capacity. The report also indicated that the average number of years between spills at Split Rock Dam would be 7.1 years.

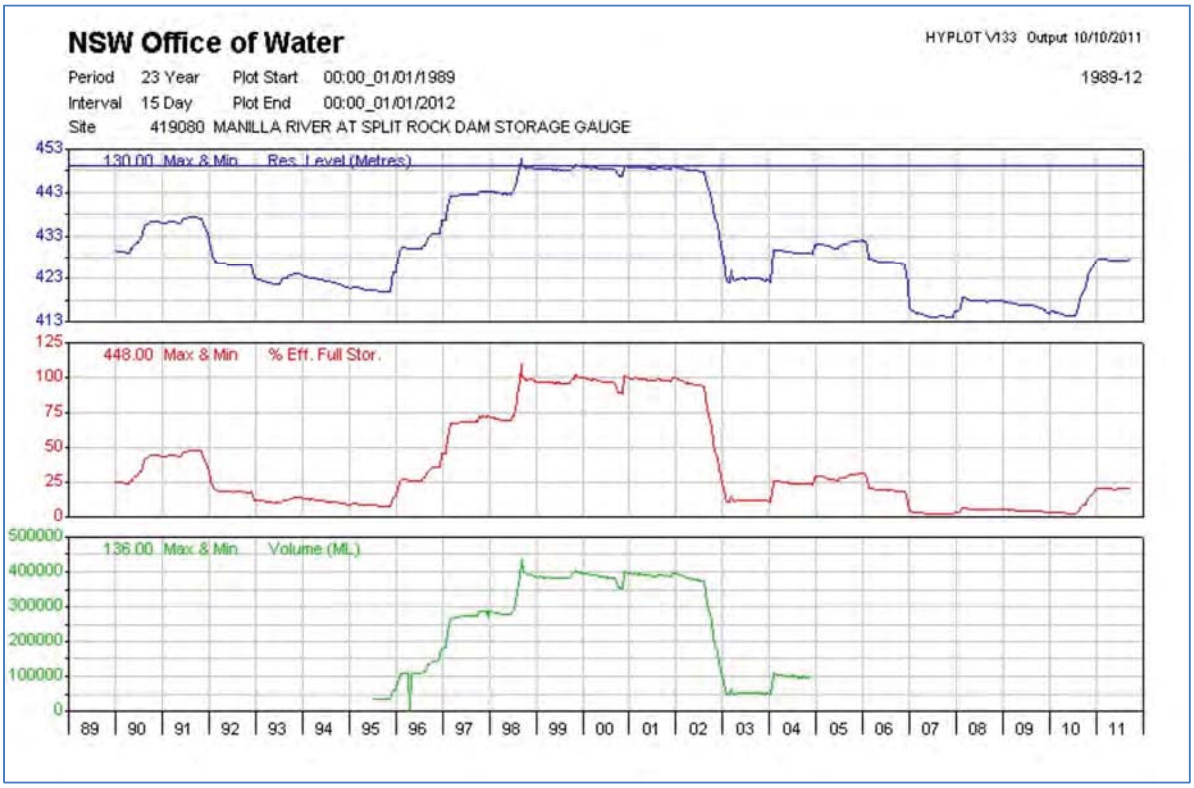
The historical record of dam volume, level and percentage full is shown in Figure 3-3. From this figure, the following is noted:

- The dam remained below 50% full dropping steadily to 10% full in the first 8 to 9 years of operation;
- After 1995 the dam filled over a period of some 3 years;
- Near the first year of being full, the 1998 flood event occurred, which resulted in discharge over the spillway; and
- Since 2003, the dam sharply dropped in volume and has been operating between empty and 25% full. (More recently, we understand the volume has risen to 40% full).

Table 3-5 Key Split Rock Dam Dimensions used in Model Configuration

Parameter	Description
Full Supply Level/Spillway Level	449.0m
Dam Crest Level	460.9m
Spillway Width	96.5m
Crest Length	484m

Figure 3-3 Split Rock Dam Storage Data (www.waterinfo.nsw - real-time data)



4. Community Consultation

4.1 Overview

The primary objectives of the flood study consultation activities were as follows:

- Informing the relevant government agencies that the study is being undertaken, outlining its objectives and inviting agencies to provide any relevant data they may hold and / or advise of any particular issues of concern;
- Similarly informing relevant local community groups; and
- Similarly informing the general public.

4.2 Floodplain Risk Management Committee

The purpose of the Floodplain Risk Management Committee is to:

- Act as both a focus and forum for the discussion of technical, social, economic, environmental and cultural issues and for the distillation of possibly differing viewpoints on these issues into a management plan; and
- Ensure that all stakeholders (often with competing desires) are equally represented. As such, the composition and roles of committee members are matters of key importance.

The Floodplain Risk Management Committee does not have any formal powers. Rather, it has an advisory role, but an important one. The principal objective of the committee is to assist the Council in the development and implementation of a management plan for the area(s) under its jurisdiction.

A Floodplain Risk Management Committee was convened by Tamworth Regional Council and included representatives from Council State Government and the committee. The committee met on:

- 20 July 2011;
- 3 August 2011;
- 16 September 2011; and
- 20 October 2011.

Minutes of the meeting are provided in Appendix C.

4.3 Consultation Activities

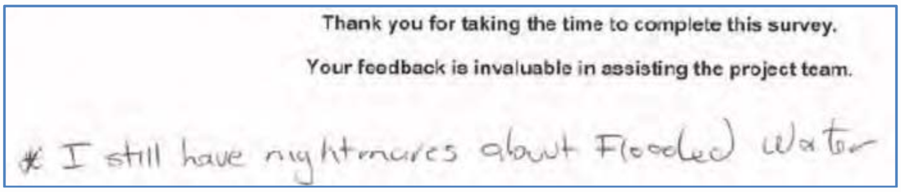
4.3.1 2011.08 - Project Notification, Newsletter and Survey

A public notice was placed in the local Manilla Express newspapers in August 2011. In addition a project information sheet and survey was forwarded to the residents in Manilla (Appendix C). A total of 97 survey responses were received. Key issues raised in the survey were:

- A large number of the residents had experienced flooding in the town of Manilla, first hand;
- Flood levels tend to rise and recede very rapidly, often within the space of a day;

- Preparation for flooding includes regular observation of river levels and lifting of belongings. In addition, listening to advice on local radio stations and from the SES. Stock, vehicles and other equipment is moved to higher ground;
- Isolation of residents is common;
- Many residents often mentioned the 1964 floods and these have been etched in memories of the Manilla community. One resident noted 8 m of flood waters through the house while another had their house completely submerged;
- A number of residents noted damages associated with flooding to dwellings;
- Residents noted that flooding had been reduced by Split Rock Dam, however could still be a high risk, if Split Rock Dam was full as occurred in the 1998 flood;
- For the school, a key response was to get school children home safely;
- A number of residents noted stormwater problems around town, after heavy localised rainfall; and
- Residents noted issues with regards to fallen trees and debris blocking flood waters and the river channel. One resident noted an observation that water holes had silted up post construction of Split Rock Dam.

In additions a number of surveys provided flood markers around town.


Thank you for taking the time to complete this survey.

Your feedback is invaluable in assisting the project team.

* I still have nightmares about Flooded Water

4.3.2 2011.10.20 - Meeting with the Flood Plain Management Committee

A meeting was held with the Floodplain Management Committee at the offices of Tamworth Regional Council. The meeting discussed the approach of the study and the program. A number of issues pertaining to the survey were discussed. In attendance were Council officers, OHE and SES. Minutes of the meeting can be found in Appendix C, together with a transcript of the presentation.

4.3.3 2011.12.14 - Meeting with the Manilla Community

A meeting was held at the Manilla Town Hall with the Manilla Community and the Floodplain Management Committee. A presentation of the overall project was provided and the community had the opportunity to provide input to the study. In particular the purpose of the flood study in the context of the overall Floodplain Risk Management Process was highlighted. The community provided valuable input with regards to experiences during flood events. In particular a number of the community had experienced the 1964 flood event.

At the meeting, preliminary flood maps were presented to the community to identify issues relating to their experiences. In attendance were Council officers, OHE and SES. The attendance can be found in Appendix C, together with a transcript of the presentation.

5. Hydrologic Model Configuration and Calibration (RORB)

5.1 General

The hydrology for the Manilla flood study was developed using the RORB hydrological model. The model was setup as an end of catchment model, producing flood hydrographs for the Namoi and Manilla Rivers upstream of the Manilla town.

RORB is a general runoff and stream flow routing program used to calculate flood hydrographs from rainfall and other channel inputs. It subtracts losses from rainfall to produce rainfall-excess and routes this through catchment storage to produce runoff hydrographs at any location. It can also be used to design retarding basins and to route floods through channel networks.

The program requires a data file to describe the particular features of the stream network being modelled and is run interactively. It can be used both for the calculation of design hydrographs and for model calibration by fitting to rainfall and runoff data of recorded events.

The model is aerially distributed, nonlinear, and applicable to both urban and rural catchments. It makes provision for temporal and areal variation of rainfall and losses and can model flows at any number of gauging stations. In addition to normal channel storage, specific modelling can be provided for retarding basins, storage reservoirs, lakes or large flood plain storages. Base flow and other channel inflow and outflow processes, both concentrated and distributed, can be modelled. (RORB 6 User Manual).

5.2 Configuration

Compilation of the RORB model included:

- Catchment delineation, in accordance with the RORB procedures. For the Manilla model a total of 21 subcatchments were delineated;
- Catchment parameter determination, namely subcatchment area and reach lengths and slopes;
- Event rainfall and concurrent flow data compilation, for calibration; and
- Design rainfall determination for generating design storm rainfall events, for the 0.5%,1%, 2%, 10% and 20% AEP events together with the Probable Maximum Flood (PMF).

The RORB model was simulated for a range of durations ranging up to 72 hours. For each event the critical duration was reported. Lag times were based on average slopes and flow velocities, ranging between 1 m/s and 2 m/s depending on slope. Percentage of impervious areas, used in the hydrology model, was 5% to represent the rural nature of the catchment. Catchment maps and sub-catchment delineation are provided in Appendix D.

5.3 Calibration

5.3.1 General

The RORB model was calibrated by variation of model parameters to obtain a good fit of the calculated to the measured hydrograph. The parameter kc is the main means of achieving a fit. The parameter, kc, can be decreased to increase the hydrograph peaks and decrease the lag time. Conversely, increasing kc does the opposite. In addition to kc, varying the initial loss is also an important means of achieving a fit. A further means is by altering the m value however use of this parameter for calibration is less common.

5.3.2 Regional kc Parameter

A number of regional estimates for the determination of kc are available throughout the literature and in the Australian Rainfall and Runoff (AR&R 2001). A number of these are offered within the RORB model for use in calibration. For the Manilla RORB model, possible regional estimates of kc parameters are tabulated below.

Table 5-1 Manilla RORB model Regional kc Parameter Estimates

Method	kc Estimate
Eastern NSW (Kleemola) (Eqn 3.20, ARR (Book V)	62.18
Australia Wide – Dyer (1994) data (Pearse et al, 2002)	93.73
Australia Wide – Yu (1989) data (Pearse et al, 2002)	78.93
RORB Default – Eqn 2.4 (RORB Manual)	157.81

5.3.3 Calibration – 1971 Storm (30/01/1971)

This event gives an indication of flooding magnitude prior to construction of Split Rock Dam. The event started with rainfall on 28/01/1971 which lasted for 5 days. The peak rainfall intensity recorded at the Barraba pluviographic rainfall station 54102 was 25.5 mm/hr in 6 minutes (at 12pm on the 29th January 1971). During this event this station recorded a total rainfall of 166.4mm. During the same period the Woolbrook pluviographic gauge recorded 92.9mm of rain. Preceding the storm, the antecedent conditions within the catchment were dry. Figure 5-1 below shows the rainfall recorded at the Woolbrook Rainfall station. The best fit calibration achieved for this event was using the regional Eastern NSW (Kleemola) kc of 62.18, and an m value of 0.8, as shown in Figure 5-2. Initial and continuing loss parameters at the Manilla gauge were 45mm and 4 mm/hr respectively, with lower losses applied to subsequent rainfall bursts recorded during this event. The losses used in this calibration are within acceptable range according to the *RORB Version 6 User Manual.* Table 5-2, provides key calibration statistics. From the figure and the table, the following is noted:

- Reasonable approximation of the 3 rainfall burst, in the flood record;
- Flood peak approximation is considered reasonable; and
- Reasonable approximation of the flood volume.

Figure 5-1 Woolbrook Rainfall Pattern

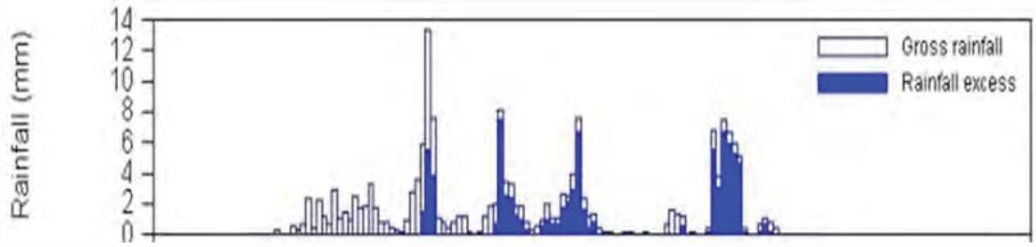
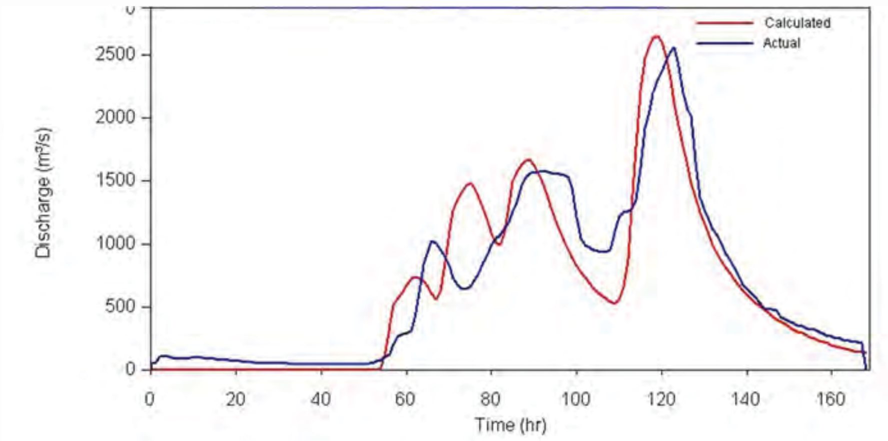


Table 5-2 1971 Storm Calibration Statistics

Item	Observed	Simulated	Difference
Storm Peak	2563	2654	+3.6%
Storm Volume	0.41E+09	0.39E+09	-5.3%
Lag (time to peak)	123	119	-3.3%

Figure 5-2 1971 Rainfall Event and Calibrated hydrograph at Manilla Railway Bridge (Gauge 419022)

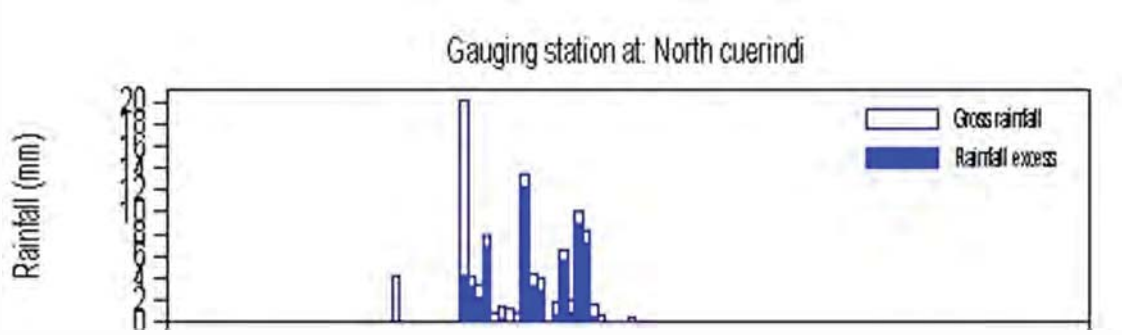


5.3.4 Calibration – 1998 Storm (03/09/1998)

This event gives an indication of flooding magnitude after construction of Split Rock Dam, and the measured storage level in the dam at the time of the event was configured in the model. The 1998 event started with rainfall on 03/09/1998 which lasted for 3 days. The peak rainfall intensity recorded at the Barraba pluviographic rainfall station 54102, was 47.7 mm/hr in 6 minutes recorded at 12am on the 4th September 1998. During this period, 98mm was recorded at Barraba. During this same Period a total rainfall of 111.2mm was recorded at the Woolbrook Gauge. No pluvio data for the Woolbrook gauge was available for this event and therefore the Barraba rainfall pattern was applied to all catchments. Preceding the storm, the antecedent conditions within the catchment were dry.

Figure 5-3 below shows the rainfall recorded at the Barraba station. The best fit calibration achieved for this event was again using the regional Eastern NSW (Kleemola) kc of 62.18, and an m value of 0.8.

Figure 5-3 Barraba Rainfall Pattern



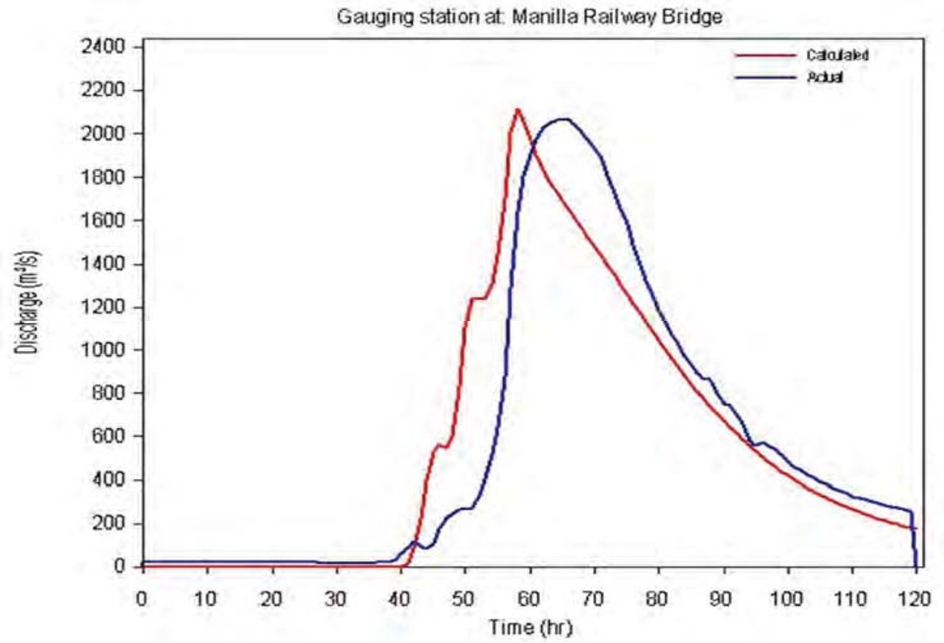
This event was simulated with Split Rock Dam at full capacity, as was the case during the event. Initial and continuing loss parameters at the Barraba gauge were 20mm and 1.9 mm/hr respectively and 25mm and 1.2 mm/hr for Woolbrook, which are within acceptable range according to the *RORB Version 6 User Manual*. Table 5-3 provides key calibration statistics. From the figure and the table, the following is noted:

- Reasonable approximation of the flood hydrograph shape;
- Flood peak approximation is considered good with an estimate of the peak to less than 1%;
- Good approximation of the flood volume; and
- The calculated peak arrives earlier than the observed peak, however this could be related to the impacts of Split Rock, and the likely impact on timing of the two peaks.

Table 5-3 1998 Storm Calibration Statistics

Item	Observed	Simulated	Difference
Storm Peak	2065	2115	+2.4%
Storm Volume	0.25E+09	0.25E+09	-0.1%
Lag (time to peak)	65	58	-10.8%
Peak Dam Water Level	450.77	451.02	+0.6%

Figure 5-4 1998 Rainfall Event and Calibrated hydrograph at Manilla Railway Bridge (Gauge 419022



5.3.5 Calibration – 2004 Storm (13/01/2004)

This event also includes the effects of Split Rock Dam and the measured storage level in the dam at the time of the event was configured in the model. The 2004 event started with rainfall on 13/01/2004 which lasted for 5 days. The peak rainfall intensity recorded by the Barraba gauge (54102) was 71.4 mm/hr, which was recorded during a 6-minute time increment on the 16th January 2004 at 9 pm. During this period a total rainfall of 165mm was recorded by the Barraba Gauge. For this same event, the Woolbrook gauge (55136) recorded 134 mm over the same period and recorded a peak rainfall intensity of 65.9 mm/hr during a 6-minute time increment on the 16th January 2004 at 8 pm. An interrogation of daily rainfall gauges throughout the catchment showed similar daily rainfall totals throughout the catchments.

Preceding the storm, the antecedent conditions within the catchment were rather wet, having received 40 mm of rainfall in the preceding 5 days. Figure 5-5 below shows the rainfall recorded at the Woolbrook and Barraba pluvio stations. The best fit calibration achieved for this event was again using the regional Eastern NSW (Kleemola) kc of 62.18, and an m value of 0.8, as shown in Figure 5-6. Initial and continuing loss parameters at the Manilla gauge were 40mm and 4 mm/hr respectively, which are within acceptable range according to the *RORB Version 6 User Manual*. Table 5-4 provides key calibration statistics. From the figure and the table, the following is noted:

- Reasonable approximation of the flood hydrograph shape, however with less favourable approximation of catchment lag;
- Flood peak approximation is considered less favourable, however the simulated peak is slight conservative compared to the observed peak; and
- Reasonable approximation of the flood volume.

Figure 5-5 Rainfall Patterns for Woolbrook and Barraba Gauges

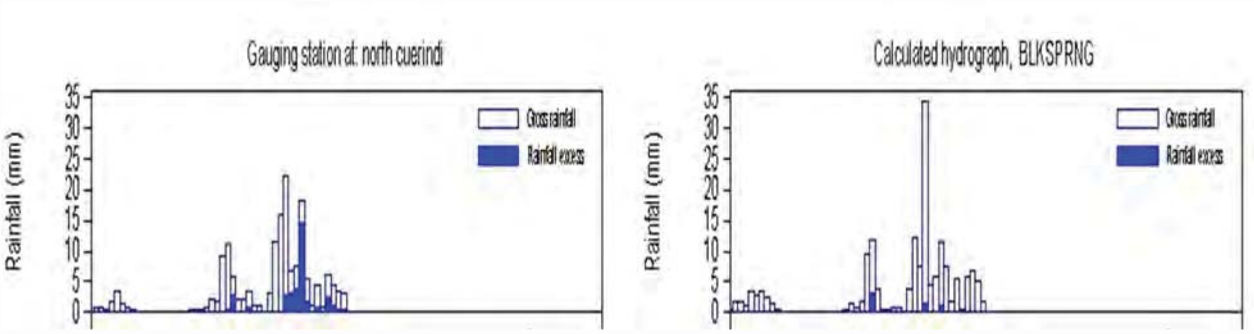
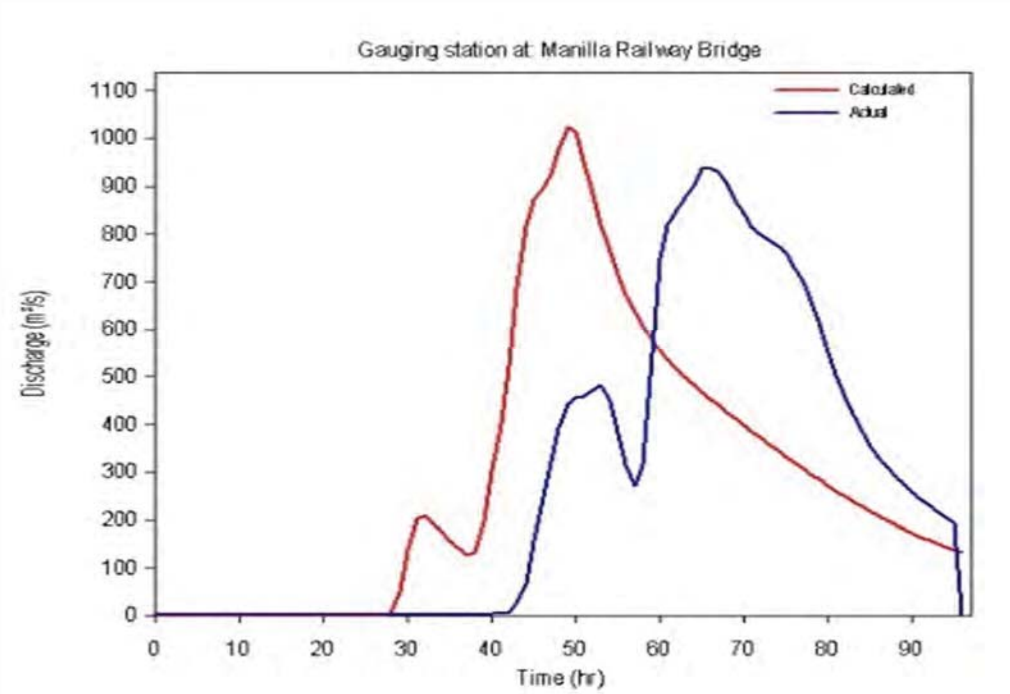


Table 5-4 2004 Storm Calibration Statistics

Item	Observed	Simulated	Difference
Storm Peak	939	1025	+9.2%
Storm Volume	0.99E+08	0.10E+09	+3.3%
Lag (time to peak)	66	49	-25.8%

Figure 5-6 2004 Rainfall Event - Calibrated hydrograph at Manilla Railway Bridge (Gauge 419022)



5.3.6 Calibration – 1964 Storm (14/01/1964)

This event is the largest event on record for Manilla. As data records for this event were not available from existing runoff gauges, the calibration was undertaken using data obtained from the Namoi Valley Flood Investigation Trust, Namoi River Flood Investigation – Report 1 (NVFIT 1964) and the Flood Information Reports, Floods in the Namoi Valley (1955, 1962, 1964, 1971, 1974, 1976), NSW Water Resources Commission (WRC). This event started with rainfall on the 13/01/1964 which lasted for 3 days. Rainfall information was available in 3-hourly intervals with a peak rainfall depth recorded at the Barraba rainfall gauge (54102) of approximately 66 mm in a 3-hour interval. During this event a total of 184mm was recorded by the Barraba gauge. Figure 5-5 below shows the rainfall recorded at the Barraba pluviographic station. The best fit calibration achieved for this event was again using the regional Eastern NSW (Kleemola) kc of 62.18, and an m value of 0.8, as shown in Figure 5-6. Initial and continuing loss parameters at the Manilla gauge were 35mm and 4 mm/hr respectively, which are within acceptable range according to the *RORB Version 6 User Manual*. Table 5-4 provides key calibration statistics. From the figure and the table, the following is noted:

- Reasonable approximation of the flood hydrograph shape, however with less favourable approximation of catchment lag;
- Flood peak approximation is within 2.2%, and the simulated peak is slight conservative compared to the observed peak; and
- Good approximation of the flood volume to within 4.5%.

It will be shown in later sections that this event compares favourably with the 1% AEP design event for the pre-Split Rock Dam scenario.

Figure 5-7 Rainfall Pattern for Barraba Gauge

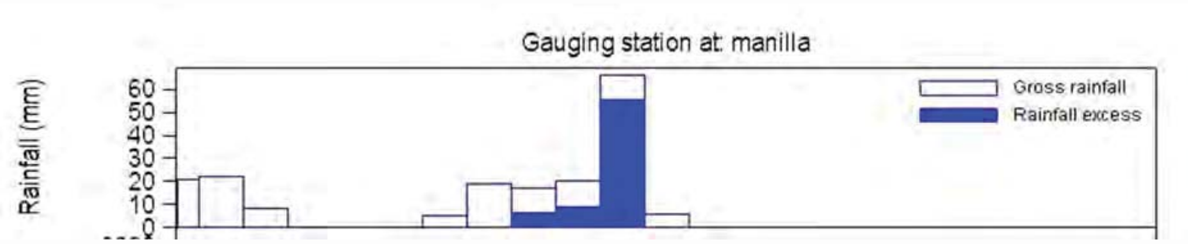
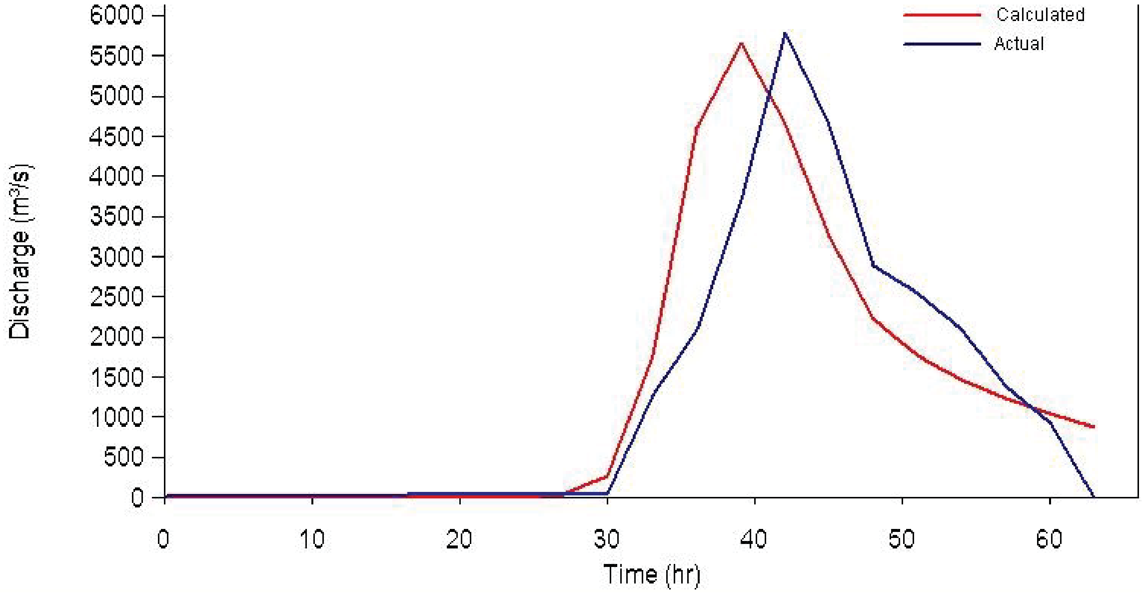


Table 5-5 1964 Storm Calibration Statistics

Item	Observed	Simulated	Difference
Storm Peak	5787	5658	-2.2%
Storm Volume	2.98E+08	3.11E+08	+4.5%
Lag (time to peak)	42	39	-7.1%

Figure 5-8 1964 Rainfall Event - Calibrated hydrograph at Manilla



5.3.7 Summary

The RORB manual (RORB Manual, Section 7.3) stresses that users need to be realistic in expectations of accuracy for calibrations, indicates that accuracies in the order of ±15% could be expected in the underlying flow data used for calibrations.

In general the RORB calibrations achieved a difference in flood peak and flood volume of approximately ±5%,using the regional (Kleemola) kc value of 62.18. Initial and continuing loss rates determined for each calibration are also noted to be very similar and consistent.

Given the matters raised in Section 3.2 relating to gauging and rating curve accuracies, it was considered that the calibrations achieved were acceptable and further optimisation of the calibration was not warranted. On this basis, it was decided to accept the regional (Kleemola) RORB kc parameter of 62.18.

6. Hydraulic Model Configuration and Calibration (TUFLOW)

6.1 General

The flood conveyance through Manilla was calculated using the TUFLOW hydraulic model.

TUFLOW is a computer program for simulating depth-averaged, two and one-dimensional free-surface flows such as occurs from floods and tides. TUFLOW was originally developed for modelling two-dimensional (2D) flows, and stands for Two-dimensional Unsteady FLOW. However, it incorporates the full functionality of the ESTRY 1D network or quasi-2D modelling system based on the full one-dimensional (1D) free-surface St Venant flow equations (see below). The 2D solution algorithm is based on Stelling 1984, and is documented in Syme 1991. It solves the full two-dimensional, depth averaged, momentum and continuity equations for free-surface flow. The scheme includes the viscosity or sub-grid-scale turbulence term that other mainstream software omit. The initial development was carried out as a joint research and development project between WBM Oceanics Australia and The University of Queensland in 1990. The project successfully developed a 2D/1D dynamically linked modelling system (Syme 1991). Latter improvements from 1998 to today focus on hydraulic structures, flood modelling, advanced 2D/1D linking and using GIS for data management (Syme 2001a, Syme 2001b). TUFLOW has also been the subject of extensive testing and validation by WBM Pty Ltd and others (Barton 2001, Huxley, 2004).

TUFLOW is specifically orientated towards establishing flow and inundation patterns in coastal waters, estuaries, rivers, floodplains and urban areas where the flow behaviour is essentially 2D in nature and cannot or would be awkward to represent using a 1D model. A powerful feature of TUFLOW is its ability to dynamically link to 1D networks using the hydrodynamic solutions of ESTRY, ISIS and XP-SWMM. The user sets up a model as a combination of 1D network domains linked to 2D domains, i.e. the 2D and 1D domains are linked to form one overall model. (BMT WBM 2010)

6.2 Configuration

The model extent for the purposes of flood mapping was defined in collaboration with Tamworth Regional Council. The final model extent was adjusted slightly to provide model stability and negate the effects of boundary conditions, as shown in Appendix E. The TUFLOW model compilation configured the key parameters as described in Table 6.1 using the following methodology:

- DTM data for the local area was imported into a digital terrain-modelling program (12D) and triangulated to represent the ground surface;
- A TUFLOW grid was generated with a cell size of 5 m^2. Each point in the grid was given an elevation based on its location in the DTM. The grid size was chosen because this is a compromise between the accuracy of the DTM data, simulation run time, model stability, and the accuracy of the results;
- All bridges within the floodplain were configured using the terrestrial survey data. These were configured within the 2D model grid;
- The flood hydrographs output by the RORB model were configured as inflows, distributed over the upstream floodplain cross-sections for both the Namoi and Manilla Rivers. Downstream boundary conditions were configured as a flow stage relationship, as shown in Figure 6-1; and

- Based on aerial photography and site inspections, hydraulic roughness coefficients for the floodplain were digitised for the floodplain and input to the model. These coefficients were digitised as a range of surfaces. Table 6-1 lists the roughness categories used in this model.

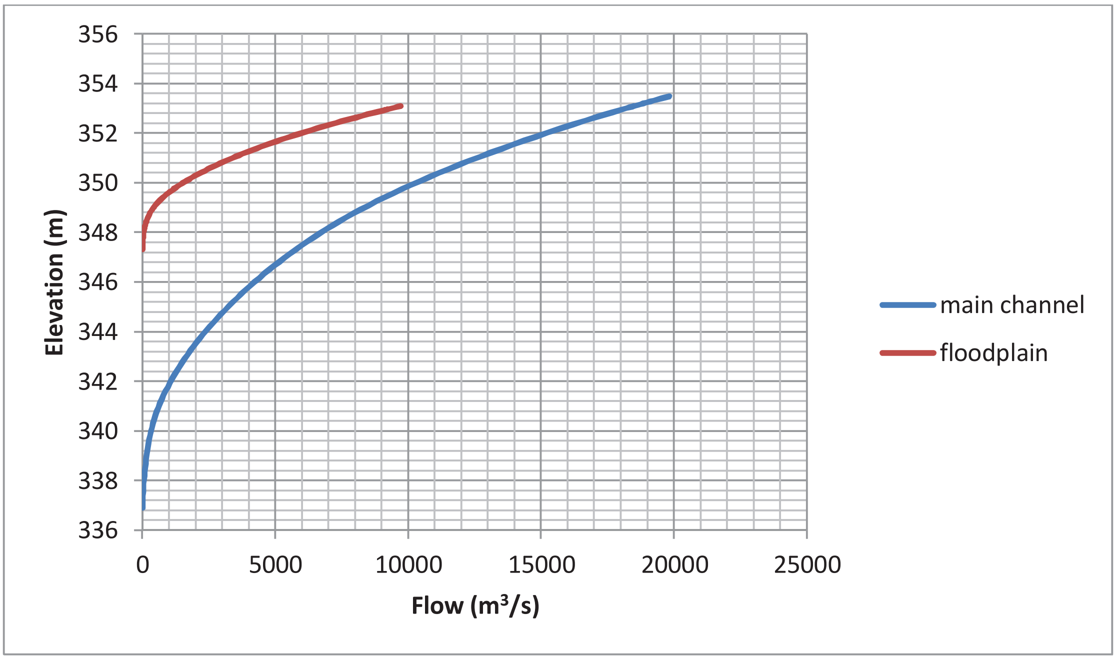
Table 6-1 TUFLOW Modelling Parameters

Feature	Value
Time step	1 second
Grid size	5m x 5m
Manning's "n" – roads	0.02
Manning's "n" – light to medium vegetation, with some trees	0.06
Manning's "n" – medium vegetation, thicker trees and some bush	0.10
Manning's "n" –dense vegetation, mostly dense bush	0.12
Manning's "n" – creeks and natural channels	0.03
Manning's "n" – developed areas (residential, commercial, industrial, farm sheds)	0.5
Manning's "n" – houses or blocked out with storage areas (zero conveyance)	2

6.2.1 Downstream Boundary Conditions

Downstream boundary conditions were configured in the TUFLOW model as a stage discharge relationship. The floodplain downstream of Manilla town flattens out considerably, with flood channels in the natural topography on the right bank of the river. This resulted in instabilities in the flood model during larger events. To this end the downstream boundary was adjusted to a position where the topography provided a natural constriction. Figure 6-1 shows the adopted elevation – discharge relationship used for the downstream boundary condition.

Figure 6-1 Elevation-Discharge Relationship for Downstream Boundary Condition



6.2.2 Significant Structures in the Floodplain

Referring to Appendix E, the following significant structures located in the Manilla floodplain were configured in the TUFLOW model.

- Mandowa Street Bridge - Bridge 1: This 85m concrete span structure is located to the north west of town upstream of the Manilla confluence on the Manilla River. It consists of a 2-lane concrete deck span and 5 concrete pylons with headstocks. This results in a waterway opening of 15.5m and a diagonal waterway opening of 18.4. The road overflow level is 350.85m AHD. Approach roads to the structure are lower than the bridge deck and overflow would be initiated before inundation of the deck;
- Manilla Street Bridge - Bridge 2: This 300m span structure is located to the northeast of town. It consists of 1 trussed span and 20 circular steel piers. This results in a waterway opening of 38.6m and a diagonal waterway opening of 39.8m. The road overflow level is 357.6 m AHD. Approach roads to the structure are level with the bridge deck and overflow would not be initiated before inundation of the deck;
- Manilla Railway Bridge – Bridge 3: This 520m spanning structure is located south of town. It consists of 2 approach spans on wooden piers over the floodplain and a central trussed span on concrete pylons spanning the Manilla River. This result in a waterway opening of 75m and a diagonal waterway opening of 76m. The deck overflow level is 357.3 m AHD. Approach roads to the structure are higher than the bridge deck and overflow would be initiated before inundation of the deck;
- Higgin's Avenue Bridge - Bridge 4: This 63m span structure is located south of town. It consists of a single 2 lane concrete deck span on 6 low set square concrete piers with headstocks. This results in a waterway opening of 8.5m and a diagonal waterway opening of 8.7m. The road overflow level is

341m AHD. Approach roads to the structure are higher than the bridge deck and overflow would not be initiated before inundation of the deck;

- Manilla Weir – Manilla weir was constructed in 1939 and is located 2.2km upstream of the Manilla confluence on the Namoi River. It consists of a 42.8m wide weir with a stepped spillway on the northern side. The upstream side of the weir is at an elevation of 346.2mAHD and drops to 344.15mAHD on the downstream side; and
- Rushes Creek Road Bridge – Bridge 5: this 29.5m spanning bridge crosses rushes creek to the south-east of town. It consists of a single 2-lane span with a road overflow level of 351.2mAHD. The bridge has been recently renewed and a low level crossing upstream has been removed with the natural creek channel reinstated.

6.3 Validation against Flood Levels at Manilla Railway Bridge

The 1971 flood event was simulated in TUFLOW in order to calibrate the model. The simulated flood levels were reviewed and model parameters adjusted in order to replicate the recorded peak water level at the Manilla Railway bridge during this event.

The table below shows favourable agreement of the simulated flood peak compared to the measured peak during the 1971 event

Table 6-2 Comparison of Flood Levels at the Manilla Railway Gauge during the 1971 Event

Event	Flood Peak Measured at the Gauge	Flood Peak simulated in the Hydraulic Model
1971 Storm (30/01/1971)	348.89 m AHD	349.12 m AHD

6.4 Validation against observed Flood Markers

A number of flood level markers, recorded during the 1964 event, exist in and around Manilla. These flood markers have been surveyed and tabulated below. While the flood markers were surveyed as part of the current study they are considered to be of low reliability, having been generally noted by residents (with exception of the Plaque). Since these flood markers were associated with the 1964 flood, and this flood closely represented a 1% AEP event (see Section 7.2.6), the flood markers have been overlaid on the 1% AEP design event in Appendix F, Figure 5.4, assuming there was no attenuation of Manilla flood hydrographs by Split Rock Dam. This scenario was achieved by re-simulating the RORB and TUFLOW models, and removing Spilt Rock Dam from the models. Referring to the figure and comparison, the following is noted:

- In the area of River Street, the simulated 1% AEP flood without Split Rock Dam compares favourably with observed flood levels; and
- In North Manilla, good agreement is achieved for the properties near Lloyd Street. The property adjacent to River Street, noted a significantly higher flood level, however this seems inconsistent with the two other flood level measurements close by.

The 1964 and 1% AEP design event, assuming there was no attenuation of Manilla flood hydrographs by Split Rock Dam, thus compare favourably with the measured flood markers.

Table 6-3 Identified Flood Markers

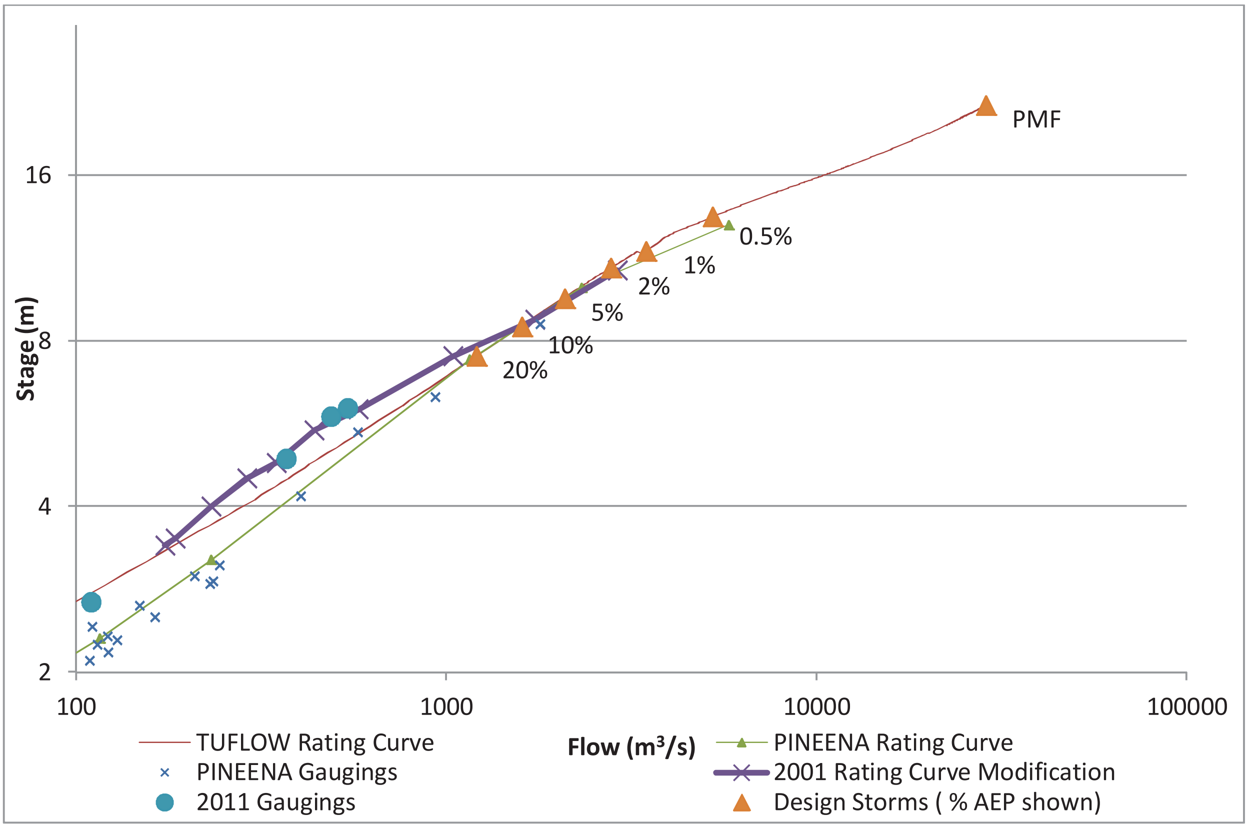
ID	Location/Type	Surveyed Level (m AHD)	Comments
FLOOD MARK	Stain On Wall	354.3	Dewhurst "8m mark"
FLOOR	113 Namoi	354.2	
RIDGE	Charles St	356.1	maybe gutter
RIDGE	Charles St	356.1	
FLOOD	Plaque	353.4	1158ft = 352.96m
FLOOD	85 River St	353.5	top of window
FLOOD	Motel Driveway	351.9	passerby

6.5 Comparison and extension of the Manilla Railway Bridge Gauge Rating Curve

The stage-discharge relationship simulated for the design events using the calibrated TUFLOW model at the Manilla Railway Bridge gauge was plotted against the PINEENA rating curve, in Figure 6-2. It is noteworthy that OEH updated the PINEENA rating curve with gauging data captured in 2011.

Although minor deviation occurs for events more frequent than required by the current study, the TUFLOW rating curve is located approximately half way between the OEH PINEENA and 2011 rating curves. For the design events simulated as part of the current study, a good correlation between the TUFLOW and PINEENA curves is observed.

Figure 6-2 Comparison of PINEENA Rating Curve with TUFLOW Result



7. Design Flood Behaviour

7.1 Overview

To determine the design flood behaviour, both the RORB and TUFLOW models were simulated, using the parameters derived through the calibrations together with design rainfall in accordance with the Australian Rainfall and Runoff (AR&R 2001). The simulations were undertaken as follows:

- The RORB model was simulated using a kc value 62.18 together with design rainfall and rainfall loss estimates in accordance with the Australian Rainfall and Runoff. Each event was simulated for a range of durations and the critical duration storm hydrograph was input to the model; and
- The results from the RORB model were used as boundary conditions for the TUFLOW model which was simulated for each event.

Further details on the input used for the simulations are provided below.

7.2 Flood Hydrographs

7.2.1 Design Rainfall

Design rainfall events were derived in accordance with the procedures of the Australian Rainfall and Runoff, Region 2 (AR&R 2001). The Intensity Frequency Duration parameters adopted for the Manilla catchment are listed in Table 7-1.

Table 7-1 Manilla IFD Parameters

Parameter	Value
2yr 1hr	27.33
2yr 12hr	4.65
2yr 72 hr	1.35
50yr 1hr	51.04
50yr 12hr	8.71
50yr 72 hr	2.31
Skew	0.32
F2 Value	4.34
F50 Value	16.04
Zone	E

7.2.2 Probable Maximum Precipitation and Flood (PMP & PMF)

Given the size of catchment and recommended thresholds, the Probable Maximum Precipitation was compiled using the Bureau of Meteorology Australia Generalised Tropical Storm Method – Revised

Version (GTSMR – BOM 2003). The PMP rainfall depths derived for a range of durations using the method are tabulated below.

Table 7-2 PMP Rainfall Depths

Duration (hrs)	PMP Rainfall Depth (mm)
24	585
36	682
48	772
72	931
96	1063
120	1120

The PMP rainfall depths were simulated in the RORB model assuming Split Rock Dam was at full supply level to calculate the PMF. Loss factors as discussed in Section 7.2.3 were applied. The PMF flood peak at the Manilla Railway Bridge was calculated to be 28700 m^3/s, with a critical duration of 36 hours.

7.2.3 Rainfall Losses

Rainfall losses were adopted in accordance with the Australian Rainfall and Runoff (AR&R 2001) Book 2 and Book 6. These recommend the losses as listed in Table 7-3.

Table 7-3 Rainfall Losses

Event	Initial Loss	Continuing Loss
Up to and including the 1% AEP event	15 mm	2.5 mm/hr
1% event up to the PMF	15 mm	1 mm/hr
PMF	15 mm	1 mm/hr

7.2.4 Design Flood Peaks at Manilla

The simulation of the RORB model was undertaken for a number of events and a number of durations, up to and including the PMF. For each event the critical duration design flood hydrograph was identified, and input as upstream boundary condition inflow. The flood peaks determined for each event are summarised below.

It is important to note that these inflows inherently contain assumptions on Split Rock Dam, which was configured to be at full supply level at the time of the event.

A further simulation was undertaken for the 1% AEP event, where the Split Rock Dam was not considered (namely removed from the model), for the purposes of comparisons to the Probabilistic Rational Method and the Flood Frequency Analysis. The flood peak at the Manilla railway bridge was calculated to be 5900 m^3/s.

Table 7-4 RORB Design Flood Peaks (with Split Rock Dam)

Flood event AEP	Manilla River Flood Peak m^3/s	Namoi River Flood Peak m^3/s	At the Manilla Railway Bridge m^3/s
20%	360	970	1205
10%	500	1280	1600
5%	680	1660	2090
2%	960	2200	2780
1%	1225	2710	3470
0.5%	2020	3305	5244
PMF	11385	17410	28710

7.2.5 Probabilistic Rational Method

The Probabilistic Rational Method was used to provide an additional estimate of the flood peak for the 1% AEP event. This method is not suitable for catchment sizes of area greater than 250 km^2 and inherently does not necessarily account for catchment effects such as attenuation. However the method gives an indication of the flood peak order of magnitude.

Using the Probabilistic Rational Method, the 1% AEP flood peak was estimated as 5300 m^3/s. In considering this estimate, it must be noted, that no influences of Split Rock Dam have been considered.

7.2.6 Comparison of 1% AEP Flood Peak Estimates

The derived flood peak estimates for a range of events using a number of methods have been tabulated below. Referring to the table below, it is noted that the various methods compare favourably, providing further confidence in the RORB model calibration. In addition the 1% design flood agrees favourably with the 1964 flood peak (approximately 5700m^3/s) at the Manilla Railway bridge for the scenario without Split Rock Dam attenuating flows.

Table 7-5 Comparison of 1% AEP Flood Peak Estimates at Manilla Railway Bridge

Flood event AEP	Flood Frequency Analysis (Section 3.2.2)	Calibrated RORB Model (Section 7.2.4)	Probabilistic Rational Method (Section 7.2.5)
Without Split Rock Dam attenuating flows (namely removed from the model)			
1%	5140 m^3/s	5900 m^3/s	5300 m^3/s
With Split Rock Dam attenuating flows			
1%	3610 m^3/s	3470 m^3/s	n/a

From Figure 7-1 and Figure 7-2 below, the flow attenuation in the Manilla River upstream of Manilla due to Split Rock Dam is clearly evident. The peak flow in the Manilla River upstream of the Manilla township is reduced by 37%. The attenuation of this peak results in a reduction in the peak flow downstream of the Namoi-Manilla confluence of 60%.

Figure 7-1 1% AEP Pre-Dam Hydrographs (Critical 18hr storm)

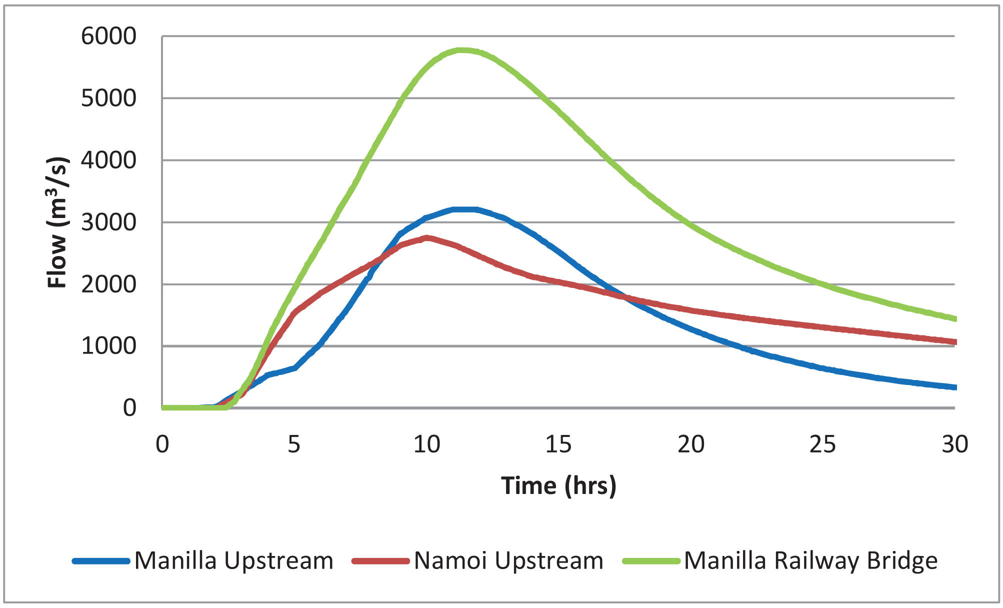
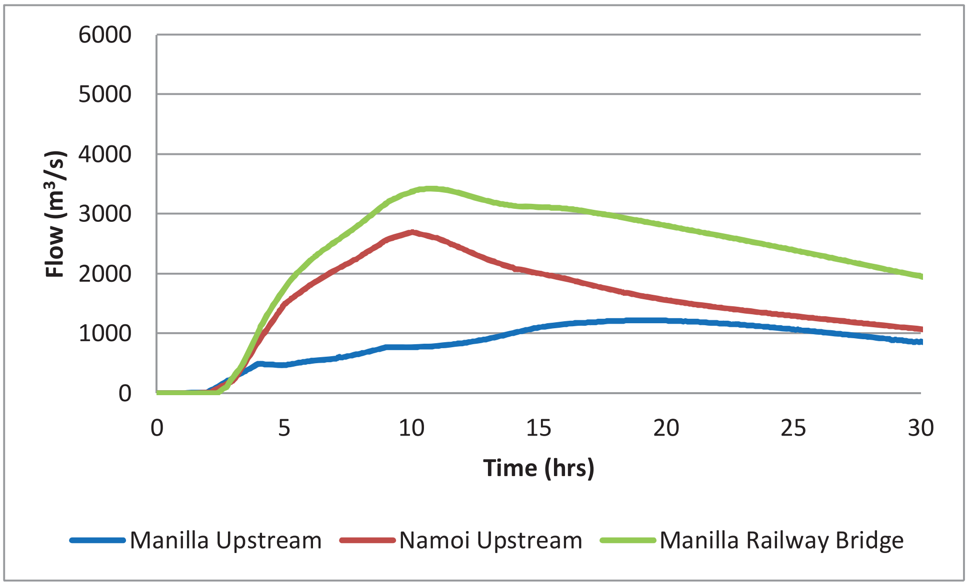


Figure 7-2 1% AEP Post-Dam Hydrographs (Critical 18hr Storm)



7.3 Flood Behaviour

7.3.1 Upstream Boundary Conditions - Flood Peaks

For the upstream boundary conditions to the TUFLOW model, the design flood hydrographs discussed in Section 7.2.4 were input to the model.

7.3.2 Downstream Boundary Conditions

Downstream boundary conditions were configured in the TUFLOW model as per the existing conditions simulations, namely by using a stage discharge relationship

7.3.3 Results

The results of the design flood simulations have been provided as a series of flood maps (Appendix F), namely as:

- a series of maps showing flood depth in blue, overlain by flood level contours;
- a series of maps showing flood velocities; and
- a series of maps showing flood hazard in accordance with the NSW Floodplain Development Manual.

Referring to the flood maps, the following is noted:

- In a 20% AEP event, flow is mostly contained to the river channels. Some spillage onto the floodplain could be expected in the area of Lloyd Street in North Manilla. In a 1% AEP event, flooding would be expected in North Manilla, north of the confluence. Wide spread flooding would also be expected at Lloyd, Charles and Manilla Streets. South and east of the confluence, areas of River Street would be inundated as would the Dewhurst and Rowan Street areas of town. Flood depths vary, from shallow depths along the edge of the floodplain to depths in excess of 5 to 10 m near the creek channel. West of the Namoi and Manilla Rivers, small areas of the floodplain would be inundated;
- Flow velocities associated with the river channel and immediately adjacent floodplain, are high, around 2 m/s and greater. There are a number of areas in the northern and western floodplains, where flow velocities are in the order of 1 m/s to 2 m/s. Further away from the main channels, the flow velocities are much lower at around 0.5 to 1 m/s;
- Large areas of the floodplain can be designated as high hazard, on account of deep flow and/or rapid flow velocities. This includes areas of town in particular along River Street and areas of North Manilla;
- In larger events; a number of areas exist, where flood runners could develop in the floodplain. This is particularly evident on the southern flood plain on the Namoi River and along River Street near the oval; and
- In a PMF wide spread flooding would be expected. Flood depths would be in excess of 10m, immediately adjacent to the creeks.

The results of the 1% AEP flood simulations have been used to derive the Flood Planning Area, namely the land below the Flood Planning Level on a Flood Planning Map. The Flood Planning Level refers to the level of a 1% AEP flood event plus 0.50m freeboard. For the current study, the Flood Planning Area Extent has been determined by abstracting the peak 1% AEP flood level plus 0.5m, at approximately 100m to 150m intervals across the entire floodplain, perpendicular to the flow. This has been intersected with the topography to produce the Flood Planning Area Extent line. In determining this Flood Planning Area Extent line, some anomalies could exist on the edge of the floodplain, when comparing to the 2D flood model results where localised flood effects could exist. The Flood Planning Map for Manilla is provided in Appendix I.

7.4 Sensitivity Analyses

7.4.1 Overview

A number of sensitivity analysis were undertaken to determine the impacts of parameters and assumptions on flood behaviour. This was achieved by making the adjustments to the models and re-simulation of both the RORB and TUFLOW models where appropriate. Since the most important event used in planning in NSW is the 1% AEP event, the assessments were primarily done for this event. The results are presented as difference maps in Appendix G. The items/assumptions assessed in the sensitivity analysis were:

- Sensitivity of rainfall loss parameters on the design flood hydrographs and flood levels;
- Sensitivity of Manning's roughness assumptions on flood levels;
- Sensitivities of culvert and bridge blockages and loss assumptions; and
- Future Climate impacts on rainfall and flood levels.

7.4.2 Sensitivity of Rainfall Loss Parameters

To assess the impacts of rainfall loss parameter assumptions, both the RORB and the TUFLOW models were re-simulated using the amended assumptions tabulated below. The impacts on the simulated flood peaks using the RORB model are shown in Table 7-7, generally showing a 14 to 20% increase in flood peak. The impacts on the 1% AEP flood level is presented in Appendix G, showing that:

- A reduction in rainfall losses as tabulated below could lead to increases of 300 to 400 mm across a number of areas in the floodplain; and
- These increases would increase the extent of flooding, particularly around Dewhurst and Rowan Streets, where additional properties would be inundated.

Table 7-6 Rainfall Loss Sensitivity Values

Event	Initial Loss	Continuing Loss	Initial Loss	Continuing Loss
	Default Value		Sensitivity Value	
Up to and including the 1% AEP event	15 mm	2.5 mm/hr	10 mm	2.0 mm/hr
1% event up to the PMF	15 mm	1 mm/hr	10 mm	0.5 mm/hr
PMF	15 mm	1 mm/hr	10 mm	0.5 mm/hr

Table 7-7 Rainfall Loss Sensitivity impacts on Flood Peaks (at Manilla Railway Bridge)

Flood event AEP	Default Value	Sensitivity Value
20%	1230	1510
10%	1600	1895

Flood event AEP	Default Value	Sensitivity Value
5%	2090	2480
2%	2780	3230
1%	3450	3920

7.4.3 Sensitivity to Manning's Roughness Assumptions

To assess the impacts of roughness assumptions, the TUFLOW model was re-simulated using the amended roughness assumptions tabulated below. These generally represent between a 10% and 40% increase in topography roughness. The impacts on the 1% AEP flood level is presented in Appendix G, showing that:

- Increases in roughness as defined in the table below could lead to increases of up to 1m across large areas of the flood plain; and
- A number of areas in the flood plain would be expected to increase in extent. For example the residential areas around River Street and Rowan Streets would be expected to experience more wide spread flooding.

Table 7-8 Roughness Sensitivity Values

Feature	Default Value	Sensitivity Value
Manning's "n" – roads	0.02	0.025
Manning's "n" – light vegetation mostly grass	0.06	0.08
Manning's "n" – medium vegetation, thicker trees and some bush	0.10	0.12
Manning's "n" –dense vegetation, mostly dense bush	0.12	0.15
Manning's "n" – creeks and natural channels	0.03	0.045
Manning's "n" – developed areas (residential, commercial, industrial, farm sheds)	0.5	0.5
Manning's "n" – houses or blocked out with storage areas (zero conveyance)	2	2

7.4.4 Sensitivities of Culvert and Bridge Blockages and Loss Assumptions

To assess the impacts of culvert and bridge blockages, the TUFLOW model was re-simulated using the amended waterway opening assumptions tabulated below. These generally represent the impacts should debris block bridges during flood events, potentially resulting in local increase in upstream flood levels and potential redistribution of flood flows. To simulate the blockages, the flood level at the structure was determined, and half of the flow depth was blocked below the bridges structure, starting at the flood water surface. The impacts on the 1% AEP flood level is presented in Appendix G, showing that:

- Flood level increases in the order of 0.2 to 0.4m could be expected throughout the study area, increasing to as much as 0.8m to 1m, immediately upstream of the bridges. This is due to local attenuation at the bridge crossings; and
- The localised blockage at the Rushes Creek Road crossing is most severe, since this is generally the bridge with the smallest waterway opening in the study area, thus blockage would have the most significant impact.

Table 7-9 Culvert and Bridge Blockages and Loss Values

Structure	Default Value	Sensitivity Value
Mandowa Street Bridge	85m concrete span structure Waterway opening of 15.5m and a diagonal waterway opening of 18.4 5 concrete pylons with headstocks	50% blockage has been assumed from the flood water surface
Manilla Street Bridge	300m span structure 1 trussed span and 20 circular steel piers Waterway opening of 38.6m and a diagonal waterway opening of 39.8m	50% blockage has been assumed from the flood water surface
Manilla Railway Bridge	520m spanning structure 2 approach spans on wooden piers over the floodplain and a central trussed span on concrete pylons spanning the Manilla River. Waterway opening of 75m and a diagonal waterway opening of 76m	The trusses on the left and right bank have been assumed to be 100% blocked
Higgin's Avenue Bridge (Causeway)	63m span structure single 2 lane concrete deck span on 6 low set square concrete piers with headstocks Waterway opening of 8.5m and a diagonal waterway opening of 8.7m.	100% blockage has been assumed
Rushes Creek Road Bridge	29.5m span bridge Single 2-lane span with Diagonal waterway opening of 8.7m	50% blockage has been assumed from the flood water surface

7.4.5 Future Climate Impacts on Rainfall

Future climate impacts on rainfall have been assessed generally in accordance with the NSW Government, Department of Environment & Climate Change, Practical Consideration of Climate Change (NSW DECC 2007) guideline. For this assessment the hydrological RORB models was updated to represent future climate rainfall intensities based on the suggestions in the guideline. This recommends simulating 10%, 20% and 30% increases in rainfall intensities. On the basis of this guideline, the estimated future climate rainfall simulated in the RORB model is tabulated below.

The impacts on the simulated flood peaks using the RORB model are shown in Table 7-11, generally showing a significant increase in flood peak. The impacts on the 1% AEP flood level is presented in Appendix G, showing that:

- A future climate with a 10% increase in rainfall could lead to flood level increases of up to between 0.6m and 0.8m across large areas of the flood plain. For a 30% increase in rainfall, increases of up to between 1.5m and 2.2m across large areas of the flood plain could be expected. The larger increases are generally downstream of the confluence; and
- A number of areas in the flood plain would be expected to increase in extent.

Table 7-10 Existing and Future Climate 1% AEP Rainfall

Rainfall	Critical Duration	Existing Climate	Future Climate (mm)		
			10%	20%	30%
mm/hr	100yr 18 hr	141.6	155.6	169.8	183.9

Table 7-11 Future Climate 1% AEP Rainfall Sensitivity impacts on Flood Peaks

Flood event AEP	Default Value	Sensitivity Value		
		10%	20%	30%
20%	1230	1500	1795	2050
10%	1600	1910	2205	2560
5%	2090	2475	2910	3355
2%	2780	3300	3840	4385
1%	3450	4060	4690	5535

8. Flood Damage Estimates

8.1 Flood Damage Extents

In order to provide a benefit-cost assessment of floodplain management options, it is necessary to estimate the costs of flood damages. Flood damages are determined by assessing the numbers of flood affected properties and then estimating a direct damage cost for a range of flooding events (in terms of flood depth). The resulting depth-damage curves are used as a basis for estimating other direct and indirect costs from flooding.

Flood affected properties were estimated from the results of hydraulic simulations from the flood study, together with floor level survey data collected as part of this study. For each design flood, flood levels were determined at each property location based on these surveyed floor levels. Numbers of inundated properties are shown in Table 8-1. It must be noted that these relatively low levels of inundation noted for events below the 1% AEP event are attributed to the influences of Split Rock dam, and its impact on attenuation of flood peaks in the Manilla River. For this assessment of flood damages, it was assumed Split Rock Dam was at Full Supply Capacity. The flood mapping shows the depth of floor level inundation for a range of events. From the mapping, the following is noted:

- In events up to the 5% AEP event (Figure D.1) floor levels of properties are not expected to be inundated across the floodplain;
- In a 2% AEP event, 1 property is expected to experience flooding above the floor level. In a 1 % AEP event the number of properties expected to experience floor level inundation is 9. The properties are primarily in the vicinity of River Street;
- Beyond the 1% event, the numbers of floor levels inundated increases rapidly with 130 floor levels inundated in a 0.5% event and 545 floor levels expected to be inundated in a PMF.

It must be noted that these relatively low levels of inundation noted for events below the 1% AEP event are attributed to the influences of Split Rock dam, and its impact on attenuation of flood peaks in the Manilla River. For this assessment of flood damages, it was assumed Split Rock Dam was at Full Supply Capacity.

Table 8-1 Flood Affected Properties

Flood event AEP	Number of Residential Dwellings Inundated
20%	0
10%	0
5%	0
2%	1
1%	9
0.5%	130
PMF	545

8.2 Depth-Damage Relationship

For most residential dwellings, flood damage increases with the depth of flooding. The Floodplain Management (FDM) and Coastal Support Section of the Department of Natural Resources (DNR, now Office of Environment and Heritage) has developed a relationship between flood depth and damage based on various parameters for house and contents value, and flooding characteristics.

The relationship is illustrated in Figure 8-1. Parameters used to derive this relationship are shown below in Table 8-2.

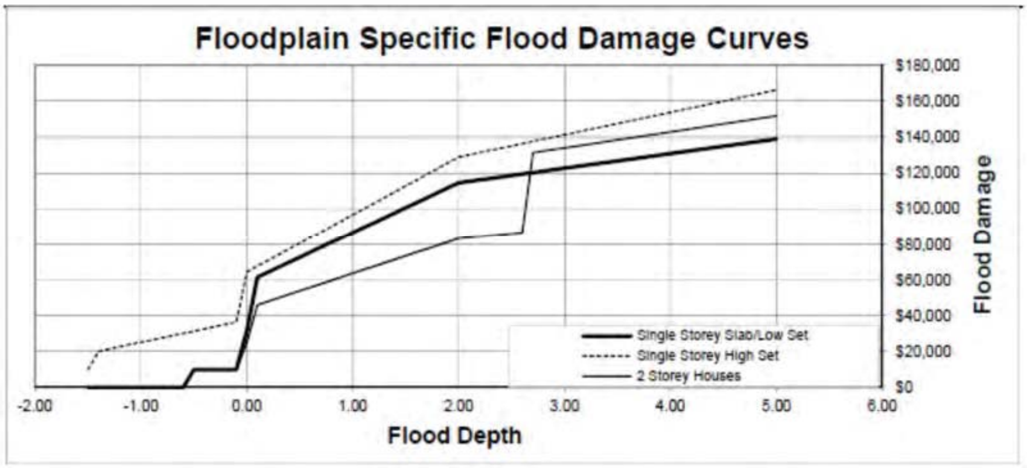


Figure 8-1 Typical Depth Damage Relationships (OEH, 2007)

Table 8-2 Parameters for Depth-Damage Relationship

Parameter	Value
Additional accommodation/ loss of rent	$220 per week
Average contents value	$60,000
Average house size	240 m^2
Clean up costs	$4,000
External damage	$6,700
Typical duration of inundation	21 hour
Typical table/bench height	0.9 m
Design Life of Options	20 year
Discount factor for Cost Calculations	7 %

8.3 Flood Damage Calculations

The following methodology was used to estimate the Average Annual Damage (AAD) and present value (PV) of the AAD over a 20-year period:

- The floor levels of properties affected by flooding for a range of flood events were estimated from the flood simulations and floor level survey;
- The cost of damage for the flooding was estimated for each flood event and depth range, using typical house and contents damage cost and the percentage of damage for the particular depth;
- A direct damage bill for each storm event was calculated;
- Flood recurrence interval was plotted against total damage and integrated to find the area under the graph, which provides the AAD; and
- A present value for the AAD was estimated based on a 7% discount rate over a 20-year period.

For Manilla, the Annual Average Damage Curve for residential properties is shown in Figure 8-2. The Annual Average Damage is estimated at $300k. Over a 20-year period, this has a Net Present Value of $3.28 million.

In comparison to other recent studies undertaken in NSW, this damage bill is relatively less. This is attributed to the influences of Split Rock dam, and its impact on attenuation of flood peaks in the Manilla River. For this assessment of flood damages, it was assumed Split Rock Dam was at Full Supply Capacity.

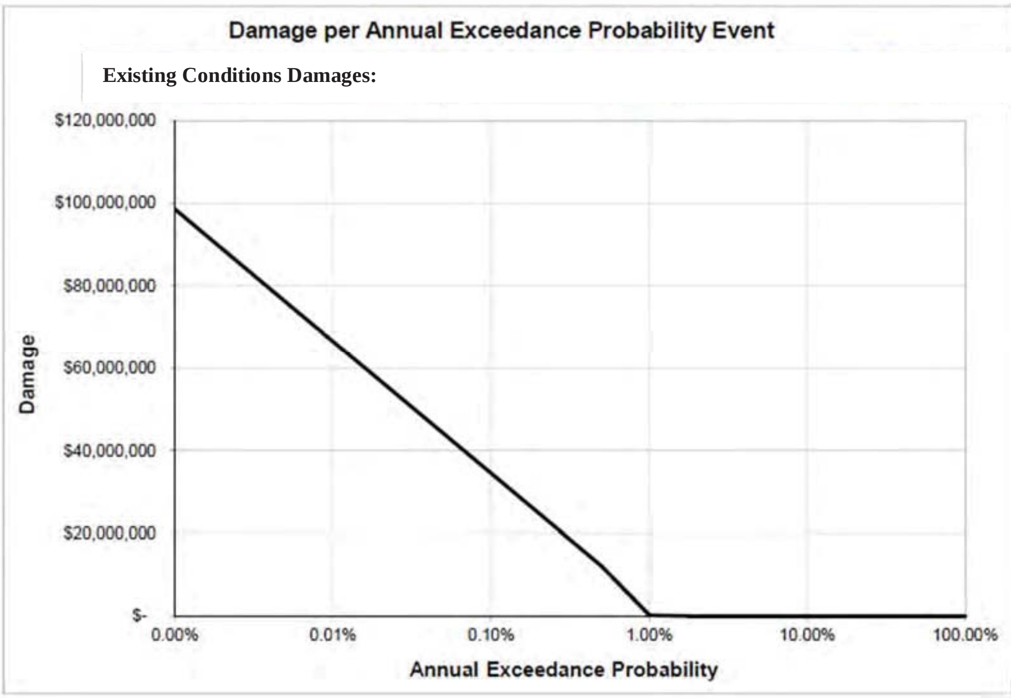


Figure 8-2 Manilla Damage Curve

9. Summary and Conclusions

- Manilla town is located at the confluence of the Manilla and Namoi Rivers which drain to Keepit Dam in the New England region of NSW. Manilla is located 43 km to the northwest of Tamworth and has population of approximately 2100. The two rivers draining through Manilla command a considerable catchment area of some 5150 km^2. The catchments are primarily rural, with number of towns located in the catchment. Floodwaters in both catchments tend to rise quickly and isolate communities and properties for several days. Many houses can be inundated in flood events necessitating evacuations. Some rainfall and river gauging data in the catchment is available, and significant events have been recorded in Manilla. Significant events noted in the literature and mentioned by residents, most notably the 1955 event and the 1964 flood;
- Tamworth Regional Council is responsible for local land use planning in Manilla. Through its Floodplain Risk Management Committee, Tamworth Regional Council proposes to prepare a comprehensive floodplain risk management plan for the study area in accordance with the NSW Government's "Floodplain Development Manual: the management of flood liable land", April 2005 (The Manual);
- The primary objective of this study was to define the main-stem flood behaviour under historical conditions and design flood behaviour under existing and future climate conditions in the study area (Figure A2 in Appendix A). The study produced information on flood levels, depths, velocities, flows, hydraulic categories, and provisional hazard categories for a full range of design and historical flood events. In addition, the study produced estimates of flood damage;
- A number of community consultation activities were undertaken as part of the study, The primary objectives of the flood study consultation activities were to inform the relevant government agencies that the study is being undertaken, informing relevant local community groups, and informing the general public. The information provided by the community, showed that a large number of the residents had experienced flooding in the town of Manilla, first hand and flood levels tend to rise and recede very rapidly. Preparation for flooding includes regular observation of river levels and lifting of belongings. In addition, listening to advice on local radio stations and from the SES. Many residents often mentioned the 1964 floods and these have been etched in memories of the Manilla community. One resident noted 8 m of flood waters through the house while another had their house completely submerged. Residents also noted that flooding had been reduced by Split Rock Dam, however could still be a high risk, if Split Rock Dam was full as occurred in the 1998 flood;
- The hydrology for the Manilla flood study was developed using the RORB hydrological model. The model was setup as an end of catchment model, producing flood hydrographs for the Namoi and Manilla Rivers upstream of the Manilla town. The RORB model was calibrated by variation of model parameters to obtain a good fit of the calculated to the measured hydrograph. A number of sensitivity analysis were undertaken on model parameters and the RORB model was simulated for a range of durations ranging up to 72 hours;
- The flood conveyance through Manilla was calculated using the TUFLOW hydraulic model. The model extent for the purposes of flood mapping was defined in collaboration with Tamworth Regional Council. The TUFLOW model compilation configured the key parameters including DTM data for the local area, triangulated to represent the ground surface. All bridges within the floodplain were configured using the terrestrial survey data. These were configured within the 2D model grid;

- To determine the design flood behaviour, both the RORB and TUFLOW models were simulated, using the parameters derived through the calibrations together with design rainfall in accordance with the Australian Rainfall and Runoff (AR&R 2011);
- The results show that in a 20% AEP event, flow is mostly contained to the river channels. Some spillage onto the floodplain could be expected in the area of Lloyd Street in North Manilla. In a 1% AEP event, flooding would be expected in North Manilla, north of the confluence. Wide spread flooding would also be expected at Lloyd, Charles and Manilla Streets. South and east of the confluence, areas of River Street would be inundated as would the Dewhurst and Rowan Street areas of town. Flood depths vary, from shallow depths along the edge of the floodplain to depths in excess of 5 to 10 m near the creek channel. West of the Namoi and Manilla Rivers, small areas of the floodplain would be inundated. Flow velocities associated with the river channel and immediately adjacent floodplain, are high, around 2 m/s and greater. There are a number of areas in the northern and western floodplains, where flow velocities are in the order of 1 m/s to 2 m/s. Further away from the main channels, the flow velocities are much lower at around 0.5 to 1 m/s. Large areas of the floodplain can be designated as high hazard, on account of deep flow and/or rapid flow velocities. This includes areas of town in particular along River Street and areas of North Manilla. In larger events, a number of areas exist, where flood runners could develop in the floodplain. This is particularly evident on the southern flood plain on the Namoi River and along River Street near the oval;
- A sensitivity assessment was undertaken on a number of key parameters. A reduction in rainfall losses could lead to increases of 300 to 400 mm across a number of areas in the floodplain. Increases in roughness could lead to increases of up to 1 m across large areas of the flood plain and a number of areas in the flood plain would be expected to increase in flood extent. A future climate with a 10% increase in rainfall could lead to flood level increases of up to between 0.6m and 0.8m across large areas of the flood plain. For a 30% increase in rainfall, increases of up to between 1.5m and 2.2m across large areas of the flood plain could be expected. The larger increases are generally downstream of the confluence. Flood level increases in the order of 0.2 to 0.4m could be expected throughout the study area due to bridge blockages, increasing to as much as 0.8m to 1m, immediately upstream of the bridges. This is due to local attenuation at the bridge crossings; and
- A flood damage assessment was undertaken using the Floodplain Management (FDM) and Coastal Support Section of the Department of Natural Resources (DNR, now Office of Environment and Heritage) relationships between flood depth and damage based on various parameters for house and contents value. From this assessment, the Annual Average Damage is estimated at $ 300k. Over a 20-year period, this has a net present value of $3.28 million. In comparison to other recent studies undertaken in NSW, this damage bill is relatively less. This is attributed to the influences of Split Rock dam, and its impact on attenuation of flood peaks in the Manilla River. For this assessment of flood damages, it was assumed Split Rock Dam was at Full Supply Capacity.

10. References

- NSW Government, 2005, Floodplain Development Manual, Management of Flood Liable Land;
- NSW DECC 2007, Practical Consideration of Climate Change, NSW Department of Environment & Climate Change;
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- RORB 6 User Manual, Monash University Department Of Civil Engineering In Conjunction With Sinclair Knight Merz Pty. Ltd. And The Support Of Melbourne Water Corporation, Rorb Version 6 Runoff Routing Program User Manual;
- BMT WBM 2010, TUFLOW User Manual
- BOM 2003, Bureau of Meteorology Australia Generalised Tropical Storm Method – Revised Version, November 2003;
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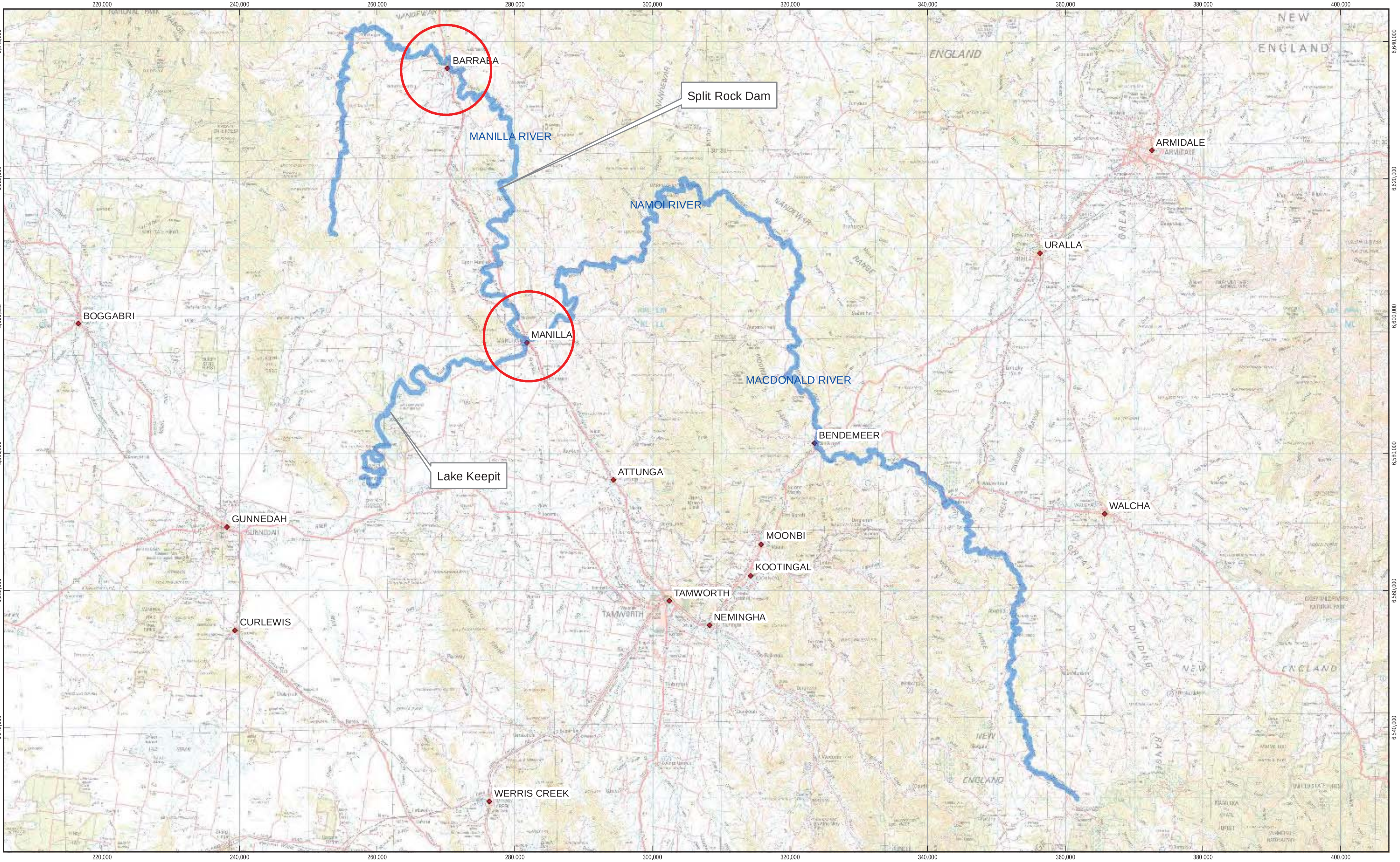
- WRC, Flood Information Reports, Floods in the Namoi Valley (1955, 1962, 1964, 1971, 1974, 1976), NSW Water Resources Commission;
- CSIRO (2007). Water availability in the Namoi. A report to the Australian Government from the CSIRO Murray-Darling Basin Sustainable Yields Project. CSIRO, Australia. 154pp;
- State Water, Keepit Dam Upgrade Environmental Assessment –m excerpt only

Appendix A

Location Maps



1:500,000

0 1 2 4 6 8 10

Kilometres (at A3)

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

LEGEND

Study Area

Tamworth Regional Council
Manilla and Barraba Flood Study

Job Number	22-15815/16
Revision	A
Date	23 December 2011

Locality Map

Figure A.1

G:\14\0102799\FINAL TEMPLATES\Rev 001\ArcGIS\GHD-A3-LANDSCAPE.mxt

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by: C Pappin

10 Bond Street Sydney NSW 2000 Australia T 61 2 9239 7000 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

1:15,000

200 100 0 200 400

Meters

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

LEGEND

Highways
Major Roads
Secondary Roads
Other Roads
TOPO Contours (1m)

Tamworth Regional Council
Manilla and Barraba Flood Study

Job Number	22-15815/16
Revision	A
Date	02.02.2012

Study Area

Figure A.2

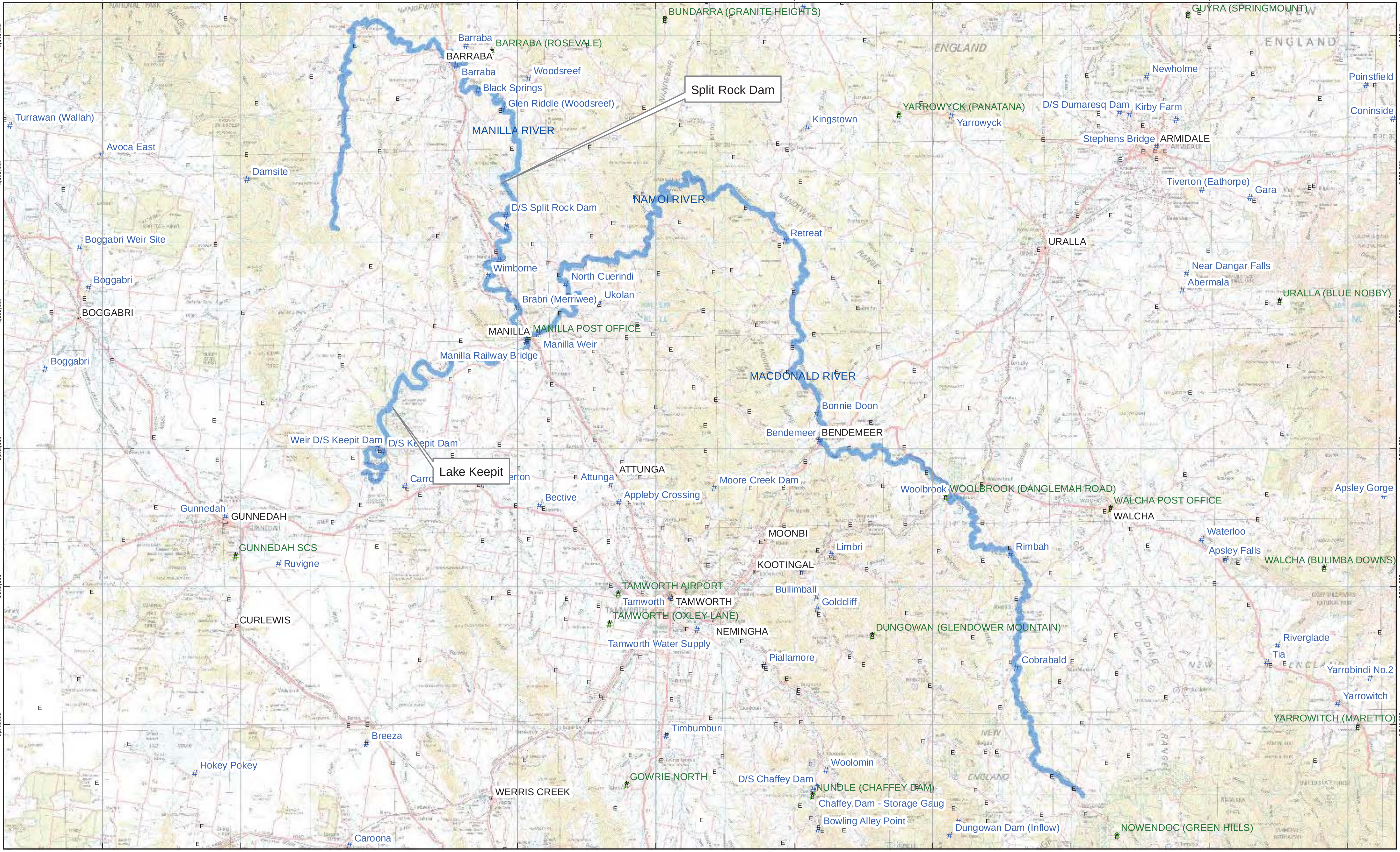
G:\14\0102799\FINAL TEMPLATES\Rev 001\ArcGIS\GHD-A3-LANDSCAPE.mxt

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by: C Pappin

10 Bond Street Sydney NSW 2000 Australia **T** 61 2 9239 7000 **F** 61 2 9239 7199 **E** sydmail@ghd.com.au **W** www.ghd.com.au

Appendix B

Gauging Information and Flood Frequency Analysis



1:500,000

0 1 2 4 6 8 10

Kilometres (at A3)

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

LEGEND

- E Daily Rainfall Data
- Pluvio-Rainfall Data
- # River Gauging Data

Tamworth Regional Council
Manilla and Barraba Flood Study

Job Number	22-15815/16
Revision	A
Date	23 Dec 2011

Gauging Information

Figure B.1

10 Bond Street Sydney NSW 2000 Australia T 61 2 9239 7000 F 61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

G:\14\0102799\FINAL TEMPLATES\Rev 001\ArcGIS\GHD-A3-LANDSCAPE.mxt

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by: C Pappin

Site 419022 NAMOI RIVER AT MANILLA RAILWAY BRIDGE
VarFrom 100.00 Stream Water Level
VarTo 141.00 Stream Discharge
Period 01/10/1939 - 30/09/2011

Date	Number	Stage	Flow	Deviation	Rating	-100% Deviation 100%
01:30_19/03/1941	1.0 *	1.130	2245.954000	[N/A]	1	..........|..........
01:30_20/03/1941	2.0 *	1.842	9069.449000	[N/A]	1	..........|..........
01:30_24/03/1941	3.0 *	1.334	4166.510000	[N/A]	1	..........|..........
01:30_03/10/1941	4.0 *	0.584	166.367000	[N/A]	1	..........|..........
01:30_12/11/1941	5.0 *	0.654	296.035000	[N/A]	1	..........|..........
01:30_17/04/1942	6.0 *	0.438	53.825000	[N/A]	1	..........|..........
01:30_18/08/1942	7.0 *	0.756	467.295000	[N/A]	1	..........|..........
01:30_27/11/1942	8.0 *	0.737	499.100000	[N/A]	1	..........|..........
01:30_02/02/1943	9.0 *	0.660	232.425000	[N/A]	1	..........|..........
01:30_16/04/1943	10.0 *	0.457	31.804000	[N/A]	1	..........|..........
01:30_17/06/1943	11.0 *	0.559	144.347000	[N/A]	1	..........|..........
01:30_06/08/1943	12.0 *	0.679	296.035000	[N/A]	1	..........|..........
01:30_04/10/1943	13.0 *	0.978	1416.564000	[N/A]	1	..........|..........
01:30_17/12/1943	14.0 *	0.673	609.196000	[N/A]	1	..........|..........
01:30_24/01/1944	15.0 *	0.686	330.288000	[N/A]	1	..........|..........
01:30_24/10/1944	16.0 *	0.521	95.415000	[N/A]	1	..........|..........
01:30_22/12/1944	17.0 *	0.330	15.168000	[N/A]	1	..........|..........
01:30_28/02/1945	18.0 *	1.168	1798.231000	[N/A]	1	..........|..........
01:30_26/09/1945	19.0 *	0.686	327.841000	[N/A]	1	..........|..........
01:30_11/12/1945	20.0 *	0.489	80.736000	[N/A]	1	..........|..........
01:30_08/04/1946	21.0 *	0.464	92.969000	[N/A]	1	..........|..........
01:30_02/07/1946	22.0 *	0.533	114.988000	[N/A]	1	..........|..........
01:30_30/09/1946	23.0 *	0.540	161.473000	[N/A]	1	..........|..........
01:30_19/11/1946	24.0 *	0.343	188.385000	[N/A]	1	..........|..........
01:30_17/12/1946	25.0 *	0.000	0.000000	[N/A]	1	..........|..........
01:30_11/02/1947	26.0 *	0.470	61.163000	[N/A]	1	..........|..........
01:30_16/07/1947	27.0 *	0.514	73.396000	[N/A]	1	..........|..........
01:30_07/01/1948	28.0 *	1.334	3153.633000	[N/A]	1	..........|..........
01:30_25/08/1948	29.0 *	0.914	1007.989000	[N/A]	1	..........|..........
01:30_25/11/1948	30.0 *	0.318	90.523000	[N/A]	1	..........|..........
01:30_29/07/1952	31.0 *	0.991	1218.393000	[N/A]	1	..........|..........
01:30_26/09/1952	32.0 *	0.933	1071.598000	[N/A]	1	..........|..........
01:30_23/10/1952	33.0 *	1.010	1433.691000	[N/A]	1	..........|..........
01:30_03/12/1952	34.0 *	0.686	296.035000	[N/A]	1	..........|..........
01:30_14/01/1953	35.0 *	0.610	156.581000	[N/A]	1	..........|..........
01:30_24/07/1953	36.0 *	0.699	327.841000	[N/A]	1	..........|..........
01:30_11/09/1953	37.0 *	0.838	729.080000	[N/A]	1	..........|..........
01:30_14/10/1953	38.0 *	0.679	293.589000	[N/A]	1	..........|..........
01:30_21/12/1953	39.0 *	0.425	24.465000	[N/A]	1	..........|..........
01:30_03/06/1954	40.0 *	0.502	51.378000	[N/A]	1	..........|..........
01:30_13/08/1954	41.0 *	0.613	129.668000	[N/A]	1	..........|..........
01:30_15/09/1954	42.0 *	0.572	78.290000	[N/A]	1	..........|..........
01:30_05/11/1954	43.0 *	2.286	11141.694000	[N/A]	1	..........|..........
02:30_05/11/1954	44.0 *	2.096	9399.733000	[N/A]	1	..........|..........
01:30_06/11/1954	45.0 *	1.740	4907.824000	[N/A]	1	..........|..........
02:30_06/11/1954	46.0 *	1.610	6011.226000	[N/A]	1	..........|..........
01:30_07/11/1954	47.0 *	1.372	3434.989000	[N/A]	1	..........|..........
01:30_20/12/1954	48.0 *	0.705	366.986000	[N/A]	1	..........|..........
01:30_10/08/1955	49.0 *	1.080	1485.070000	[N/A]	1	..........|..........
01:30_24/10/1955	50.0 *	8.573	154623.424000	[N/A]	1	..........|..........
02:30_24/10/1955	51.0 *	9.335	182025.119000	[N/A]	1	..........|..........
01:30_25/10/1955	52.0 *	5.448	49665.455000	[N/A]	1	..........|..........
02:30_25/10/1955	53.0 *	6.325	80492.175000	[N/A]	1	..........|..........
01:30_26/10/1955	54.0 *	4.178	34922.399000	[N/A]	1	..........|..........
01:30_27/10/1955	55.0 *	3.124	21050.303000	[N/A]	1	..........|..........

* after gauge number indicates Weighted Mean Gauge Height method

Site 419022 NAMOI RIVER AT MANILLA RAILWAY BRIDGE
VarFrom 100.00 Stream Water Level
VarTo 141.00 Stream Discharge
Period 01/10/1939 - 30/09/2011

Date	Number	Stage	Flow	Deviation	Rating	-100% Deviation 100%
01:30_28/10/1955	56.0 *	2.515	14062.906000	[N/A]	1	..........|..........
00:00_23/11/1955	57.0 *	1.051	1445.940000	[N/A]	1	..........|..........
01:30_23/11/1955	58.0 *	1.048	1445.925000	[N/A]	1	..........|..........
01:30_26/01/1956	59.0 *	0.864	751.099000	[N/A]	1	..........|..........
01:30_16/04/1956	60.0 *	1.054	1450.817000	[N/A]	1	..........|..........
01:30_31/07/1956	61.0 *	1.226	2803.774000	[N/A]	1	..........|..........
01:30_20/09/1956	62.0 *	0.914	1059.365000	[N/A]	1	..........|..........
01:30_27/11/1956	63.0 *	0.762	462.402000	[N/A]	1	..........|..........
01:30_13/02/1957	64.0 *	0.648	247.104000	[N/A]	1	..........|..........
01:30_05/04/1957	65.0 *	0.876	161.473000	[N/A]	1	..........|..........
01:30_12/06/1957	66.0 *	0.711	124.775000	[N/A]	1	..........|..........
02:30_12/06/1957	67.0 *	0.711	129.668000	[N/A]	1	..........|..........
01:30_22/08/1957	68.0 *	0.737	168.814000	[N/A]	1	..........|..........
01:30_22/10/1957	69.0 *	0.635	63.610000	[N/A]	1	..........|..........
01:30_13/11/1957	70.0 *	0.616	36.699000	[N/A]	1	..........|..........
02:30_13/11/1957	71.0 *	0.616	37.677000	[N/A]	1	..........|..........
01:30_18/12/1957	72.0 *	0.671	112.542000	[N/A]	1	..........|..........
02:30_18/12/1957	73.0 *	0.686	107.648000	[N/A]	1	..........|..........
01:30_21/01/1958	74.0 *	0.625	56.271000	[N/A]	1	..........|..........
01:30_22/01/1958	75.0 *	1.082	1022.668000	[N/A]	1	..........|..........
01:30_21/02/1958	76.0 *	0.815	349.859000	[N/A]	1	..........|..........
01:30_25/02/1958	77.0 *	0.648	102.756000	[N/A]	1	..........|..........
01:30_25/03/1958	78.0 *	0.625	75.844000	[N/A]	1	..........|..........
01:30_03/06/1958	79.0 *	0.648	73.396000	[N/A]	1	..........|..........
01:30_02/07/1958	80.0 *	0.808	342.521000	[N/A]	1	..........|..........
01:30_28/08/1958	81.0 *	0.820	349.859000	[N/A]	1	..........|..........
01:30_05/11/1958	82.0 *	0.738	310.714000	[N/A]	1	..........|..........
01:30_01/12/1958	83.0 *	0.610	63.610000	[N/A]	1	..........|..........
01:30_07/01/1959	84.0 *	1.250	2167.664000	[N/A]	1	..........|..........
01:30_17/03/1959	85.0 *	0.792	486.868000	[N/A]	1	..........|..........
01:30_23/04/1959	86.0 *	0.738	332.734000	[N/A]	1	..........|..........
01:30_01/06/1959	87.0 *	0.695	193.279000	[N/A]	1	..........|..........
01:30_22/07/1959	88.0 *	0.838	567.605000	[N/A]	1	..........|..........
01:30_23/09/1959	89.0 *	1.052	1184.142000	[N/A]	1	..........|..........
01:30_29/10/1959	90.0 *	0.811	496.654000	[N/A]	1	..........|..........
01:30_25/11/1959	91.0 *	0.866	665.468000	[N/A]	1	..........|..........
01:30_13/01/1960	92.0 *	0.663	181.047000	[N/A]	1	..........|..........
01:30_02/03/1960	93.0 *	0.631	112.542000	[N/A]	1	..........|..........
01:30_15/03/1960	94.0 *	0.668	185.939000	[N/A]	1	..........|..........
01:30_11/05/1960	95.0 *	0.674	159.027000	[N/A]	1	..........|..........
01:30_22/07/1960	96.0 *	1.225	2047.781000	[N/A]	1	..........|..........
01:30_02/08/1960	97.0 *	1.551	3782.405000	[N/A]	1	..........|..........
01:30_16/08/1960	98.0 *	0.969	1010.435000	[N/A]	1	..........|..........
01:30_30/08/1960	99.0 *	0.811	508.887000	[N/A]	1	..........|..........
01:30_27/09/1960	100.0 *	1.414	3368.934000	[N/A]	1	..........|..........
01:30_03/11/1960	101.0 *	0.808	484.421000	[N/A]	1	..........|..........
01:30_23/11/1960	102.0 *	1.628	4839.315000	[N/A]	1	..........|..........
01:30_16/01/1961	103.0 *	0.642	151.688000	[N/A]	1	..........|..........
01:30_06/02/1961	104.0 *	0.564	53.825000	[N/A]	1	..........|..........
01:30_21/03/1961	105.0 *	0.579	68.503000	[N/A]	1	..........|..........
01:30_19/04/1961	106.0 *	0.576	53.825000	[N/A]	1	..........|..........
01:30_15/05/1961	107.0 *	0.622	97.863000	[N/A]	1	..........|..........
01:30_21/06/1961	108.0 *	0.683	166.367000	[N/A]	1	..........|..........
01:30_17/07/1961	109.0 *	0.634	100.310000	[N/A]	1	..........|..........
01:30_15/08/1961	110.0 *	0.710	225.084000	[N/A]	1	..........|..........

* after gauge number indicates Weighted Mean Gauge Height method

Site 419022 NAMOI RIVER AT MANILLA RAILWAY BRIDGE
VarFrom 100.00 Stream Water Level
VarTo 141.00 Stream Discharge
Period 01/10/1939 - 30/09/2011

Date	Number	Stage	Flow	Deviation	Rating	-100% Deviation 100%
01:30_26/09/1961	111.0 *	0.735	298.481000	[N/A]	1	..........|..........
01:30_06/11/1961	112.0 *	0.677	200.618000	[N/A]	1	..........|..........
02:30_06/11/1961	113.0 *	0.671	185.939000	[N/A]	1	..........|..........
01:30_12/12/1961	114.0 *	0.832	631.216000	[N/A]	1	..........|..........
02:30_12/12/1961	115.0 *	0.829	616.536000	[N/A]	1	..........|..........
01:30_05/03/1962	116.0 *	0.872	423.257000	[N/A]	1	..........|..........
01:30_06/03/1962	117.0 *	0.869	376.773000	[N/A]	1	..........|..........
01:30_10/04/1962	118.0 *	1.896	6539.686000	[N/A]	1	..........|..........
02:30_10/04/1962	119.0 *	1.859	6520.120000	[N/A]	1	..........|..........
01:30_30/04/1962	120.0 *	0.835	354.753000	[N/A]	1	..........|..........
02:30_30/04/1962	121.0 *	0.835	325.395000	[N/A]	1	..........|..........
01:30_12/06/1962	122.0 *	0.890	413.470000	[N/A]	1	..........|..........
02:30_12/06/1962	123.0 *	0.890	425.703000	[N/A]	1	..........|..........
01:30_02/07/1962	124.0 *	0.814	212.851000	[N/A]	1	..........|..........
02:30_02/07/1962	125.0 *	0.814	222.638000	[N/A]	1	..........|..........
01:30_14/08/1962	126.0 *	0.850	310.714000	[N/A]	1	..........|..........
02:30_14/08/1962	127.0 *	0.850	322.947000	[N/A]	1	..........|..........
01:30_17/09/1962	128.0 *	0.896	455.062000	[N/A]	1	..........|..........
02:30_17/09/1962	129.0 *	0.896	415.918000	[N/A]	1	..........|..........
01:30_18/10/1962	130.0 *	0.792	173.706000	[N/A]	1	..........|..........
02:30_18/10/1962	131.0 *	0.792	185.939000	[N/A]	1	..........|..........
01:30_13/11/1962	132.0 *	0.811	386.558000	[N/A]	1	..........|..........
02:30_13/11/1962	133.0 *	0.811	396.345000	[N/A]	1	..........|..........
01:30_13/12/1962	134.0 *	0.811	274.015000	[N/A]	1	..........|..........
02:30_13/12/1962	135.0 *	0.811	298.481000	[N/A]	1	..........|..........
01:30_15/01/1963	136.0 *	0.841	574.945000	[N/A]	1	..........|..........
02:30_15/01/1963	137.0 *	0.841	572.498000	[N/A]	1	..........|..........
01:30_06/02/1963	138.0 *	0.814	455.062000	[N/A]	1	..........|..........
02:30_06/02/1963	139.0 *	0.814	481.975000	[N/A]	1	..........|..........
01:30_13/03/1963	140.0 *	0.625	73.396000	[N/A]	1	..........|..........
02:30_13/03/1963	141.0 *	0.625	70.951000	[N/A]	1	..........|..........
01:30_09/04/1963	142.0 *	0.884	665.468000	[N/A]	1	..........|..........
02:30_09/04/1963	143.0 *	0.884	606.751000	[N/A]	1	..........|..........
01:30_06/05/1963	144.0 *	0.933	782.904000	[N/A]	1	..........|..........
02:30_06/05/1963	145.0 *	0.933	765.777000	[N/A]	1	..........|..........
01:30_29/05/1963	146.0 *	1.210	2360.943000	[N/A]	1	..........|..........
02:30_29/05/1963	147.0 *	1.210	2312.011000	[N/A]	1	..........|..........
01:30_18/07/1963	148.0 *	1.317	3053.324000	[N/A]	1	..........|..........
02:30_18/07/1963	149.0 *	1.317	3173.206000	[N/A]	1	..........|..........
01:30_22/08/1963	150.0 *	0.933	961.503000	[N/A]	1	..........|..........
02:30_22/08/1963	151.0 *	0.933	988.417000	[N/A]	1	..........|..........
01:30_02/10/1963	152.0 *	1.177	2020.869000	[N/A]	1	..........|..........
02:30_02/10/1963	153.0 *	1.177	1998.850000	[N/A]	1	..........|..........
01:30_22/10/1963	154.0 *	0.902	785.350000	[N/A]	1	..........|..........
02:30_22/10/1963	155.0 *	0.902	848.962000	[N/A]	1	..........|..........
01:30_14/11/1963	156.0 *	0.890	719.292000	[N/A]	1	..........|..........
02:30_14/11/1963	157.0 *	0.890	751.099000	[N/A]	1	..........|..........
01:30_06/12/1963	158.0 *	0.747	423.257000	[N/A]	1	..........|..........
02:30_06/12/1963	159.0 *	0.747	420.811000	[N/A]	1	..........|..........
01:30_07/01/1964	160.0 *	0.689	269.123000	[N/A]	1	..........|..........
02:30_07/01/1964	161.0 *	0.689	271.569000	[N/A]	1	..........|..........
01:30_26/02/1964	162.0 *	0.884	362.092000	[N/A]	1	..........|..........
02:30_26/02/1964	163.0 *	0.884	371.879000	[N/A]	1	..........|..........
01:30_07/04/1964	164.0 *	0.890	308.268000	[N/A]	1	..........|..........
02:30_07/04/1964	165.0 *	0.890	308.268000	[N/A]	1	..........|..........

* after gauge number indicates Weighted Mean Gauge Height method

Site 419022 NAMOI RIVER AT MANILLA RAILWAY BRIDGE
VarFrom 100.00 Stream Water Level
VarTo 141.00 Stream Discharge
Period 01/10/1939 - 30/09/2011

Date	Number	Stage	Flow	Deviation	Rating	-100% Deviation 100%
01:30_20/05/1964	166.0 *	0.917	477.081000	[N/A]	1	..........|..........
02:30_20/05/1964	167.0 *	0.917	472.188000	[N/A]	1	..........|..........
01:30_24/06/1964	168.0 *	1.065	1103.404000	[N/A]	1	..........|..........
02:30_24/06/1964	169.0 *	1.062	1096.063000	[N/A]	1	..........|..........
01:30_28/07/1964	170.0 *	1.119	1475.282000	[N/A]	1	..........|..........
02:30_28/07/1964	171.0 *	1.119	1382.312000	[N/A]	1	..........|..........
01:30_19/08/1964	172.0 *	0.942	628.769000	[N/A]	1	..........|..........
01:30_22/09/1964	173.0 *	0.939	611.644000	[N/A]	1	..........|..........
00:00_29/09/1964	174.0 *	2.926	20260.000000	[N/A]	1	..........|..........
00:01_29/09/1964	175.0 *	2.895	19817.460000	[N/A]	1	..........|..........
00:00_30/09/1964	176.0 *	2.170	10547.292000	[N/A]	1	..........|..........
02:30_30/09/1964	177.0 *	1.868	6361.089000	[N/A]	1	..........|..........
01:30_29/10/1964	178.0 *	0.991	1003.095000	[N/A]	1	..........|..........
02:30_29/10/1964	179.0 *	0.991	1052.026000	[N/A]	1	..........|..........
01:30_20/11/1964	180.0 *	0.872	604.303000	[N/A]	1	..........|..........
02:30_20/11/1964	181.0 *	0.872	601.858000	[N/A]	1	..........|..........
01:30_06/01/1965	182.0 *	0.735	227.531000	[N/A]	1	..........|..........
02:30_06/01/1965	183.0 *	0.735	229.977000	[N/A]	1	..........|..........
01:30_09/02/1965	184.0 *	0.634	85.630000	[N/A]	1	..........|..........
02:30_09/02/1965	185.0 *	0.634	85.630000	[N/A]	1	..........|..........
01:30_11/03/1965	186.0 *	0.634	95.415000	[N/A]	1	..........|..........
02:30_11/03/1965	187.0 *	0.634	105.202000	[N/A]	1	..........|..........
01:30_11/04/1965	188.0 *	0.570	32.783000	[N/A]	1	..........|..........
02:30_11/04/1965	189.0 *	0.570	33.028000	[N/A]	1	..........|..........
01:30_22/04/1965	190.0 *	0.607	63.610000	[N/A]	1	..........|..........
01:30_26/05/1965	191.0 *	0.591	56.271000	[N/A]	1	..........|..........
02:30_26/05/1965	192.0 *	0.591	58.717000	[N/A]	1	..........|..........
01:30_07/07/1965	193.0 *	0.652	114.988000	[N/A]	1	..........|..........
02:30_07/07/1965	194.0 *	0.652	110.096000	[N/A]	1	..........|..........
01:30_17/08/1965	195.0 *	0.622	107.648000	[N/A]	1	..........|..........
02:30_17/08/1965	196.0 *	0.622	107.648000	[N/A]	1	..........|..........
01:30_16/02/1966	197.0 *	0.466	3.596000	[N/A]	1	..........|..........
02:30_16/02/1966	198.0 *	0.466	3.889000	[N/A]	1	..........|..........
01:30_07/03/1966	199.0 *	0.439	1.540000	[N/A]	1	..........|..........
01:30_13/04/1966	200.0 *	0.457	3.572000	[N/A]	1	..........|..........
02:30_13/04/1966	201.0 *	0.457	3.596000	[N/A]	1	..........|..........
01:30_20/05/1966	202.0 *	0.485	3.938000	[N/A]	1	..........|..........
02:30_20/05/1966	203.0 *	0.485	3.816000	[N/A]	1	..........|..........
01:30_23/06/1966	204.0 *	0.594	63.610000	[N/A]	1	..........|..........
02:30_23/06/1966	205.0 *	0.594	61.163000	[N/A]	1	..........|..........
01:30_04/08/1966	206.0 *	0.543	25.689000	[N/A]	1	..........|..........
02:30_04/08/1966	207.0 *	0.543	24.709000	[N/A]	1	..........|..........
01:30_02/09/1966	208.0 *	0.948	910.125000	[N/A]	1	..........|..........
01:30_11/10/1966	209.0 *	0.680	161.473000	[N/A]	1	..........|..........
01:30_10/11/1966	210.0 *	2.417	9541.636000	[N/A]	1	..........|..........
01:30_09/12/1966	211.0 *	0.826	543.139000	[N/A]	1	..........|..........
02:30_09/12/1966	212.0 *	0.826	540.692000	[N/A]	1	..........|..........
03:00_09/12/1966	213.0 *	0.799	489.314000	[N/A]	1	..........|..........
03:30_09/12/1966	214.0 *	0.799	506.441000	[N/A]	1	..........|..........
01:30_11/01/1967	215.0 *	0.762	371.879000	[N/A]	1	..........|..........
02:30_11/01/1967	216.0 *	0.762	381.666000	[N/A]	1	..........|..........
01:30_06/02/1967	217.0 *	0.600	88.077000	[N/A]	1	..........|..........
01:30_10/02/1967	218.0 *	0.564	57.250000	[N/A]	1	..........|..........
02:30_10/02/1967	219.0 *	0.564	58.717000	[N/A]	1	..........|..........
01:30_21/04/1967	220.0 *	0.680	198.172000	[N/A]	1	..........|..........

* after gauge number indicates Weighted Mean Gauge Height method

Site 419022 NAMOI RIVER AT MANILLA RAILWAY BRIDGE
VarFrom 100.00 Stream Water Level
VarTo 141.00 Stream Discharge
Period 01/10/1939 - 30/09/2011

Date	Number	Stage	Flow	Deviation	Rating	-100% Deviation 100%
01:30_17/05/1967	221.0 *	0.619	102.756000	[N/A]	1	..........|..........
01:30_07/06/1967	222.0 *	0.616	107.648000	[N/A]	1	..........|..........
01:30_11/07/1967	223.0 *	0.768	413.470000	[N/A]	1	..........|..........
01:30_05/09/1967	224.0 *	0.728	288.695000	[N/A]	1	..........|..........
02:30_05/09/1967	225.0 *	0.728	300.929000	[N/A]	1	..........|..........
01:30_21/09/1967	226.0 *	0.710	271.569000	[N/A]	1	..........|..........
02:30_21/09/1967	227.0 *	0.710	244.658000	[N/A]	1	..........|..........
01:30_24/10/1967	228.0 *	1.631	5377.566000	[N/A]	1	..........|..........
02:30_24/10/1967	229.0 *	1.750	5340.871000	[N/A]	1	..........|..........
01:30_13/12/1967	230.0 *	0.585	78.290000	[N/A]	1	..........|..........
02:30_13/12/1967	231.0 *	0.555	73.396000	[N/A]	1	..........|..........
01:30_05/01/1968	232.0 *	0.472	44.038000	[N/A]	1	..........|..........
01:30_13/02/1968	233.0 *	0.902	374.325000	[N/A]	1	..........|..........
01:30_13/03/1968	234.0 *	0.841	217.745000	[N/A]	1	..........|..........
02:30_13/03/1968	235.0 *	0.838	207.959000	[N/A]	1	..........|..........
01:30_08/05/1968	236.0 *	0.671	29.114000	[N/A]	1	..........|..........
02:30_08/05/1968	237.0 *	0.671	29.847000	[N/A]	1	..........|..........
01:30_08/07/1968	238.0 *	0.838	259.336000	[N/A]	1	..........|..........
02:30_08/07/1968	239.0 *	0.838	259.336000	[N/A]	1	..........|..........
01:30_21/08/1968	240.0 *	1.423	2578.688000	[N/A]	1	..........|..........
01:30_30/10/1968	241.0 *	0.896	386.558000	[N/A]	1	..........|..........
01:30_19/11/1968	242.0 *	0.792	266.677000	[N/A]	1	..........|..........
02:30_19/11/1968	243.0 *	0.768	227.531000	[N/A]	1	..........|..........
01:30_02/02/1969	244.0 *	0.847	291.141000	[N/A]	1	..........|..........
02:30_02/02/1969	245.0 *	0.850	293.589000	[N/A]	1	..........|..........
01:30_12/02/1969	246.0 *	0.838	362.092000	[N/A]	1	..........|..........
01:30_13/03/1969	247.0 *	0.610	11.328000	[N/A]	1	..........|..........
02:30_13/03/1969	248.0 *	0.610	11.033000	[N/A]	1	..........|..........
01:30_07/05/1969	249.0 *	0.680	61.163000	[N/A]	1	..........|..........
01:30_09/07/1969	250.0 *	0.887	318.055000	[N/A]	1	..........|..........
02:30_09/07/1969	251.0 *	0.887	318.055000	[N/A]	1	..........|..........
01:30_11/08/1969	252.0 *	0.920	335.180000	[N/A]	1	..........|..........
02:30_11/08/1969	253.0 *	0.920	318.055000	[N/A]	1	..........|..........
01:30_08/09/1969	254.0 *	2.006	5928.045000	[N/A]	1	..........|..........
01:30_23/09/1969	255.0 *	1.076	638.555000	[N/A]	1	..........|..........
02:30_23/09/1969	256.0 *	1.076	631.216000	[N/A]	1	..........|..........
01:30_12/12/1969	257.0 *	1.116	1206.161000	[N/A]	1	..........|..........
01:30_30/12/1969	258.0 *	0.908	391.452000	[N/A]	1	..........|..........
01:30_13/02/1970	259.0 *	0.942	364.540000	[N/A]	1	..........|..........
01:30_16/03/1970	260.0 *	0.905	166.367000	[N/A]	1	..........|..........
01:30_17/03/1970	261.0 *	0.957	286.248000	[N/A]	1	..........|..........
01:30_16/04/1970	262.0 *	0.832	95.415000	[N/A]	1	..........|..........
01:30_05/05/1970	263.0 *	0.863	1.395000	[N/A]	1	..........|..........
01:30_09/06/1970	264.0 *	0.872	130.647000	[N/A]	1	..........|..........
01:30_14/07/1970	265.0 *	0.826	97.373000	[N/A]	1	..........|..........
01:30_13/08/1970	266.0 *	0.768	54.314000	[N/A]	1	..........|..........
01:30_08/09/1970	267.0 *	0.799	95.660000	[N/A]	1	..........|..........
01:30_29/09/1970	268.0 *	1.865	6052.820000	[N/A]	1	..........|..........
01:30_12/10/1970	269.0 *	0.957	626.322000	[N/A]	1	..........|..........
01:30_03/11/1970	270.0 *	0.856	340.074000	[N/A]	1	..........|..........
01:30_15/12/1970	271.0 *	1.250	1844.717000	[N/A]	1	..........|..........
01:30_24/03/1971	272.0 *	0.939	978.629000	[N/A]	1	..........|..........
01:30_10/05/1971	273.0 *	0.856	437.936000	[N/A]	1	..........|..........
02:30_10/05/1971	274.0 *	0.856	440.384000	[N/A]	1	..........|..........
01:30_09/06/1971	275.0 *	0.823	396.345000	[N/A]	1	..........|..........

* after gauge number indicates Weighted Mean Gauge Height method

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Site    419022          NAMOI RIVER AT MANILLA RAILWAY BRIDGE
VarFrom   100.00        Stream Water Level
VarTo     141.00        Stream Discharge
Period  01/10/1939 - 30/09/2011

Date              Number      Stage          Flow Deviation Rating -100% Deviation  100%
01:30_16/07/1971  276.0 *     0.789     396.345000     [N/A]      1 ..........|..........
01:30_11/08/1971  277.0 *     1.460    3351.807000     [N/A]      1 ..........|..........
01:30_22/09/1971  278.0 *     2.637   12820.046000     [N/A]      1 ..........|..........
01:30_28/09/1971  279.0 *     1.902    6825.936000     [N/A]      1 ..........|..........
01:30_28/10/1971  280.0 *     0.789     393.899000     [N/A]      1 ..........|..........
02:30_28/10/1971  281.0 *     0.792     430.596000     [N/A]      1 ..........|..........
01:30_02/12/1971  282.0 *     1.058    1093.617000     [N/A]      1 ..........|..........
01:30_03/02/1972  283.0 *     0.719     264.229000     [N/A]      1 ..........|..........
01:30_29/02/1972  284.0 *     0.658     154.134000     [N/A]      1 ..........|..........
01:30_22/03/1972  285.0 *     0.634     130.158000     [N/A]      1 ..........|..........
01:30_10/04/1972  286.0 *     0.786     437.936000     [N/A]      1 ..........|..........
01:30_18/05/1972  287.0 *     0.792     149.240000     [N/A]      1 ..........|..........
01:30_30/05/1972  288.0 *     0.820     122.329000     [N/A]      1 ..........|..........
01:30_29/06/1972  289.0 *     0.832     115.967000     [N/A]      1 ..........|..........
01:30_12/07/1972  290.0 *     0.789     118.170000     [N/A]      1 ..........|..........
01:30_06/09/1972  291.0 *     0.762      77.800000     [N/A]      1 ..........|..........
01:30_28/09/1972  292.0 *     0.716      43.059000     [N/A]      1 ..........|..........
01:30_04/10/1972  293.0 *     0.792      86.363000     [N/A]      1 ..........|..........
01:30_11/10/1972  294.0 *     0.881     182.025000     [N/A]      1 ..........|..........
01:30_14/12/1972  295.0 *     1.024     606.751000     [N/A]      1 ..........|..........
01:30_24/01/1973  296.0 *     0.768     124.775000     [N/A]      1 ..........|..........
01:30_14/02/1973  297.0 *     1.344    2407.427000     [N/A]      1 ..........|..........
01:30_22/03/1973  298.0 *     0.713      92.969000     [N/A]      1 ..........|..........
01:30_16/04/1973  299.0 *     0.686      61.163000     [N/A]      1 ..........|..........
01:30_08/05/1973  300.0 *     0.735     116.701000     [N/A]      1 ..........|..........
01:30_28/05/1973  301.0 *     0.695      58.228000    -11.40    115 .........*|..........
01:30_18/06/1973  302.0 *     0.893     371.879000     -0.01    115 ..........*..........
01:30_16/07/1973  303.0 *     0.930     437.936000     -5.68    115 .........*|..........
01:30_03/08/1973  304.0 *     0.875     337.626000      2.30    115 ..........*..........
01:30_14/08/1973  305.0 *     0.805     203.066000      1.53    115 ..........*..........
01:30_18/09/1973  306.0 *     1.003     692.381000      0.15    115 ..........*..........
01:30_26/10/1973  307.0 *     0.911     753.544000     -1.63    120 ..........*..........
01:30_09/11/1973  308.0 *     1.003    1017.775000     -5.84    120 .........*|..........
01:30_19/03/1974  309.0 *     0.847     259.336000     -4.39    125 ..........*..........
01:30_17/04/1974  310.0 *     0.814     207.225000     -3.08    125 ..........*..........
01:30_28/05/1974  311.0 *     0.850     276.462000     -0.15    125 ..........*..........
01:30_20/08/1974  312.0 *     0.877     308.000000     -8.02    125 .........*|..........
01:30_10/10/1974  313.0 *     1.056     897.999000      0.72    125 ..........*..........
01:30_27/11/1974  314.0 *     0.891     390.000000      6.06    125 ..........|*.........
01:30_06/02/1975  315.0 *     0.538       1.129000    -26.39    135 .......*..|..........
01:30_11/03/1975  316.0 *     0.927     520.000000     -0.40    135 ..........*..........
01:30_08/04/1975  317.0 *     0.938     440.000000     -3.01    140 ..........*..........
01:30_07/05/1975  318.0 *     0.837     187.000000     -5.27    140 .........*|..........
01:30_25/06/1975  319.0 *     2.259     985.000000    -90.10    140 .*........|..........
01:30_08/08/1975  320.0 *     0.910     385.000000      2.50    140 ..........*..........
01:30_24/09/1975  321.0 *     0.945     456.999000     -3.72    140 ..........*..........
01:30_29/10/1975  322.0 *     1.113    1088.998000     -2.31    140 ..........*..........
01:30_03/12/1975  323.0 *     0.880     299.000000      1.22    140 ..........*..........
01:30_02/06/1976  324.0 *     0.910     373.000000     -0.70    140 ..........*..........
01:30_11/08/1976  325.0 *     0.926     625.000000     -0.77    145 ..........*..........
01:30_27/10/1976  326.0 *     0.987     807.000000     -5.19    145 .........*|..........
01:30_25/11/1976  327.0 *     0.975     822.000000      1.81    145 ..........*..........
01:30_11/01/1977  328.0 *     0.740      59.599000    -49.26    145 .....*....|..........
01:30_16/02/1977  329.0 *     0.696      68.800000      2.04    145 ..........*..........
01:30_06/04/1977  330.0 *     0.924     600.000000     -3.64    145 ..........*..........
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* after gauge number indicates Weighted Mean Gauge Height method

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Site    419022          NAMOI RIVER AT MANILLA RAILWAY BRIDGE
VarFrom   100.00        Stream Water Level
VarTo     141.00        Stream Discharge
Period  01/10/1939 - 30/09/2011

Date              Number      Stage          Flow Deviation Rating -100% Deviation  100%
01:30_03/05/1977  331.0 *     0.817    429.000000     -7.01    150 .........*|..........
01:30_09/06/1977  332.0 *     1.175   1799.998000      0.80    150 ..........*..........
01:30_20/07/1977  333.0 *     1.050   1270.998000      0.95    150 ..........*..........
01:30_24/08/1977  334.0 *     0.872    684.000000      7.18    150 ..........|*.........
01:30_28/09/1977  335.0 *     0.835    512.000000     -1.37    150 ..........*..........
01:30_10/11/1977  336.0 *     0.709    195.999000     17.12    150 ..........|.*........
01:30_08/12/1977  337.0 *     0.660    155.000000     -3.74    155 ..........*..........
01:30_01/03/1978  338.0 *     0.739    306.000000     -0.62    155 ..........*..........
01:30_12/04/1978  339.0 *     0.777    398.000000     -2.09    155 ..........*..........
01:30_10/05/1978  340.0 *     0.737    225.000000    -25.91    155 .......*..|..........
01:30_21/06/1978  341.0 *     1.660   4719.995000     -0.13    160 ..........*..........
01:30_17/08/1978  342.0 *     1.080   1429.998000      4.35    160 ..........*..........
01:30_27/09/1978  343.0 *     1.072   1432.998000      7.02    160 ..........|*.........
01:30_25/10/1978  344.0 *     0.912    638.000000    -17.08    160 ........*.|..........
01:30_07/11/1978  345.0 *     1.545   3839.998000     -2.18    160 ..........*..........
01:30_28/11/1978  346.0 *     0.880    615.000000     -7.36    160 .........*|..........
01:30_23/01/1979  347.0 *     0.822    502.000000      5.24    160 ..........|*.........
01:30_28/02/1979  348.0 *     0.635    117.000000     -7.28    165 .........*|..........
01:30_18/04/1979  349.0 *     0.685    212.000000      5.82    165 ..........|*.........
01:30_30/05/1979  350.0 *     0.748    306.000000     -7.12    165 .........*|..........
01:30_11/07/1979  351.0 *     0.750    313.000000     -6.41    165 .........*|..........
09:00_21/08/1979  352.0 *     0.772    354.000000     -9.79    165 .........*|..........
16:00_31/10/1979  353.0 *     0.921    810.000000     -2.53    165 ..........*..........
16:00_05/12/1979  354.0 *     0.710    283.000000     13.64    165 ..........|*.........
10:00_16/01/1980  355.0 *     0.637    142.000000     10.18    165 ..........|*.........
10:50_20/02/1980  356.0 *     0.517     17.399000    -18.15    165 ........*.|..........
15:45_19/03/1980  357.0 *     0.480      8.899000     -5.33    165 .........*|..........
13:00_22/04/1980  358.0 *     0.433      1.799000    -21.78    165 ........*.|..........
15:30_29/05/1980  359.0 *     0.620    116.000000      8.41    165 ..........|*.........
13:00_11/06/1980  360.0 *     0.622    112.000000      2.33    165 ..........*..........
14:00_09/07/1980  361.0 *     0.938    840.000000     -4.82    165 ..........*..........
15:30_12/08/1980  362.0 *     0.660    164.000000      1.86    165 ..........*..........
16:00_17/09/1980  363.0 *     0.545     40.799000     13.30    165 ..........|*.........
09:30_22/10/1980  364.0 *     0.438      4.099000     43.49    165 ..........|...*......
01:30_27/11/1980  365.0 *     0.405   -999.000000     [N/A]    165 ..........|..........
10:30_15/01/1981  366.0 *     0.440      0.689000    -77.77    165 ..*.......|..........
15:00_25/02/1981  367.0 *     0.563     49.999000      3.55    165 ..........*..........
09:00_23/04/1981  368.0 *     0.428      2.080000     19.70    165 ..........|.*........
12:00_10/06/1981  369.0 *     1.178   1629.998000     -9.18    165 .........*|..........
16:00_21/07/1981  370.0 *     0.780    375.000000     -9.64    165 .........*|..........
14:00_02/09/1981  371.0 *     0.785    401.000000     -6.39    165 .........*|..........
16:00_27/10/1981  372.0 *     0.885    547.000000     -4.99    166 ..........*..........
10:00_15/12/1981  373.0 *     0.558     34.299000      4.00    166 ..........*..........
16:00_03/02/1982  374.0 *     0.450      2.220000     -2.15    166 ..........*..........
12:00_18/03/1982  375.0 *     0.900    654.000000      5.48    166 ..........|*.........
16:00_06/07/1982  376.0 *     0.620     81.099000      3.34    166 ..........*..........
12:00_14/09/1982  377.0 *     0.512     13.800000     -5.47    166 .........*|..........
17:00_08/11/1982  378.0 *     0.497     10.800000      2.28    166 ..........*..........
12:00_05/01/1983  379.0 *     0.735    241.000000      0.89    166 ..........*..........
12:00_01/03/1983  380.0 *     0.750    223.000000      0.31    167 ..........*..........
12:00_16/03/1983  381.0 *     0.418      0.300000    115.17    167 ..........|.........*
17:00_11/04/1983  382.0 *     0.457      4.510000      0.72    167 ..........*..........
11:00_09/06/1983  383.0 *     1.130   1349.998000      2.21    167 ..........*..........
10:00_22/07/1983  384.0 *     1.015    900.000000      2.39    167 ..........*..........
16:00_19/09/1983  385.0 *     1.200   1569.998000     -3.68    167 ..........*..........
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* after gauge number indicates Weighted Mean Gauge Height method

Site 419022 NAMOI RIVER AT MANILLA RAILWAY BRIDGE
VarFrom 100.00 Stream Water Level
VarTo 141.00 Stream Discharge
Period 01/10/1939 - 30/09/2011

Date	Number	Stage	Flow	Deviation	Rating	-100% Deviation 100%
12:00_15/11/1983	386.0 *	0.805	323.000000	0.90	167	..........*..........
14:00_09/07/1984	387.0 *	0.848	420.000000	-11.58	168	.........*|..........
10:00_01/08/1984	388.0 *	1.948	5939.995000	-0.58	169	..........*..........
12:00_04/09/1984	389.0 *	1.000	933.000000	3.09	169	..........*..........
12:00_14/02/1985	390.0 *	0.615	92.599000	-7.90	200	.........*|..........
10:30_10/05/1985	391.0 *	0.798	398.000000	-4.17	200	..........*..........
09:30_12/07/1985	392.0 *	1.772	6409.996000	25.74	200	..........|..*.......
13:30_12/09/1985	393.0 *	1.251	2179.999000	6.53	200	..........|*.........
12:10_05/12/1985	394.0 *	0.923	748.000000	1.13	200	..........*..........
14:15_03/02/1986	395.0 *	0.622	109.000000	8.43	201	..........|*.........
13:00_20/02/1986	396.0 *	0.566	40.400000	-7.82	201	.........*|..........
15:30_17/03/1986	397.0 *	0.446	3.330000	-2.29	201	..........*..........
14:30_29/04/1986	398.0 *	0.430	2.680000	15.64	202	..........|.*........
15:30_02/06/1986	399.0 *	0.576	59.500000	-0.12	202	..........*..........
08:40_01/07/1986	400.0 *	0.547	30.000000	-5.81	203	.........*|..........
15:45_11/08/1986	401.0 *	1.195	1728.998000	-3.17	204	..........*..........
12:30_23/10/1986	402.0 *	0.750	312.000000	0.58	204	..........*..........
11:15_10/12/1986	403.0 *	0.600	90.400000	6.35	204	..........|*.........
11:30_23/01/1987	404.0 *	0.575	44.200000	-8.40	205	.........*|..........
14:35_09/04/1987	405.0 *	0.558	37.000000	0.55	205	..........*..........
10:00_12/06/1987	406.0 *	0.582	58.500000	9.03	205	..........|*.........
09:15_22/07/1987	407.0 *	0.620	81.899000	-10.00	205	.........*|..........
09:30_08/09/1987	408.0 *	1.348	2329.999000	-7.80	205	.........*|..........
12:50_10/11/1987	409.0 *	0.645	125.000000	0.45	205	..........*..........
00:00_05/01/1988	410.0	1.185	1590.000000	-8.49	205	.........*|..........
00:00_01/03/1988	411.0	0.649	136.000000	-0.55	210	..........*..........
00:00_10/05/1988	412.0	0.727	284.000000	7.84	210	..........|*.........
00:00_27/06/1988	413.0	0.736	280.000000	-0.40	211	..........*..........
00:00_23/08/1988	414.0	0.825	458.000000	-3.66	211	..........*..........
00:00_07/10/1988	415.0	0.912	684.000000	-3.43	211	..........*..........
00:00_24/11/1988	416.0	0.765	341.000000	-0.39	211	..........*..........
00:00_19/01/1989	417.0	0.611	81.600000	0.57	211	..........*..........
00:00_28/02/1989	418.0	0.574	52.000000	3.97	212	..........*..........
00:00_18/04/1989	419.0	0.811	430.000000	-3.18	212	..........*..........
00:00_05/06/1989	420.0	0.735	290.000000	3.87	212	..........*..........
00:00_02/08/1989	421.0	2.324	10500.000000	2.74	212	..........*..........
00:00_26/09/1989	422.0	0.669	212.000000	28.07	212	..........|..*.......
00:00_27/11/1989	423.0	0.690	212.000000	6.71	212	..........|*.........
00:00_08/02/1990	424.0	1.138	1390.000000	-3.41	212	..........*..........
00:00_27/03/1990	425.0	0.602	68.200000	-11.58	212	.........*|..........
00:00_23/05/1990	426.0	0.881	542.000000	-11.29	212	.........*|..........
10:00_25/07/1990	427.0	1.081	1180.000000	-3.44	212	..........*..........
10:50_02/08/1990	428.0	2.241	9830.000000	4.68	212	..........*..........
10:40_05/08/1990	429.0	2.990	18000.000000	4.79	212	..........*..........
11:20_14/09/1990	430.0	1.158	1520.000000	-0.05	212	..........*..........
11:40_24/09/1990	431.0	1.077	1150.000000	-4.80	212	..........*..........
11:00_21/11/1990	432.0	0.617	86.800000	-7.96	212	.........*|..........
13:40_30/01/1991	433.0	0.272	1920.000000	[N/A]	212	..........|..........
16:45_12/03/1991	434.0	0.613	83.500000	-6.72	212	.........*|..........
16:40_14/05/1991	435.0	0.550	36.600000	-0.87	213	..........*..........
10:50_09/07/1991	436.0	0.618	114.000000	4.62	213	..........*..........
16:35_02/09/1991	437.0	0.609	97.900000	2.03	213	..........*..........
15:15_05/11/1991	438.0	0.600	83.800000	-0.24	213	..........*..........
08:45_14/11/1991	439.0	1.766	4750.000000	3.61	213	..........*..........
07:40_15/11/1991	440.0	1.526	2950.000000	-4.63	213	..........*..........

* after gauge number indicates Weighted Mean Gauge Height method

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Site     419022           NAMOI RIVER AT MANILLA RAILWAY BRIDGE
VarFrom   100.00          Stream Water Level
VarTo     141.00          Stream Discharge
Period  01/10/1939 - 30/09/2011

Date              Number      Stage          Flow Deviation Rating -100% Deviation  100%
14:45_26/11/1991  441.0      0.833     469.000000     -5.13    213 .........*|..........
09:40_07/01/1992  442.0      1.165    1400.000000     -4.70    213 ..........*..........
14:30_10/03/1992  443.0      0.670     216.000000     16.29    213 ..........|.*........
13:45_12/05/1992  444.0      0.597      93.300000     12.92    214 ..........|*.........
15:00_08/07/1992  445.0      0.665     177.000000     -1.01    214 ..........*..........
17:00_08/09/1992  446.0      0.786     365.000000     -6.66    214 .........*|..........
11:15_16/11/1992  447.0      0.704     236.000000     -0.33    214 ..........*..........
11:30_20/01/1993  448.0      0.557      47.400000      5.66    214 ..........|*.........
08:30_17/03/1993  449.0      0.488      11.600000     -0.27    214 ..........*..........
13:20_18/03/1993  450.0      0.527      26.500000     -0.05    214 ..........*..........
11:20_17/05/1993  451.0      0.555      43.100000     -0.85    214 ..........*..........
15:35_20/07/1993  452.0      0.869     492.000000     -3.64    215 ..........*..........
13:55_20/09/1993  453.0      0.807     377.000000      0.84    215 ..........*..........
12:10_16/11/1993  454.0      0.667     131.000000     -7.34    215 .........*|..........
15:30_17/11/1993  455.0      0.669     149.000000      3.16    215 ..........*..........
16:30_15/03/1994  456.0      0.602      78.100000     16.97    215 ..........|.*........
14:20_12/05/1994  457.0      0.541      28.600000      2.63    215 ..........*..........
08:45_14/07/1994  458.0      0.575      43.500000     -6.82    215 .........*|..........
08:00_15/09/1994  459.0      0.520      21.800000     -5.22    216 .........*|..........
13:10_21/11/1994  460.0      0.523      26.100000      6.66    216 ..........|*.........
07:50_18/01/1995  461.0      0.510      24.800000     31.27    216 ..........|..*.......
08:20_15/03/1995  462.0      0.734     262.000000     -9.27    216 .........*|..........
07:45_08/06/1995  463.0      0.598      84.200000      0.55    216 ..........*..........
14:40_08/08/1995  464.0      0.612     103.000000      1.34    216 ..........*..........
09:00_15/09/1995  465.0      0.681     195.000000     -3.21    216 ..........*..........
14:30_09/10/1995  466.0      1.007     873.000000     -8.02    216 .........*|..........
16:20_17/10/1995  467.0      0.716     238.000000     -7.15    216 .........*|..........
09:00_24/11/1995  468.0      1.160    1220.000000     -0.34    217 ..........*..........
11:30_22/02/1996  469.0      0.925     535.000000     -0.15    217 ..........*..........
12:45_12/03/1996  470.0      0.736     170.000000     -2.38    217 ..........*..........
15:15_29/04/1996  471.0      0.653      75.600000     -4.04    217 ..........*..........
11:40_10/05/1996  472.0      1.074     965.000000      3.41    217 ..........*..........
09:05_11/07/1996  473.0      0.845     371.000000     -0.85    217 ..........*..........
09:00_05/09/1996  474.0      1.725    4460.000000      5.37    218 ..........|*.........
15:30_17/10/1996  475.0      0.985     802.000000      8.42    218 ..........|*.........
11:20_28/10/1996  476.0      0.786     323.000000      1.45    218 ..........*..........
11:40_20/12/1996  477.0      2.150    8070.000000      1.23    218 ..........*..........
13:10_06/03/1997  478.0      1.135    1250.000000      5.34    218 ..........|*.........
09:00_18/04/1997  479.0      0.707     146.000000    -22.85    218 ........*.|..........
12:45_14/05/1997  480.0      0.700     144.000000    -20.01    218 ........*.|..........
09:40_25/07/1997  481.0      0.652     120.000000     -3.07    218 ..........*..........
08:25_11/09/1997  482.0      0.693     167.000000     -2.36    218 ..........*..........
12:10_20/11/1997  483.0      0.695     177.000000      1.97    218 ..........*..........
06:20_17/12/1997  484.0      0.670     147.000000      2.61    218 ..........*..........
11:05_16/01/1998  485.0      0.560      41.200000      0.49    218 ..........*..........
11:20_25/02/1998  486.0      0.585      58.000000     -1.33    218 ..........*..........
13:20_26/03/1998  487.0      0.537      29.400000     -1.05    218 ..........*..........
13:10_21/04/1998  488.0      0.533      27.300000     -2.25    218 ..........*..........
08:00_14/05/1998  489.0      0.636     109.000000      1.51    218 ..........*..........
08:30_16/07/1998  490.0      0.926     578.000000     -3.02    218 ..........*..........
12:00_06/11/1998  491.0      1.115     866.000000      2.47    219 ..........*..........
10:20_26/11/1998  492.0      1.112     834.000000     -0.24    219 ..........*..........
13:00_28/01/1999  493.0      0.756     132.000000     -1.57    219 ..........*..........
12:30_18/03/1999  494.0      0.763     149.000000      5.73    219 ..........|*.........
11:30_20/05/1999  495.0      0.764     138.000000     -2.75    219 ..........*..........

* after gauge number indicates Weighted Mean Gauge Height method
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Site    419022          NAMOI RIVER AT MANILLA RAILWAY BRIDGE
VarFrom   100.00        Stream Water Level
VarTo     141.00        Stream Discharge
Period  01/10/1939 - 30/09/2011

Date              Number      Stage          Flow Deviation Rating -100% Deviation  100%
13:45_11/06/1999  496.0      0.818     188.000000     -6.21    219 .........*|..........
16:20_08/07/1999  497.0      0.940     316.000000     -1.52    220 ..........*..........
08:25_15/07/1999  498.0      0.878     215.000000     -5.04    220 .........*|..........
16:30_13/09/1999  499.0      0.928     286.000000     -5.01    220 .........*|..........
10:15_09/11/1999  500.0      1.975    6070.000000     -3.17    220 ..........*..........
13:05_18/01/2000  501.0      0.758     106.000000      1.46    220 ..........*..........
08:55_08/03/2000  502.0      0.740      85.400000     -6.52    220 .........*|..........
09:05_24/05/2000  503.0      0.751      96.600000     -2.67    220 ..........*..........
08:40_14/07/2000  504.0      0.840     198.000000     10.61    220 ..........|*.........
12:35_14/09/2000  505.0      1.071     642.000000     -1.07    220 ..........*..........
12:30_15/09/2000  506.0      1.138     889.000000      1.53    220 ..........*..........
07:05_10/11/2000  507.0      0.967     382.000000      2.24    220 ..........*..........
07:20_11/01/2001  508.0      0.777     134.000000     12.26    220 ..........|*.........
08:00_06/04/2001  509.0      0.968     450.000000      2.05    221 ..........*..........
10:00_23/05/2001  510.0      0.850     220.000000      0.00    221 ..........*..........
11:35_08/08/2001  511.0      0.885     271.000000     -1.25    221 ..........*..........
10:30_18/10/2001  512.0      1.072     731.000000      2.42    221 ..........*..........
06:50_14/12/2001  513.0      0.945     423.000000      8.69    221 ..........|*.........
08:30_22/02/2002  514.0      0.770     135.000000      4.32    221 ..........*..........
08:45_24/04/2002  515.0      0.690      62.100000      0.53    221 ..........*..........
16:00_19/06/2002  516.0      0.734      89.500000     -7.23    221 .........*|..........
17:10_14/08/2002  517.0      1.280    1440.000000      0.23    221 ..........*..........
13:45_16/08/2002  518.0      1.633    3440.000000      0.14    221 ..........*..........
13:00_20/08/2002  519.0      1.520    2860.000000      6.01    221 ..........|*.........
10:40_05/09/2002  520.0      1.278    1430.000000      0.10    221 ..........*..........
15:35_23/10/2002  521.0      1.359    1690.000000     -5.79    221 .........*|..........
12:55_07/11/2002  522.0      1.434    2220.000000      1.49    221 ..........*..........
13:00_07/11/2002  523.0      1.434    2230.000000      1.95    221 ..........*..........
15:10_12/12/2002  524.0      1.307    1520.000000     -2.01    221 ..........*..........
13:30_24/01/2003  525.0      1.184    1020.000000     -4.93    222 ..........*..........
12:45_30/01/2003  526.0      0.721      85.200000     -0.70    222 ..........*..........
15:15_11/02/2003  527.0      0.670      34.400000      0.55    223 ..........*..........
10:30_12/02/2003  528.0      0.652      23.500000     -6.50    223 .........*|..........
15:40_29/04/2003  529.0      0.833     200.000000      2.90    223 ..........*..........
11:05_03/07/2003  530.0      0.782     124.000000     -2.31    223 ..........*..........
13:55_12/08/2003  531.0      0.742      84.140000     -0.52    223 ..........*..........
08:00_14/08/2003  532.0      0.758     100.057000      0.10    223 ..........*..........
15:25_28/10/2003  533.0      0.784     124.312000     -3.91    223 ..........*..........
06:50_16/12/2003  534.0      0.738      93.268000     -6.69    224 .........*|..........
10:20_24/02/2004  535.0      0.822     207.906000     -1.20    225 ..........*..........
16:05_20/04/2004  536.0      0.700      68.699000     -0.34    225 ..........*..........
09:15_22/04/2004  537.0      0.676      43.888000     -3.40    225 ..........*..........
15:30_07/06/2004  538.0      0.738     104.841000     -5.91    225 .........*|..........
15:30_11/08/2004  539.0      0.897     304.235000     -3.48    225 ..........*..........
15:35_11/08/2004  540.0      0.897     308.055000     -2.27    225 ..........*..........
12:30_22/10/2004  541.0      0.863     261.361000     -0.82    225 ..........*..........
15:05_26/10/2004  542.0      1.118     814.221000     -4.74    225 ..........*..........
09:55_28/10/2004  543.0      0.989     507.720000     -0.12    225 ..........*..........
16:45_08/12/2004  544.0      0.818     197.219000     -4.12    225 ..........*..........
16:50_08/12/2004  545.0      0.818     191.328000     -6.98    225 .........*|..........
07:20_17/02/2005  546.0      0.655      40.850000     -0.57    226 ..........*..........
06:45_24/02/2005  547.0      0.672      48.631000     -6.70    226 .........*|..........
09:30_18/04/2005  548.0      0.662      41.888000     -7.53    226 .........*|..........
10:15_06/06/2005  549.0      0.637      28.007000     -8.91    226 .........*|..........
15:15_10/08/2005  550.0      0.929     346.953000      1.90    226 ..........*..........

* after gauge number indicates Weighted Mean Gauge Height method
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Site 419022 NAMOI RIVER AT MANILLA RAILWAY BRIDGE
VarFrom 100.00 Stream Water Level
VarTo 141.00 Stream Discharge
Period 01/10/1939 - 30/09/2011

Date	Number	Stage	Flow	Deviation	Rating	-100% Deviation 100%
08:30_11/08/2005	551.0	0.907	310.438000	2.87	226	..........*..........
15:15_12/10/2005	552.0	0.842	198.973000	-1.14	226	..........*..........
11:00_27/10/2005	553.0	0.820	182.755000	5.43	226	..........|*.........
14:50_20/12/2005	554.0	0.902	259.185000	0.41	227	..........*..........
14:55_20/12/2005	555.0	0.902	254.997000	-1.21	227	..........*..........
08:30_20/02/2006	556.0	0.710	65.489000	8.00	227	..........|*.........
08:30_20/03/2006	557.0	0.661	29.034000	-6.58	227	.........*|..........
16:45_11/04/2006	558.0	0.715	65.545000	2.76	227	..........*..........
16:50_11/04/2006	559.0	0.715	63.797000	0.02	227	..........*..........
12:45_20/06/2006	560.0	0.788	130.628000	9.54	227	..........|*.........
12:50_20/06/2006	561.0	0.788	125.443000	5.20	227	..........|*.........
13:25_14/08/2006	562.0	0.717	63.879000	-1.82	227	..........*..........
10:40_17/10/2006	563.0	0.612	15.304000	6.84	227	..........|*.........
10:45_05/12/2006	564.0	1.636	3022.174000	-1.59	227	..........*..........
10:50_05/12/2006	565.0	1.636	2859.837000	-6.88	227	.........*|..........
10:44_15/01/2007	566.0	0.694	55.261000	-3.93	228	..........*..........
08:20_30/01/2007	567.0	0.672	46.917000	6.07	228	..........|*.........
13:10_10/04/2007	568.0	0.630	23.293000	-2.62	228	..........*..........
14:17_21/06/2007	569.0	0.723	71.648000	-8.41	228	.........*|..........
14:19_21/06/2007	570.0	0.723	74.453000	-4.83	228	..........*..........
07:32_17/08/2007	571.0	0.703	65.256000	2.70	228	..........*..........
07:34_17/08/2007	572.0	0.703	66.344000	4.41	228	..........*..........
06:43_19/10/2007	573.0	0.646	28.020000	-8.88	228	.........*|..........
08:00_15/11/2007	574.0	0.895	258.328000	-9.28	228	.........*|..........
08:55_12/12/2007	575.0	1.223	1076.673000	-4.24	228	..........*..........
09:00_12/12/2007	576.0	1.223	1111.366000	-1.16	228	..........*..........
14:31_27/02/2008	577.0	0.893	210.396000	-8.93	229	.........*|..........
14:35_27/02/2008	578.0	0.893	213.292000	-7.67	229	.........*|..........
12:08_16/04/2008	579.0	0.655	26.378000	-7.93	230	.........*|..........
12:12_16/04/2008	580.0	0.658	27.411000	-8.59	230	.........*|..........
08:51_20/06/2008	581.0	0.892	293.262000	2.22	230	..........*..........
08:57_20/06/2008	582.0	0.892	282.734000	-1.45	230	..........*..........
07:55_08/07/2008	583.0	0.767	114.190000	-5.91	230	.........*|..........
15:18_05/08/2008	584.0	0.830	180.243000	-9.53	230	.........*|..........
10:08_16/10/2008	585.0	0.908	302.212000	-2.94	230	..........*..........
10:15_16/10/2008	586.0	0.908	285.275000	-8.38	230	.........*|..........
07:20_16/12/2008	587.0	1.832	4194.480000	-6.00	230	.........*|..........
12:04_17/02/2009	588.0	0.767	133.000000	9.59	230	..........|*.........
08:08_08/04/2009	589.0	0.899	287.000000	-3.42	230	..........*..........
14:35_15/06/2009	590.0	0.856	259.680000	9.53	230	..........|*.........
16:10_06/08/2009	591.0	0.813	182.650000	3.36	230	..........*..........
07:40_14/10/2009	592.0	0.723	81.190000	6.00	230	..........|*.........

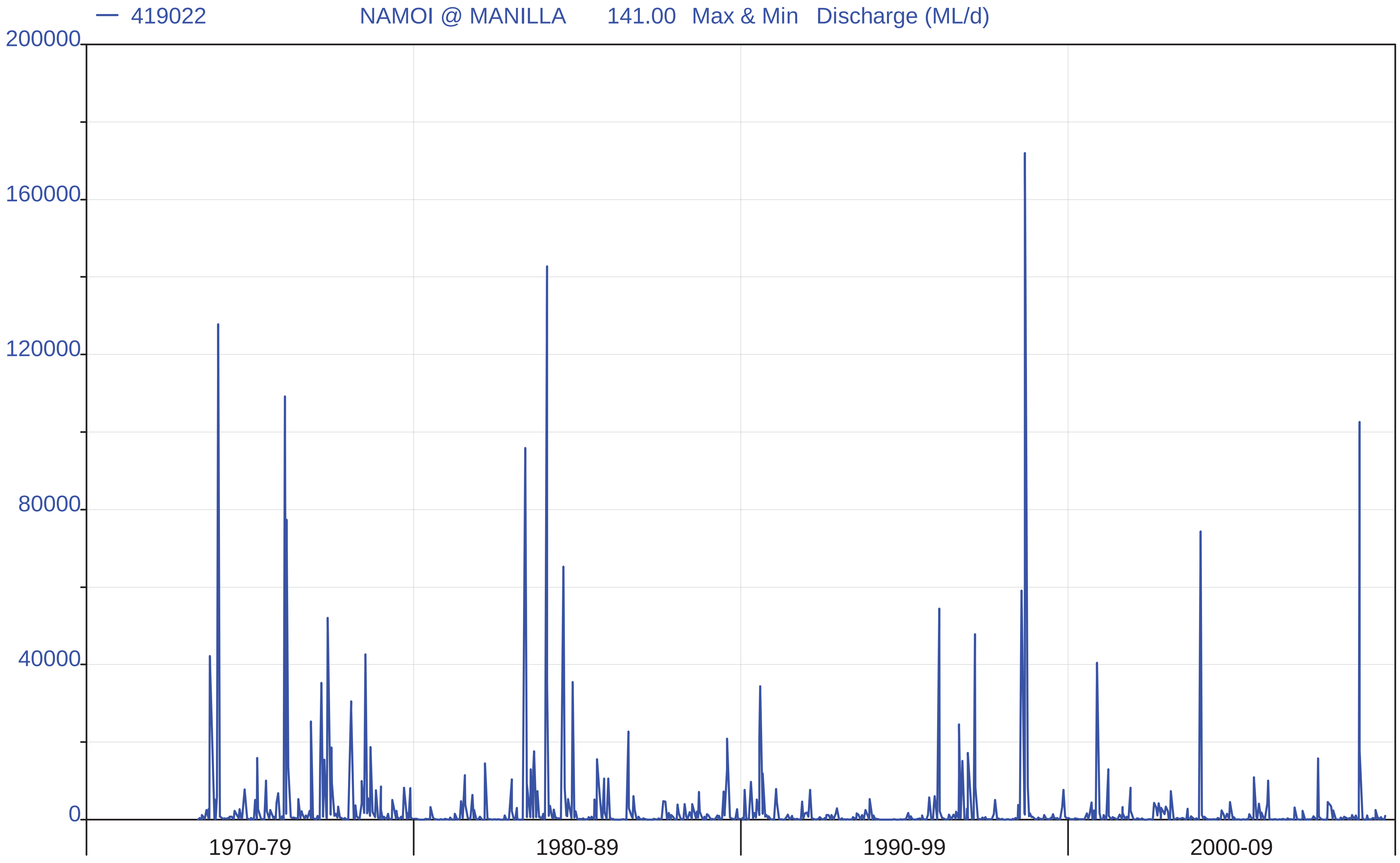
* after gauge number indicates Weighted Mean Gauge Height method

NSW Office of Water PINNEENA 9.3

HYPLOT V132 Output 23/12/2011

Period 40 Year Plot Start 00:00_01/01/1970 1970-10

Interval 1 Month Plot End 00:00_01/01/2010



NSW Office of Water PINNEENA 9.3

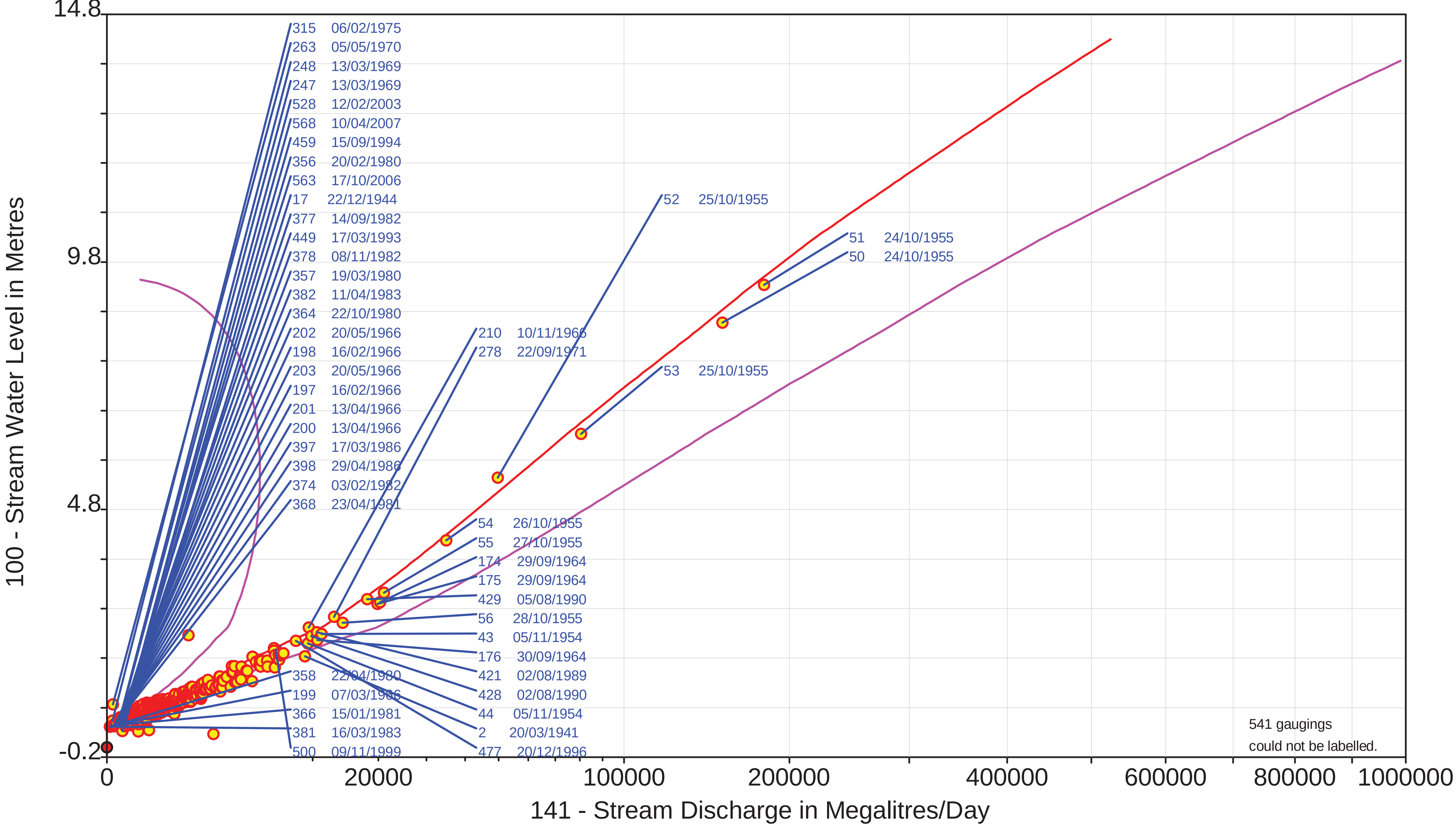
HYGPLOT V128 Output 23/12/2011

419022 NAMOI RIVER AT MANILLA RAILWAY BRIDGE

Gaugings from 19/03/1941 to 14/10/2009

o Good ● Doubtful ● Bad

Rating Table 230.01 01/04/2008 to Present



Appendix C

Community Consultation

MANILLA FLOOD STUDY
CONSULTANT MEETING No 1

12 NOON, 20 JULY 2O11, LEVEL 2, RAY WALSH HOUSE, TAMWORTH

PRESENT:-

James McPherson [JM] - GHD

Dr Rainer Berg [RB] - GHD [by phone link]

Murray Russell [MR] - TRC

Graeme McKenzie [GM] - TRC

William Ash [WA] - TRC

1. INTRODUCTION

The meeting was convened to confirm the Manilla Flood Study methodology and Programme and to respond to any Request for Information (RFIs) GHD may have raised.

RB joined the meeting by phone link.

2. PROJECT PLAN

RB briefed the meeting on the proposed methodology.

Methodology is to comply with Section 4 Flood Study of the Consultants Brief and RB outlined the following components:-

- Modelling Platform.

  RB reported that the level of detail in the Modelling Platforms was still to be determined. GHD will liaise with Office of Environment and Heritage (OEH) to finalise the model details.

  All communication between GHD and OEH is to be documented and copied to TRC.

- Hydrology

  RB stated RORB model set up GHD will develop the model then using hydraulic information including Frequency Analysis and measurements of events in creeks compare the actuals to the results of the model. The model will then be calibrated against a number of recorded historical and observed flood peaks using river gauging stations as benchmarks.

  Survey information is not essential in building this model.

- Community Consultation

  RB briefed the meeting on the consultation process and information sought from the Manilla community. GHD will draft the questionnaire and media material to be issued, TRC will review, approve and issue under cover of TRC letterhead and include contact details. Current documentation and process being employed on Coffs Harbour Flood Study will be amended and utilized for Manilla.

  Issue of material will be by post based on TRC Rates database for property owners. Community Groups will be contacted. Letterboxing may be considered. Time frame/s for response will be specified.

  Information requested will include historical floods, levels and impacts on property.

  This item needs to be actioned ASAP.

- Hydraulic Models

  RB reported GHD had built 2 ‘raw’ models [Tuflow and Mikell] in the previous week. Models are to be tested using rainfall events and flood peaks. RB stated the type of model is yet to be determined and the level of information to be included in the model [2 Flow or 2D] will be clarified within 2 weeks. The concurrence of OEH is required as to the type of model.

Both Hydrology and survey are required to be complete in order that the selected hydraulic model can be completed and calibrated against identified flood marks determined from TRC information and community knowledge.

GHD has obtained rainfall records from the Bureau of Meteorology [BOM] and has purchased flow data for waterways. This information will be used by GHD to determine the event it will use to calibrate the model/s. Results from 3-4 gauges with data periods with co-incidental large events would be utilized to determine large events for the purposes of calibration.

Once calibrated flood events can be modelled, properties at risk identified and estimates of damage prepared.

- Mapping

  Maps are to be able to be interfaced with TRC GIS capability. GHD is to liaise with TRC GIS operator the ensure compatibility.

  [Note following the meeting JM and WA met with TRC, GIS operator Joe Bagster to establish the lines of communication to ensure mapping meets with TRC requirements]

  GHD is programming to have mapping complete by last week of October 2011.

- Climate Change

  GHD stated the impact of climate change is difficult to model due to inputs being estimates only. Accordingly GHD is running its model with practical considerations as inputs.

  In respect of predicted increased rainfall, GHD is proposing to run 200 and 500 year events through the model to estimate future flood levels and the impact of such events on the town.

  Final inputs to be identified following further search of relevant data.

- Programme

  GHD stated it would prepare and issue to TRC the community questionnaire during the last week of July 2011.

  TRC requested that the programme show the Christmas/ New Year break.

  TRC requested the programme include milestones, hold points and meetings, including meetings with Floodplain Management Committee.

  A list of deliverables and dates of issue to TRC are to be included.

3. SURVEY

RB reported GHD can continue to progress without survey at this time.

GHD has issued a brief to the preferred Surveyor [Peter Baxter] and is waiting on final pricing before advising TRC. This is expected during the first week of August with field work to commence immediately with a 6 week programme to complete.

Survey information is required to build the hydraulic model.

Initial tasks include site visit and walk to determine the information required is identified and ensure such information is correct. Information will include ground and creek levels and properties at risk locations and floor levels.

Information from survey will be used to further develop the hydraulic model/s and calibrate the model/s against historic flood levels established from historical information including TRC records and community response.

On completion of these tasks GHD will run the hydrographs through the model and map the flood effected areas.

4. CLIENT [TRC] INFORMATION

GHD requested TRC to provide the following information:-

- TRC LEP Map
- Plan of Cadesta
- Contour maps [if available]
- Ariel Photos
- Previous flood information and estimates
- Information on bridges, openings in culverts etc
- Information on Manilla weir
- Local historical information held by Community Groups etc
- Bridges blocked in previous flood events giving levels if available.
- Information on Split Rock Dam [State Water] including, time of construction, filling, water storage characteristics and discharge.

GHD requested it be allowed to access and use information available under Licence Agreements. TRC will facilitate this request.

GHD will email WA with a comprehensive list of requested information by 27 July 2011.

5. DOCUMENTATION LISTING

GHD to prepare a list of documents, issue to TRC and integrate into the programme.

6. OTHER BUSINESS

GHD requested TRC Purchase Orders for the Study.

There being no further business the meeting closed at 1.15 pm.

Next meeting to be advised.

WA and JM met with Joe Bagster following the meeting to discuss mapping information and interface with TRC GIS System.

MANILLA FLOOD STUDY
NEWSLETTER NO.1, August 2011

About the project

As part of the NSW Government's Floodplain Risk Management Process, Tamworth Regional Council is developing a Flood Study for Manilla.

Manilla is located on the Namoi River at the junction of the Namoi and Manilla Rivers in the Namoi River catchment. The town is bisected by these two rivers and access is provided by a number of bridges. The Manilla River passes through Split Rock Reservoir upstream of the town and the Namoi River drains to Lake Keepit, downstream of the town.

Floodwaters rise quickly and can isolate properties and communities for several days. Many houses could be affected during a flood, necessitating evacuations.

Rainfall and river gauging data in the catchment is limited, however significant events have been recorded on a number of stream gauges.

The objective of this Flood Study is to define the flood behaviour under recent historical conditions and predict flood behaviour under existing and future conditions in the study area. The output will provide flood levels, depths, velocities, flows, hydraulic categories, and provisional hazard categories.

GHD have been contracted by Council to carry out the Manilla Flood Study.

Study Tasks

In general terms, the following key tasks will be undertaken:

- Collect, compile and review available flood data relating to the study area in order to obtain a full understanding of flooding issues in the study area;
- Undertake community consultation to gather information on historical flooding in the area and the impact of flooding on the local community;
- Gather additional survey of watercourses and structures (for example bridges, culverts, road levels);
- Develop flood models to simulate historical and design floods. Calibrate and validate these models against recent historical flood data (for example the April 2009 event); and
- Map the extent of flooding, flood level contours and provisional flood hazards for the study area.

Community Information

Council and GHD are committed to listening to the concerns and issues of the community and stakeholders, and strategies are in place to ensure that this information is integrated into the study. There will be opportunities throughout the study for the local community and stakeholders to feedback their concerns and issues.

As a first step, the project team is keen to learn when and where previous flooding has occurred in Manilla and the surrounding areas, and how you and your property were affected.

Attached is a survey questionnaire that all members of the community are encouraged to complete and return (postage paid). This is an opportunity to ensure that you have your say and that the information is captured.

For more information contact

Lynne Clayton
Stakeholder Engagement
Manilla Flood Study
Reply Paid 83475
GHD, Level 15, 133 Castlereagh Street
Sydney NSW 2000
Facsimile – 02 9239 7199
Email – community.input@ghd.com.au

Project Information Line
1800 810 680 (free call)

Tamworth REGIONAL COUNCIL

ABN: 52 631 074 450

More than just a city. More than just one place.

Manilla Flood Study Survey

Name: --

Address: --

Telephone: Mob: --

Please include my details in the stakeholder database to receive further information on the project ☐ *(Please tick)*

1. How long have you lived (or did you live) in Manilla? _____ Years_____ Months
2. Have you ever seen or experienced a flood while living in Manilla? Yes ☐ No ☐ *(Please tick)*
3. If yes, in what year/s did the floods take place?

____

4. What effects did the flood have on you and your property?

____

5. How quickly do flood waters rise, and how long do flood waters pond, or do they drain rapidly?

____

____

6. Did you note any flood markers? (Flood markers could be lines on buildings that show the peak flood level during the flood event)

____

7. How do you prepare for a flood?

____

____

6. Do you get isolated in a flood and is your property access restricted by flood waters?

____

7. Are there any other issues you would like us to take into consideration?

____

____

____

Thank you for taking the time to complete this survey.

Your feedback is invaluable in assisting the project team.

BARRABA FLOOD STUDY
NEWSLETTER NO.1, August 2011

About the project

As part of the NSW Government's Floodplain Risk Management Process, Tamworth Regional Council is developing a Flood Study for Barraba.

Barraba is located on the Manilla River upstream of Split Rock Reservoir in the Manilla River catchment. The town is located south of the river along The Fossickers Way. The Manilla River passes through Split Rock Reservoir downstream of the town.

Floodwaters rise quickly and can isolate properties and communities for several days. Many houses could be affected during a flood, necessitating evacuations.

Rainfall and river gauging data in the catchment is limited, however significant events have been recorded on a number of stream gauges.

The objective of this Flood Study is to define the flood behaviour under recent historical conditions and predict flood behaviour under existing and future conditions in the study area. The output will provide flood levels, depths, velocities, flows, hydraulic categories, and provisional hazard categories.

GHD have been contracted by Council to carry out the Barraba Flood Study.

Study Tasks

In general terms, the following key tasks will be undertaken:

- Collect, compile and review available flood data relating to the study area in order to obtain a full understanding of flooding issues in the study area;
- Undertake community consultation to gather information on historical flooding in the area and the impact of flooding on the local community;
- Gather additional survey of watercourses and structures (for example bridges, culverts, road levels);
- Develop flood models to simulate historical and design floods. Calibrate and validate these model against recent historical flood data (for example the April 2009 event); and
- Map the extent of flooding, flood level contours and provisional flood hazards for the study area.

Community Information

Council and GHD are committed to listening to the concerns and issues of the community and stakeholders, and strategies are in place to ensure that this information is integrated into the study. There will be opportunities throughout the study for the local community and stakeholders to feedback their concerns and issues.

As a first step, the project team is keen to learn when and where previous flooding has occurred in Barraba and the surrounding areas, and how you and your property were affected.

Attached is a survey questionnaire that all members of the community are encouraged to complete and return (postage paid). This is an opportunity to ensure that you have your say and that the information is captured.

For more information contact

Lynne Clayton
Stakeholder Engagement
Barraba Flood Study
Reply Paid 83475
GHD, Level 15, 133 Castlereagh Street
Sydney NSW 2000
Facsimile – 02 9239 7199
Email – community.input@ghd.com.au

Project Information Line
1800 810 680 (free call)

REGIONAL | COUNCIL
Tamworth

ABN: 52 631 074 450

More than just a city. More than just one place.

Barraba Flood Study Survey

Name: --

Address: --

Telephone: Mob: --

Please include my details in the stakeholder database to receive further information on the project ☐ *(Please tick)*

1. How long have you lived (or did you live) in Barraba? _____ Years _____ Months

2. Have you ever seen or experienced a flood while living in Barraba? Yes ☐ No ☐ *(Please tick)*

3. If yes, in what year/s did the floods take place?

____

4. What effects did the flood have on you and your property?

____

5. How quickly do flood waters rise, and how long do flood waters pond, or do they drain rapidly?

____

____

6. Did you note any flood markers? (Flood markers could be lines on buildings that show the peak flood level during the flood event)

____

7. How do you prepare for a flood?

____

____

6. Do you get isolated in a flood and is your property access restricted by flood waters?

____

7. Are there any other issues you would like us to take into consideration?

____

____

____

Thank you for taking the time to complete this survey.

Your feedback is invaluable in assisting the project team.

MANILLA FLOOD STUDY
CONSULTANT MEETING No 2

3.00 PM, 3 AUGUST 2O11,

LEVEL 2, RAY WALSH HOUSE, TAMWORTH

PRESENT:-

James McPherson [JM] - GHD

Dr Rainer Berg [RB] - GHD

William Ash [WA] - TRC

APOLOGIES

Murray Russell [MR] - TRC

Graeme McKenzie [GM] - TRC

1. INTRODUCTION

The meeting was convened to discuss progress on the Manilla Flood Study, confirm methodology and to respond to any Request for Information (RFIs) GHD may have raised.

2. PROJECT PLAN

RB confirmed the proposed methodology for the Study.

Methodology is to comply with Section 4 Flood Study of the Consultants Brief and RB outlined the following components:-

- Modelling Platform.

  RB reported that the level of detail in the Modelling Platforms was still to be determined. GHD will liaise with Office of Environment and Heritage (OEH) to finalise the model details and reported he would be meeting with Neal Albert [NA] of OEH immediately following this meeting. Matters concerning the methodology would be discussed with OEH.

  WA confirmed communication between GHD and OEH is to be documented and copied to TRC.

- Hydrology

  RB stated RORB model set up GHD will develop the model then using hydraulic information including Frequency Analysis and measurements of events in creeks compare the actuals to the results of the model. The model will then be calibrated against a number of recorded historical and observed flood peaks using river gauging stations as benchmarks.

  Survey information is not essential in building this model.

- Community Consultation

  RB briefed the meeting on the consultation process and information sought from the Manilla community. GHD will draft the questionnaire and media material to be circulated to Manilla residents and issue drafts to TRC on 5 Aug 2011. TRC will review, approve and issue under cover of TRC letterhead and include GHD contact details.

  TRC confirmed Issue of material will be by post, based on TRC Rates database for property owners. In addition each property will be contacted to ensure tenants are included in the survey. Community Groups will be contacted. Time frame/s for response will be specified.

  Information requested will include historical floods, levels and impacts on property.

This item needs to be actioned ASAP. GHD confirmed issue of draft documents by 5 Aug

- Hydraulic Models

  RB confirmed GHD had built 2 'raw' models [Tuflow and Mikell] during the first week of the Study. Models are to be tested using rainfall events and flood peaks. RB stated the type of model is yet to be determined and the level of information to be included in the model [2 Flow or 2D] will be clarified in the immediate future. The concurrence of OEH is required as to the type of model. This will be an item for discussion with OEH following this meeting.

  Both Hydrology and survey are required to be complete in order that the selected hydraulic model can be completed and calibrated against identified flood marks determined from TRC information and community knowledge.

  GHD has obtained rainfall records from the Bureau of Meteorology [BOM] and has purchased flow data for waterways. This information will be used by GHD to determine the event it will use to calibrate the model/s. Results from 3-4 gauges with data periods with co-incidental large events would be utilized to determine large events for the purposes of calibration.

  Once calibrated flood events can be modelled, properties at risk identified and estimates of damage prepared.

- Mapping

  Maps to be interfaced with TRC GIS capability. GHD and TRC GIS operator are in communication to ensure compatibility.

  GHD is programming to have mapping complete by last week of October 2011.

- Climate Change

  GHD stated the impact of climate change is difficult to model due to inputs being estimates only. Accordingly GHD is running its model with practical considerations as inputs.

  In respect of predicted increased rainfall, GHD is proposing to run 200 and 500 year events through the model to estimate future flood levels and the impact of such events on the town.

  Final inputs to be identified following further search of relevant data.

- Programme

  TRC had previously requested that the programme show the Christmas/ New Year break.

  GHD tabled a revised programme including milestones, hold points, deliverables and meetings.

  A list of and dates of issue to TRC have been included.

3. SURVEY

RB confirmed GHD can continue to progress without survey at this time.

GHD has issued a brief to the preferred Surveyor [Peter Baxter] and is conducting a site inspection with Baxter tomorrow, 4 Aug 2011. Following the site inspection GHD will prepare draft plans showing survey limits and issue to TRC and OEH for approval.

The model areas have to be determined prior to preparing final pricing for the survey. Field work will commence on TRC approval of the survey limits and survey cost with a 6 week programme to complete.

GHD confirmed survey information is required to build the hydraulic model.

Initial tasks are to determine the information required is identified and ensure such information is correct. Information will include ground and creek levels and properties at risk locations and floor levels.

Information from survey will be used to further develop the hydraulic model/s and calibrate the model/s against historic flood levels established from historical information including TRC records and community response.

On completion of these tasks GHD will run the hydrographs through the model and map the flood effected areas.

4. CLIENT [TRC] INFORMATION

GHD confirmed it had signed the Licence Agreements that allowed accessing and using information held by TRC and that information is being made available.

GHD confirmed TRC has provided the following information:-

- TRC LEP Map
- Plan of Cadesta
- Contour maps
- Ariel Photos [limited]
-

GHD confirmed it required the following information ASAP

- Previous flood information and estimates
- Information on bridges, openings in culverts etc
- Information on Manilla weir
- Local historical information held by Community Groups etc
- Bridges and/or other structures blocked in previous flood events, giving levels if available.
- Information on Split Rock Dam [State Water] including, time of construction, filling, water storage characteristics and discharge.

GHD has issued TRC with a comprehensive list of information requested.

TRC handed to GHD copies of documents containing historical information on previous floods.

A catalogue of these documents will be issued to GHD.

TRC will continue to search its archives for further documents and/or information relating to historical flood information.

5. DOCUMENTATION LISTING

GHD has issued a list of documents to TRC and integrated these into the programme.

6. OTHER BUSINESS

GHD requested TRC Purchase Orders for the Study.

There being no further business the meeting closed at 3.45 pm.

Next meeting to be advised.

MANILLA FLOOD STUDY
CONSULTANT MEETING No 3

10.00 am FRIDAY 16 SEPTEMBER 2O11

LEVEL 2, RAY WALSH HOUSE, TAMWORTH

PRESENT:-

James McPherson [JM] - GHD

Dr Rainer Berg [RB] - GHD [by phone link]

Neal Albert [NA] - Office of Environment and Heritage

Andrew Falkenmire [AF] - Office of Environment and Heritage

Peter Baxter [PB] - Peter Baxter Surveyors, Sub-Consultant to GHD

Thomas Baxter [TB] - TRC

William Ash [WA] - TRC

APOLOGIES

Murray Russell [MR] - TRC

Graeme McKenzie [GM] - TRC

1. INTRODUCTION

The meeting was convened to review progress on and provide the management team with visibility of the technical aspects of the Manilla Flood Study and to respond to any Requests for Information (RFIs) GHD may have raised.

RB joined the meeting by phone link.

2. PROJECT PROGRAMME STATUS

RB briefed the meeting by phone link, on the progress against the programme and a summary of his report follows:-

2.1 Programme

- A site visit in concert with the ground survey team headed by PB has been carried out. The topography of the terrain was inspected. RB reported the area was not as heavily wooded as previously thought, the main wooded area being at the confluence of the Namoi River and Halls Creek. Flood channel was open and banks were not steep.
- From on site observations the Survey Brief was confirmed by GHD and PB.
- Number of houses to have floor levels established for damage calculations will be calculated using the PMF + 0.5M.
- PB reported survey control points have been established. These will be used by both the ground survey team and to calibrate the existing aerial survey information. Areometrex ‘holes’ will be filled in and ‘rough’ contours established.
- PB reported that structures affected by flooding i.e. bridges and culverts would be surveyed next week.
- PB. Model will be in HECRAS format. From the basic model areas inundated during PMF flood events can be delineated estimating from 100 yr x 3 beyond the form lines and the aerial information can be used to determine ‘rough’ DTM.
- PB reported GHD is on programme.

2.2 Hydrology

- RB has previously stated RORB model set up GHD will develop the model then using hydraulic information including Frequency Analysis and measurements of events in creeks compare the actuals to the results of the model. The model will then be calibrated against a number of recorded historical and observed flood peaks using river gauging stations as benchmarks. Survey information is not essential in building this model.
- RB reported Hydrology model has been built and is ready for calibration using information from previous rain and flood events and set systems flow gauges for calibration. RB stated GHD has a good understanding of flows from historical records from previous information providing basic information on the magnitude of flows.

2.3 Hydraulics

- Construction and accuracy of the Hydraulic Model is dependant on the provision of correct survey information. PB stated model would be TUFLOW and GHD would build a substantial part of the model using form lines the replace the inputted data with the more accurate DTM when this became available. PB stated GHD would commence to build the model/s during week commencing 19 September 2011.
- RB stated GHD Is considering 2 model options and would discuss this with OEH to ensure the model meets OEHs criteria before making the final decision. NA stated OEH concurs with GHDs approach with the proviso the OEH needs to be comfortable with the ‘raw’ models flood frequency. OEH and GHD would discuss this matter after the meeting and would inform the meeting on the outcome of the discussions.

2.4 Survey

- RB/PB confirmed site Information will include ground and creek levels and properties at risk locations and floor levels.

- PB confirmed that Manilla ground survey would start week commencing 19 Sept 2011. Control points will be established to allow calibration of Areometrex and confirm ground survey.
- PB stated the Areometrex has an accuracy of +/- 150mm. This is to be confirmed.
- TB to follow up with Areometrex to expedite transfer of information.
- A brief of survey and how this integrates with the modelling software is to be provided. TB to review.
- TB stated all survey information is to be available for use by all levels of Government without limitations.
- PB requested any historical information TRC holds in respect of previous flood levels including flood markers [if any].
- Maps are to be able to be interfaced with TRC GIS capability. GHD is to liaise with TRC GIS operator the ensure compatibility. GHD is programming to have mapping complete by last week of October 2011.

- In respect of Climate Change GHD has previously stated the impact of climate change is difficult to model due to inputs being estimates only. Accordingly GHD is running its model with practical considerations as inputs. In respect of predicted increased rainfall, GHD is proposing to run 200 and 500 year events through the model to estimate future flood levels and the impact of such events on the town. Final inputs to be identified following further search of relevant data.

COMMUNITY CONSULTATION

- WA reported Newsletter and questionnaire had been distributed to the Manilla area. RB stated that responses to the questionnaire had been received in GHDs Sydney office and these are currently being reviewed.
- WA advised TRC is establishing the Floodplain Management Committee and is seeking representatives of the community to sit on the committee. Adverts seeking Expressions of Interest local residents to join the committee have been placed in local newspapers.
- The first Committee meeting is scheduled for 6 Oct 2011. The meeting noted this matter is urgent.
- RB stated community involvement through the Committee is fundamental in gaining the communities approval of the Study and ongoing Management Plans. Local knowledge of historical flood events greatly assists with calibration of the models and this knowledge can be utilized by 'running' these known events through the model and gaining Committee/community acceptance as to the accuracy of the model/s and confidence as to predicting future flood events.

..

4. CLIENT [TRC] INFORMATION

- GHD requested TRC to expedite the Areometrex information

.

5. DOCUMENTATION LISTING

GHD to prepare a list of deliverables and issue to TRC and integrate into the programme.

6. OTHER BUSINESS

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There being no further business the meeting closed at 11.00 a.m.

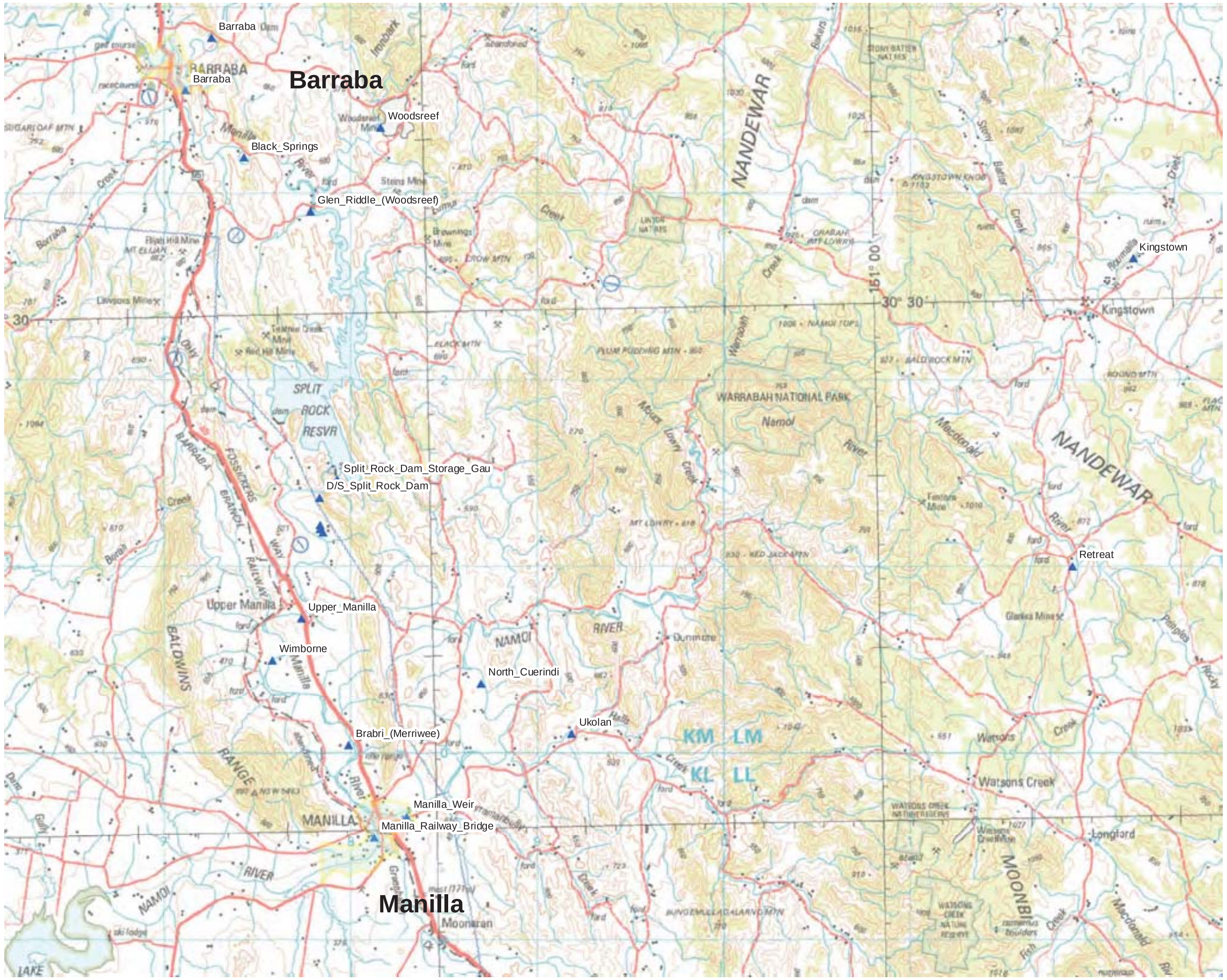
Next meeting to be advised.

Barraba & Manilla Floodplain Risk Management

FPMC Meeting

19/10/2011

Locations


Barraba Dam
Barraba
Barraba
Woodsreef
Black_Springs
Glen_Riddle_(Woodsreef)
Kingstown
Split_Rock_Dam_Storage_Gau
D/S_Split_Rock_Dam
Retreat
Upper_Manilla
Wimborne
North_Cuerindi
Ukolan
Brabri_(Merriwee)
Manilla_Weir
Manilla_Railway_Bridge
Manilla

Flood History

Manilla

- 1840
- Feb 1864 – drowned 4/12
- 1910
- Since 1941 (gauging start) – 16 minor, 3 moderate & 2 major floods
- Feb 1955 – major, highest since 1910
- Jan 1964 – major, worst in 100yrs
- 1971, 1984, 1998, 2004….

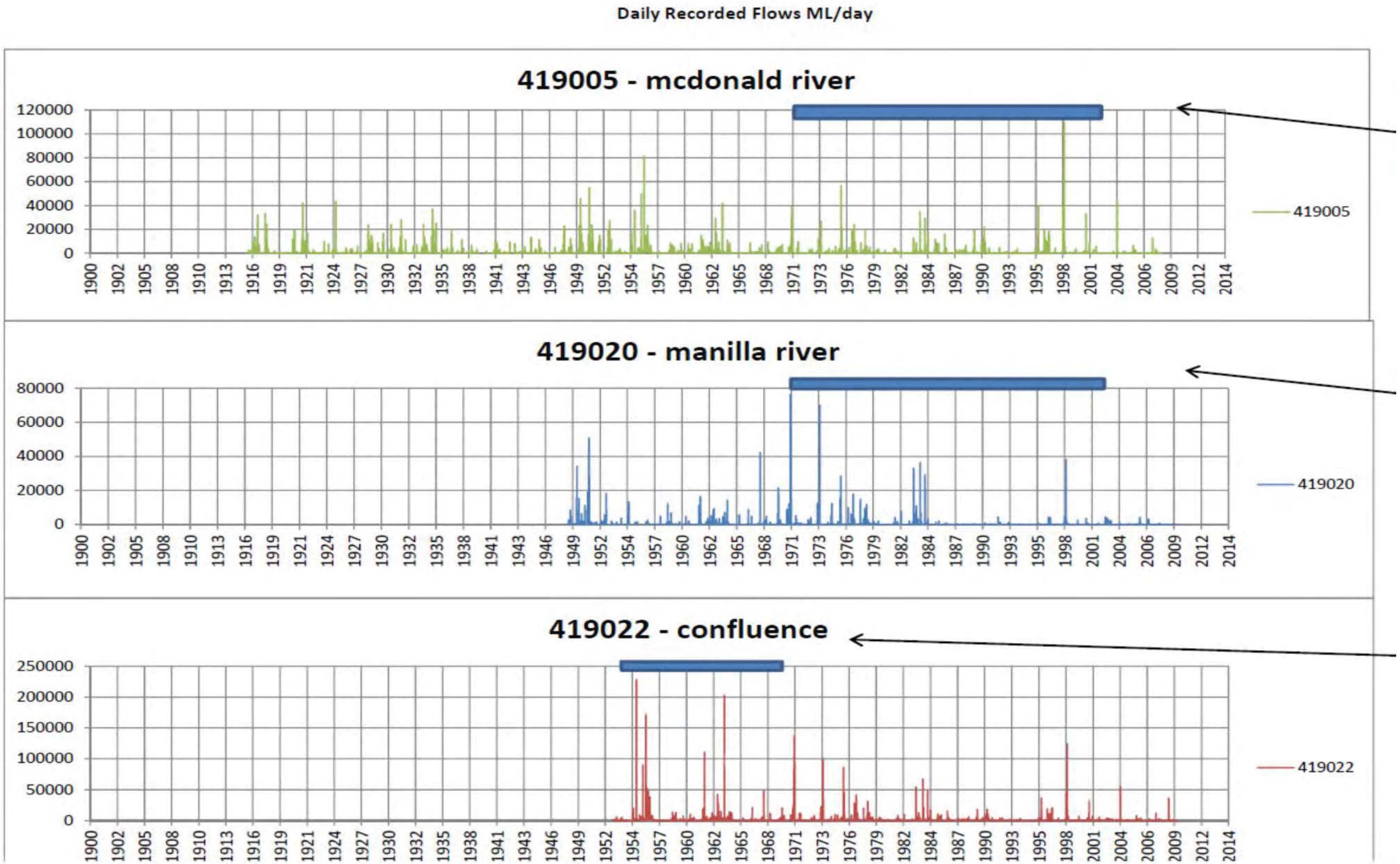
Barraba

- 1864
- 1964 – worst in 100yrs
- 1955
- 1971
- 1974, 1984, 1998, 2003, 2004

View from south, looking upstream, with showground in foreground

View from north, looking downstream the Namoi River

Manilla and Barraba Flood History



Floodplain Development Manual

the management of flood liable land

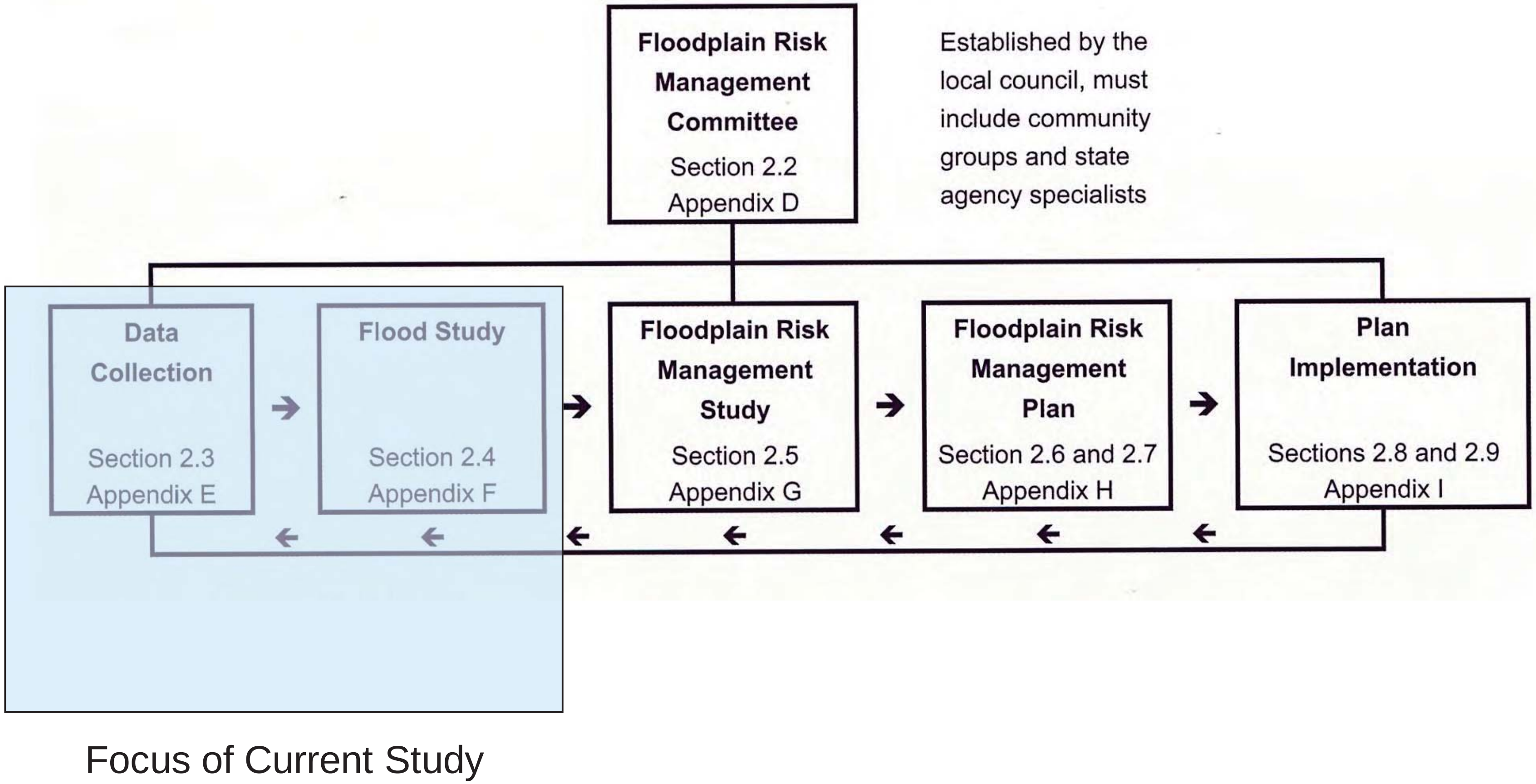
New South Wales Government

- Reduce the social and financial costs from the risks associated with occupying the floodplain;
- Increase the sustainable benefits of using the floodplain; and
- Improve or maintain floodplain ecosystems dependent on flood inundation.

3 types of Flood Risks

- **Existing flood risk**, associated with current development on flood prone land. For example, this may be the risk to existing development areas that can be effectively managed by the construction of a levee;
- **Future flood risk**, associated with any new development on flood prone land. For example, this may be the risk to future development areas that can be managed by adopting appropriate development limits, and minimum fill levels for lots and minimum floor levels for buildings; and
- **Continuing flood risk**, is the risk remaining, in both existing and future development areas. This is the risk from rarer floods which may result in levee overtopping or flooding of. The consequences of these rarer floods may include danger to personal safety and damages to infrastructure, and both public and private property.

Floodplain Risk Management Process



Floodplain Management Committee

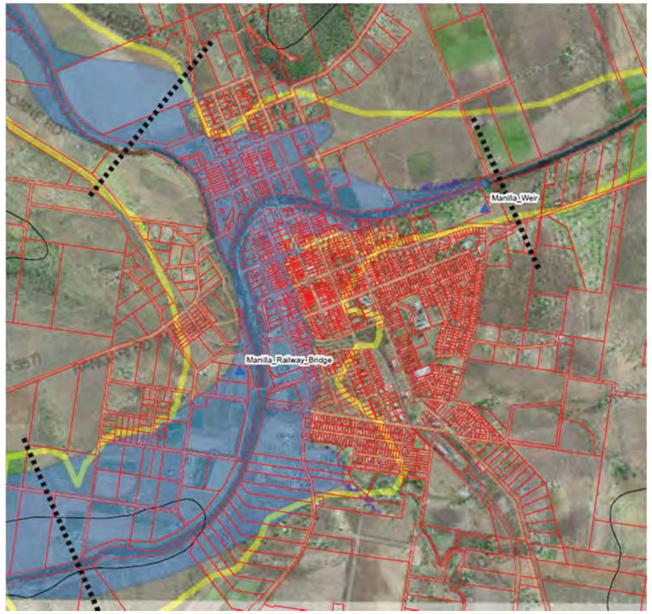
- Acts as both a focus and forum for the discussion of technical, social, economic, environmental and cultural issues and for the distillation of possibly differing viewpoints on these issues into a management plan
- Ensures that all stakeholders (often with competing desires) are equally represented. As such, the composition and roles of committee members are matters of key importance
- Does not have any formal powers. Rather, it has an advisory role, but an important one. The principal objective of the committee is to assist the Council in the development and implementation of a management plan for the area(s) under its jurisdiction

Flood Study - Key Tasks

- Obtain Survey
- Community Involvement and Input
- Calculate Flood Peaks & Hydrographs
- Calculate Flood Levels
- Provide Flood Mapping
- Undertake Flood Damage Assessments

Survey

- Currently underway
- Using photogrammetry
- Manilla being prioritised
- Bridge surveys done
- Barraba photogrammetry underway



Community Involvement

- Media Release
- Newsletter & Survey

For more information contact:

Lynne Clayton
Stakeholder Engagement
Manilla Flood Study
Reply Paid 83475
GHD, Level 15, 133 Castlereagh Street
Sydney NSW 2000
Facsimile – 02 9239 7199
Email – community.input@ghd.com.au

Project Information Line
1800 810 680 (free call)

Survey Returns

- Manilla - 92
- Barraba - 60

Tamworth Regional Council

ABN: 52 631 074 450
More than just a city. More than just one place.

Manilla Flood Study Survey

Name: MRS A. JENNER.

Address: 48 NAMOI STREET MANILLA 2346 N.S.W.

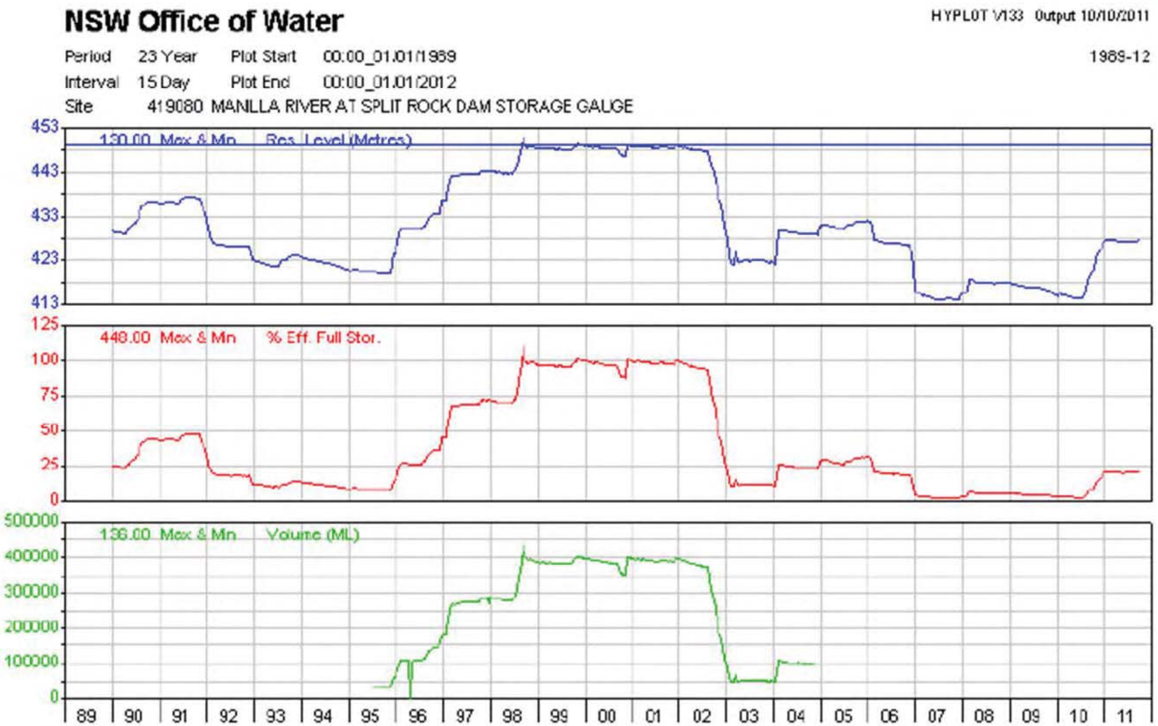
Telephone: 67851 474 Mob: ——

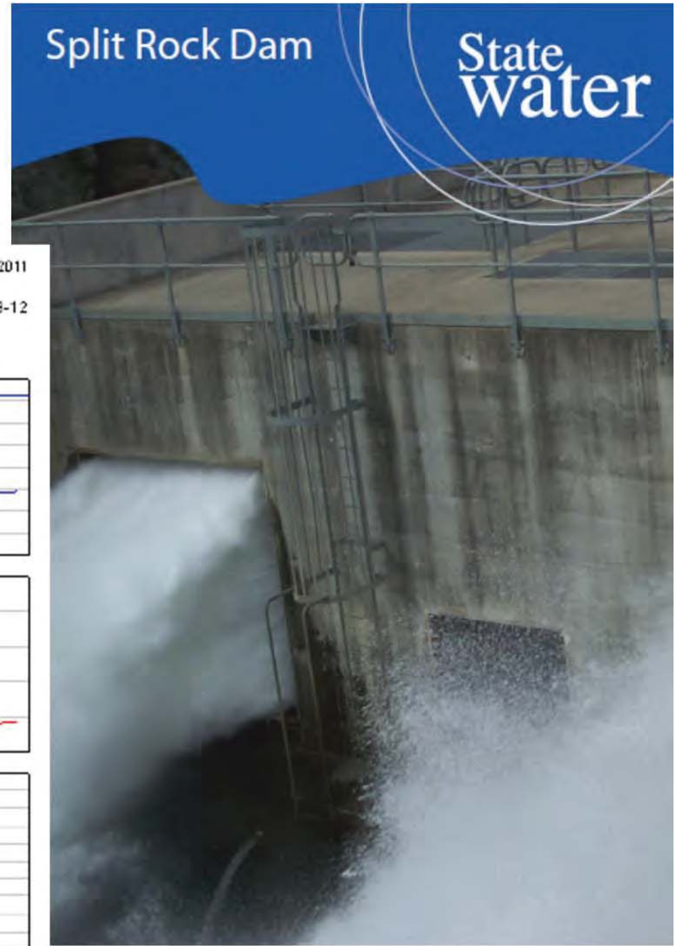
Please include my details in the stakeholder database to receive further information on the project ☐ *(Please tick)*

1. How long have you lived (or did you live) in Manilla? 80 Years 6 Months
2. Have you ever seen or experienced a flood while living in Manilla? Yes ☑ No ☐ *(Please tick)*
3. If yes, in what year/s did the floods take place?
   14TH JANUARY 1964
4. What effects did the flood have on you and your property?
   ~~[illegible]~~ DAMEAGED ALL FLOOR COVERINGS
5. How quickly do flood waters rise, and how long do flood waters pond, or do they drain rapidly?
   RISE QUICKLY.
   DRAIN AWAY QUICKLY.
6. Did you note any flood markers? (Flood markers could be lines on buildings that show the peak flood level during the flood event)
   MUDDY MARKS ON WALLS
7. How do you prepare for a flood?
   LIKE ANYONE ELSE WOULD.
6. Do you get isolated in a flood and is your property access restricted by flood waters?
   ONLY, THE ONCE
7. Are there any other issues you would like us to take into consideration?
   DON'T WANT TO SEE ANY. MORE

Thank you for taking the time to complete this survey.
Your feedback is invaluable in assisting the project team.

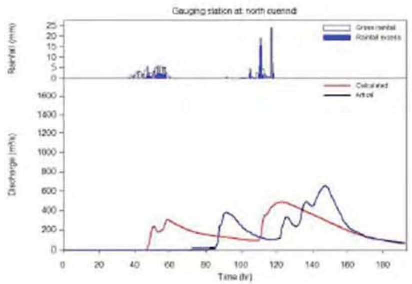
Split Rock Dam

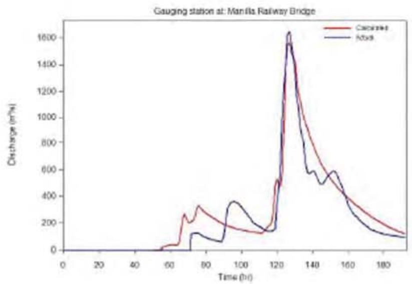


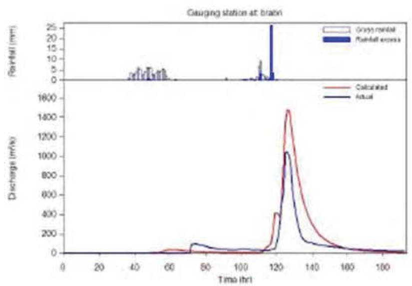


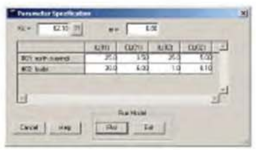
Flood Peaks & Hydrographs

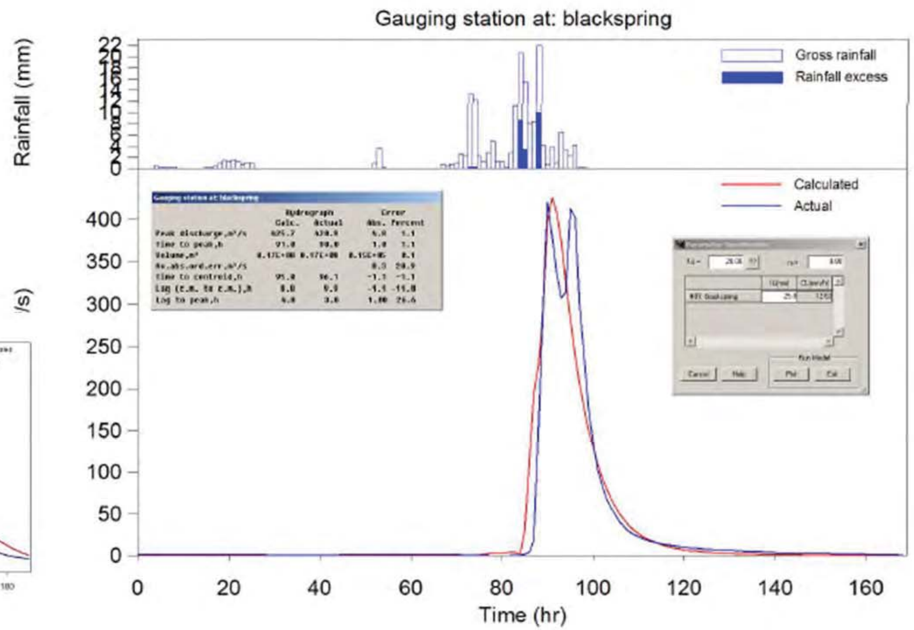
- Compile Rainfall / Runoff model
- Calibrate Rainfall / Runoff Model







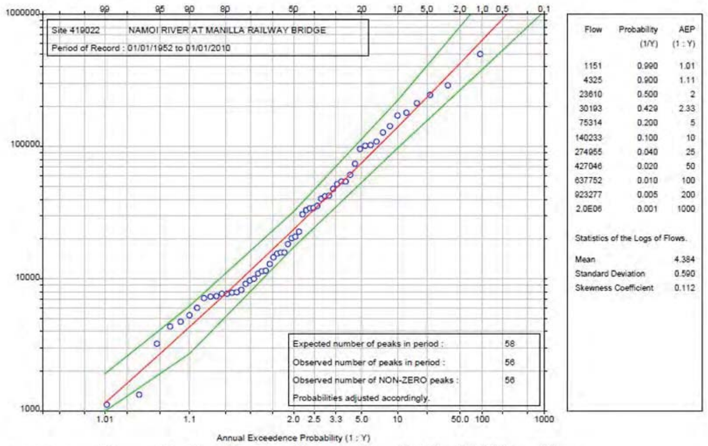


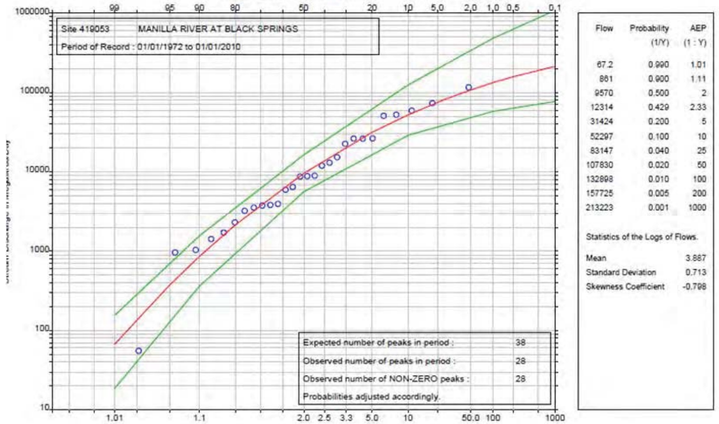


Flood Levels & Maps

- Compile Flood Level model
- Calibrate Flood Level model
- Simulate Flood Level Model
- Produce Flood Mapping

Example
Only



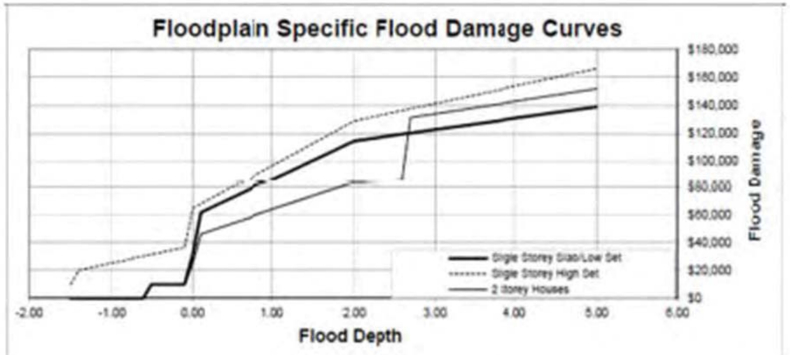


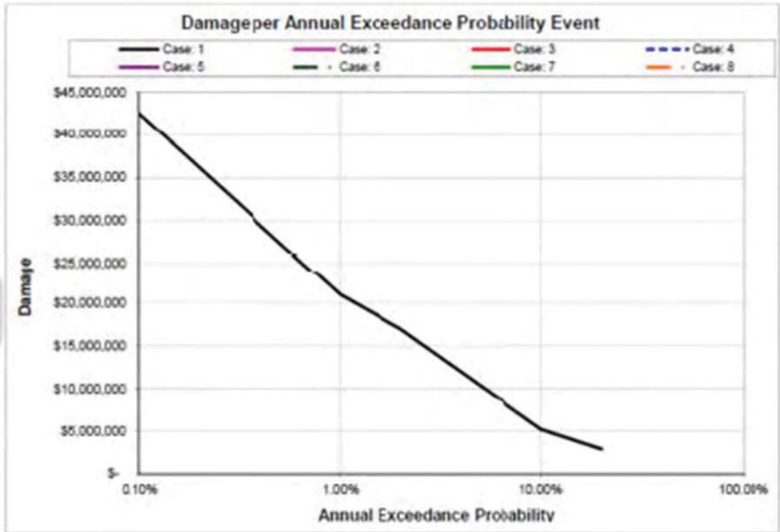
100yr Barraba approx 1000m3/s
100yr Manilla approx 7400m3/s

Assessment - Flood Damage

- AAD $????? million
- NPV over 20-years $??? million

Flood Event	Number of Dwellings Inundated
5-year	4
10-year	10
50-year	146
100-year	186
PMF	335





Floodplain Management Options

Floodplain Management Options

Property Modification

- Land Use Planning.
- House raising or Flood Proofing of Buildings.
- Voluntary Purchase of High Hazard Properties

Response Modification

- Flood Warning Systems and Evacuation Plans.
- Flood Insurance and Recovery.
- Public Flood Awareness Scheme

Flood Modification

- Flood Mitigating Dams or Detention Basins.
- Levees.

Assessment of Options

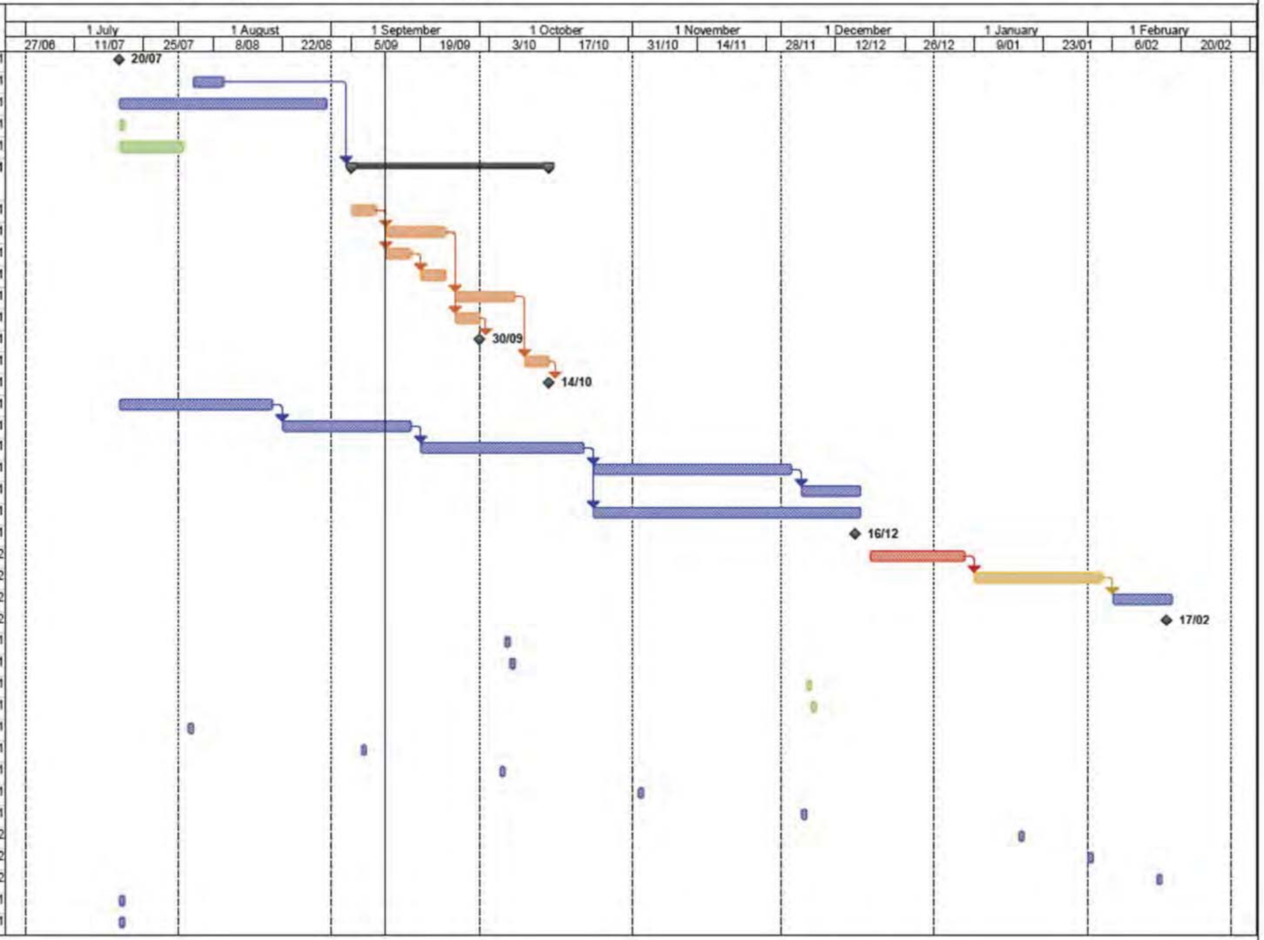
Category	Issues
Social	◗ The capacity of the option to reduce flood hazards and personal safety risks to the community, ◗ How the option will influence property values; ◗ The capacity of the option to promote community growth; and ◗ The level of disruption to the community, either through implementing the option or through the resulting floodplain behaviour.
Economic and Financial	◗ The capital costs associated with implementing the option; ◗ The ongoing or maintenance costs of the option; and ◗ The costs or savings of flood damage after the option is implemented.
Environmental	◗ Change to ecology, habitats, riparian vegetation, and the “natural state” of the river; ◗ Pollution; ◗ Energy and resources required to implement the option; and ◗ Energy and resources required for maintaining and decommissioning the option.

Progress

Tamworth Regional Council

Project Program - Manilla and Barraba Flood Studies

ID	Task Name	Duration	Start	Finish
1	Inception meeting	0 days	Wed 20/07/11	Wed 20/07/11
2	Site Visit	4 days	Thu 4/08/11	Tue 9/08/11
3	Data Collection and Review	6 wks	Wed 20/07/11	Tue 30/08/11
4	Set-up of communication mechanisms	0.2 wks	Wed 20/07/11	Wed 20/07/11
5	Questionnaire Survey, Newsletter, Media	1.8 wks	Wed 20/07/11	Mon 1/08/11
6	**Survey (Baxter Geo Consulting and Axiometrex)**	**30 days**	**Mon 5/09/11**	**Fri 14/10/11**
7	Manilla and Barrab Controls (PB)	5 days	Mon 5/09/11	Fri 9/09/11
8	Process Manilla Data (Areometrex)	10 days	Mon 12/09/11	Fri 23/09/11
9	Additional Survey Manilla (PB)	5 days	Mon 12/09/11	Fri 16/09/11
10	Additional Survey Barraba (PB)	5 days	Mon 19/09/11	Fri 23/09/11
11	Process Barraba Data (Aerometrix)	10 days	Mon 26/09/11	Fri 7/10/11
12	Finalise Manilla (PB/Aerometriex)	5 days	Mon 26/09/11	Fri 30/09/11
13	Complete Manilla DTM	0 days	Fri 30/09/11	Fri 30/09/11
14	Finalise Barraba (PB/Areometrex)	5 days	Mon 10/10/11	Fri 14/10/11
15	Complete Barrab DTM	0 days	Fri 14/10/11	Fri 14/10/11
16	Hydrology - RORB Model setup (M & B)	4.6 wks	Wed 20/07/11	Fri 19/08/11
17	Hydrology - RORB Model Calibration (M & B)	4 wks	Mon 22/08/11	Fri 16/09/11
18	Hydraulics - Manilla	5 wks	Mon 19/09/11	Fri 21/10/11
19	Hydraulics - Barraba	6 wks	Mon 24/10/11	Fri 2/12/11
20	Flood Damage Costs	2 wks	Mon 5/12/11	Fri 16/12/11
21	Draft Flood Study Reports	8 wks	Mon 24/10/11	Fri 16/12/11
22	Milestone 2 - Delivery of Draft Reports	0 days	Fri 16/12/11	Fri 16/12/11
23	Christmas Break	15 days?	Mon 19/12/11	Fri 6/01/12
24	Council review of Flood Study Reports	4 wks	Mon 9/01/12	Fri 3/02/12
25	Final Flood Study Reports Including Printing	2 wks	Mon 6/02/12	Fri 17/02/12
26	Milestone 3 - Delivery of Final Report	0 days	Fri 17/02/12	Fri 17/02/12
27	Manilla - Floodplain Management Committee	1 day?	Thu 6/10/11	Thu 6/10/11
28	Barraba - Floodplain Management Commitee	1 day?	Fri 7/10/11	Fri 7/10/11
29	Community Workshop - Barraba	1 day	Tue 6/12/11	Tue 6/12/11
30	Community Workshop - Manilla	1 day	Wed 7/12/11	Wed 7/12/11
31	Meeting 1	1 day?	Wed 3/08/11	Wed 3/08/11
32	Meeting 2	1 day?	Wed 7/09/11	Wed 7/09/11
33	Meeting 3	1 day?	Wed 5/10/11	Wed 5/10/11
34	Meeting 4	1 day?	Wed 2/11/11	Wed 2/11/11
35	Meeting 5	1 day?	Mon 5/12/11	Mon 5/12/11
36	Meeting 6	1 day?	Wed 18/01/12	Wed 18/01/12
37	Meeting 7	1 day?	Wed 1/02/12	Wed 1/02/12
38	Meeting 8	1 day?	Wed 15/02/12	Wed 15/02/12
39	Meeting 9 - TBC	1 day?	Wed 20/07/11	Wed 20/07/11
40	Meeting 10 - TBC	1 day?	Wed 20/07/11	Wed 20/07/11



www.ghd.com

TAMWORTH REGIONAL COUNCIL
MANILLA FLOOD STUDY
FLOODPLAIN RISK MANAGEMENT COMMITTEE

INAUGRAL MEETING
MINUTES

1.00pm Thursday 20 October 2011
Ray Walsh House, Peel Street Tamworth

Attendees

Neal Albert	[NA]	Office of Environment and Heritage
Andrew Galvin	[AG]	State Emergency Services
Dr Rainer Berg	[RB]	GHD
Peter Resch	[PR]	Tamworth Regional Council (TRC)
Graeme McKenzie	[GM]	TRC
William Ash	[WA]	TRC
Tom Baxter	[TB]	TRC [part time]

Apologies

Andrew Falkenmire	[AF]	Office of Environment and Heritage
Murray Russell	[MR]	TRC
Ray Tait	[RT]	TRC (detained on Council business)

Item 1 Introduction

WA opened the Inaugral Floodplain Risk Management Committee meeting noting those attending and apologies.

WA stated there had been a lack of response from residents of Manilla to sit on the Floodplain Risk Management Committee [Committee] despite newspaper advertisements inviting locals to apply and direct approach to specific individuals. Therefore Manilla community was not represented at this meeting.

RB stated a broad representation and community involvement through the Committee is fundamental in gaining the communities approval of the Study and ongoing Management Plans. Local knowledge of historical flood events greatly assists with calibration of the models and this knowledge can be utilized by 'running' these known events through the model/s, gaining Committee/community acceptance as to the accuracy of the model/s and a level of confidence as to predicting future flood events.

The Committee agreed that local representation is essential to the ultimate success of the Study in particular the Risk Management Plan and a number of actions to secure local members were canvassed including the drafting of TRC staff from the area and contact with the local Community Development Committees.

The meeting agreed that TRC Planning Department is to be represented on the Committee.

GM/WA to action.

Item 2. Election of Committee Chairman

The meeting proposed that RT be approached to Chair the Committee.

Following this proposal PR contacted RT by telephone. RT agreed to Chair the Committee. The Committee confirmed RT as its Chairman.

The Committee has no formal powers and acts as a forum for the discussion and over viewing of the reports and dissemination of information from the studies findings to the community and other interested parties.

It is important that all stakeholders be equally represented.

Matters for discussion include the technical, social, environmental, economic and cultural impacts of flooding in the areas the subject of the study.

Item 3 Address by Dr Rainer Berg outlining the process, procedures and objectives of Flood Studies in flood prone areas.

RB addressed the Meeting with an overhead presentation providing an overview of the process, procedures and objectives of Flood Studies generally and how these applied specifically to both Manilla and Barraba.

RB has provided an electronic copy of the presentation. This is being forwarded to all Committee members as an attachment to these minutes.

RB explained the structure of both Manilla and Barraba Flood Studies was based on and in accordance with the NSW Government Floodplain Management Manual [Manual] with the functions and status of the Committee being detailed in Appendix D.

RB stated the work being undertaken by GHD in its current commission is defined in the Manual in Section 2.3 Data Collection and Section 2.4 Flood Study.

The Study examines from historic events the existing and future flood risk to the subject area and the information gained is incorporated into the Floodplain Risk Management Plan and its implementation.

Item 4. Report on current status of Manilla Flood Study and programme to completion of the Flood Study phase.

RB provided a status report on the progress of the Manilla Flood Study using the Gantt Chart Programme as the demonstration tool and briefed the Committee on information gained to date including historical events and Progress against the programme.

The salient points are:-

- The major flood events in Manilla since the commencement of river gauging as measured from the gauging stations were in 1955, 1962, 1964 [worst in 100 years] 1971, 1984, 1998 and 2004.

  RB stated that information from the river gauges varied in content and usefulness depending on the length of time they had been in operation and the frequency of data collection. Only a small number of gauges provide sufficient data to assist with accurate modelling. A log of flood records from a number of river gauges was included in GHDs presentation.

- The major flood impact on Manilla is downstream of the confluence of the Manilla and Namoi Rivers and Greenhatch Creek.

- A site visit in concert with the ground survey team determined the general topography of the area including vegetation and flood channels.

- From discussions with TRCs GIS operators and on-site observations the Survey Brief was confirmed as providing sufficient accurate information to build the models.

- In respect of flood damage assessment it is essential for each property deemed to be subject to flooding to have accurate information to determine the type of property [residential, commercial, industrial], type of construction and the height of the potential flood over the property using the PMF + 0.5m. The number of properties requiring floor levels to be determined for damage calculations have been estimated from previous events and projecting to PMF =0.5m
- PB reported survey control points have been established. These are being utilized to calibrate the existing aerial survey information. Areometrex 'holes' will be filled in and 'rough' contours established.
- PB reported that structures affected by flooding i.e. bridges and culverts will be surveyed next week and information 'fed' into the models.
- PB included record of water levels in Split Rock Dam and noted that the last major flood in 1998 coincided with high levels of water in the dam. Since the dam has lower levels [2003/2004 on] no major flooding has occurred. The hydraulic models will take the dam and its effect on Manilla flooding into consideration.
- PB stated response from the community to the questionnaire had been good and the information provided processed for use in developing the models.
- RB has previously stated RORB model set up and GHD will develop the model then, using hydraulic information including Frequency Analysis and measurements of events in creeks, compare the actuals to the results of the model. The model will then be calibrated against a number of recorded historical and observed flood peaks using river gauging stations and historical flood levels as benchmarks. Complete survey information is not essential in finalising the construction of this model. RB reported Hydrology model has been built and calibration is in train using information from previous rain and flood events and records from flow gauges for calibration. RB stated GHD has a good understanding of flows from historical records providing basic information on the magnitude of flows. The model will replicate rainfall events to match what happens in the waterways. The objective is to have the model able to replicate what actually happens in real terms.

- RB stated OEH has approved the use of the TUFLOW model for the hydraulics as meeting its [OEHs] criteria.
- Construction and accuracy of the Hydraulic Model is dependant on the provision of correct survey information. PB confirmed the model is TUFLOW and GHD will build a substantial part of the model using form lines then replace the data with the more accurate DTM when this became available. PB stated GHD had commenced the Model using current data. Model completion is dependant on finalisation of field survey and correlation with areometrex.

4.1 Survey

- RB/PB confirmed Site Information will include ground and creek levels and properties at risk locations and floor levels.
- NA raised the matter of Quality Assurance in respect of survey citing problems with previous ariel survey information provided to OEH and noted that survey information gathered during the Flood Studies is required for use by NSW Government and therefore the need for accuracy is paramount.
- Thomas Baxter was invited to brief the Meeting on how QA of the survey information could be effected. TB stated that from previous experience LPI

was not ‘geared’ to QA the form of information being obtained by the systems used on this project but he would contact the LPI to investigate if that organisation could assist with QA. In the absence of LPI assistance GHD to investigate how the survey information can be subjected to QA.

The accuracy stated for areometrex as +/- 150mm is to be confirmed.

Item 5 Community Consultation

- RB stated that responses to the questionnaire had been received in GHDs Sydney office and the information contained is being processed and incorporated into the Study Data.
- As stated above there has been a lack of response from residents of Manilla to sit on the Committee despite newspaper advertisements and direct approach to specific individuals inviting locals to apply to be involved in the process.
- The Committee agreed that local representation is essential to the ultimate success of the Study in particular the Risk Management Plan and a number of actions to secure local members were identified including the drafting of TRC staff from the area and contact with the local Community Development Committees.
- RB proposed that the public meeting at Manilla be held on or about 7 December 2011. The Meeting concurred and TRC is to convene.

Item 6 Discussion on format, presentation and release of Study findings in Final Report

Report will comply with standards and format described in the Floodplain Risk Management Plan.

Item 7 Discussion on actions post Flood Study Final Report

Following acceptance of the Flood Study Final Report the actions will Comply with the Flow Chart as contained in Appendix C of the Floodplain Risk Management Plan.

Item 8 General business

There being no further business the Meeting closed at 2.30pm

Next Meeting: to be advised.

NEWSPAPER INSTRUCTIONS
REGIONAL COUNCIL NEWS ADS

PAPER	TO APPEAR (DATE)	JOB NUMBER	AUTHORISED BY
MANILLA EXPRESS	TUESDAY 13 DECEMBER 2011	AUF010-1598-400	BILL ASH

MANILLA FLOOD STUDIES – COMMUNITY INFORMATION SESSION

Tamworth Regional Council has engaged consultants to carry out the Manilla Flood Study, to define flooding in Manilla and inform Council's planning for the management of flooding.

Residents who have questions about the study, or who have been affected by flooding previously, are invited to a Community Information Session being held at 6.00pm, 14 December at the Manilla Town Hall.

Should you have any enquiries about the information session or the flood study, please contact William Ash, Senior Engineer, on 6767 5738 or 0417 964 972.

Churches of Manilla and Barraba. The program covers a variety of activities, these include: Surfing/Swimming, Sand Modelling, Talks by the guest speaker Rev. Chris Brennan of Glen Innes, Discussion Groups, Music and Competitions. There is an Extreme Team Challenge and many other things to do. Registration Forms have been distributed, but for anyone wanting more detailed information please contact one of the following: John Barwick phone 6785 1251, Robert Bowman 6785 7315, Rev. Vince Wall 6785 1627, Joe or Estelle McDonald 67697569.

XMAS LIGHTS REMINDER

A reminder that entries in the 2011 Christmas Lights competition close this Friday, 16th December. Entry form is published on page 5 of today's paper. Enter and you could be in the running for $400 worth of Coles Myers vouchers courtesy of Essential Energy.

ENGAGED

Di and Rod Taylor are delighted to announce that Bede and Nicole are engaged.

5 DAY WEATHER FORECAST

Wednesday - 12 to 24, partly cloudy.

Thursday - 12 to 23, possible afternoon shower.

Friday - 12 to 27, partly cloudy.

Saturday - 13 to 27, partly cloudy.

Sunday - 15 to 25, shower or two.

DAM LEVELS

Keepit: Storage 407,318 megalitres, 95.7 percent of capacity average discharge 3,631 megalitres per day. **Split Rock:** Storage 161,122 megalitres, 40.3 percent of capacity, discharge 10 megalitres per day.

Tamworth Regional Council
ABN: 52 631 074 450
More than just a city. More than just one place.

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NEWSPAPER INSTRUCTIONS
REGIONAL COUNCIL NEWS ADS

PAPER	TO APPEAR (DATE)	JOB NUMBER	AUTHORISED BY
BARRABA GAZETTE	WEDNESDAY 14 DECEMBER 2011	AUD085-1598	BILL ASH

BARRABA FLOOD STUDIES – COMMUNITY INFORMATION SESSION

Tamworth Regional Council has engaged consultants to carry out the Barraba Flood Study, to define flooding in Barraba and inform Council's planning for the management of flooding.

Residents who have questions about the study, or who have been affected by flooding previously, are invited to a Community Information Session being held at 6.00pm, 15 December at the Barraba Council Chambers.

Should you have any enquiries about the information session or the flood study, please contact William Ash, Senior Engineer, on 6767 5738 or 0417 964 972.

...orations. Come along evening.

THE BARRABA GAZETTE & CHRISTMAS

December publishing dates for the Gazette are:

Wednesday 7th, 14th, 21st December

The final paper for the year, 21st December, will include our traditional Business House "Christmas Wish" section. Anyone wishing to place a advertisement in this section of the paper is asked to contact the Gazette Office before Thursday, 15th December.

The first paper for 2012 will be published on Wednesday 18th January.

... Community Inc is planning a meeting late January to begin the planning for Frost over Barraba. A notice for this meeting will be in the first Gazette of the new ... Barraba Artisans and Farmers' Market or Frost Over Barraba, please contact Helen Birt, BCI Publicity Officer, Ph 6782 1857 or email helen.birt@bigpond.com

Shop Locally And Save!

Tamworth REGIONAL COUNCIL

ABN: 52 631 074 450

More than just a city. More than just one place.

BARRABA FLOOD STUDIES – COMMUNITY INFORMATION SESSION

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NEWSPAPER INSTRUCTIONS
REGIONAL COUNCIL NEWS ADS

PAPER	TO APPEAR (DATE)	JOB NUMBER	AUTHORISED BY
NORTHERN DAILY LEADER	SATURDAY 10 DECEMBER 2011	AUD085-1598	BILL ASH

BARRABA FLOOD STUDIES – COMMUNITY INFORMATION SESSION

Tamworth Regional Council has engaged consultants to carry out the Barraba Flood Study, to define flooding in Barraba and inform Council's planning for the management of flooding.

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NEWSPAPER INSTRUCTIONS
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PAPER	TO APPEAR (DATE)	JOB NUMBER	AUTHORISED BY
NORTHERN DAILY LEADER	SATURDAY 10 DECEMBER 2011	AUF010-1598-400	BILL ASH

MANILLA FLOOD STUDIES – COMMUNITY INFORMATION SESSION

Tamworth Regional Council has engaged consultants to carry out the Manilla Flood Study, to define flooding in Manilla and inform Council's planning for the management of flooding.

Residents who have questions about the study, or who have been affected by flooding previously, are invited to a Community Information Session being held at 6.00pm, 14 December at the Manilla Town Hall.

Should you have any enquiries about the information session or the flood study, please contact William Ash, Senior Engineer, on 6767 5738 or 0417 964 972.

You're Invited... COUNCIL MEETING

The public is invited to attend Council's DECEMBER Meeting as under:

Meeting	Day	Date	Time	Venue
Ordinary Council	Tuesday	132 December 2011	6.30pm	Council Chambers 4th Floor Ray Walsh House 437 Peel Street Tamworth

Community Consultation: Members of the public may address the Council on matters and issues listed in the Business Paper. Each speaker addressing the Council Meeting will be allowed three minutes.

Members of the public giving prior notification to Council's Administration Staff by 12 noon on the day of the Meeting of their intention to address the Council Meeting will be given priority.

Council's Administration Staff will be pleased to assist with enquiries – telephone 6767 5444 during normal business hours.

Business Papers are available from:

Friday afternoon prior to meeting date on Tamworth Regional Council Website www.tamworth.nsw.gov.au/Council OR

Monday Morning prior to Meeting for collection from Tamworth Regional Council Customer Services Counter at Barraba, Manilla, Nundle or Tamworth Offices and available at the Meeting at Tamworth.

PART CLOSURE OF TAMWORTH REGIONAL COUNCIL THURSDAY 15 DECEMBER 2011

Please be advised that all Tamworth Regional Council Offices and Facilities will be closed due to a Council Function as under:

Barraba Office will close on Thursday 15 December 2011 at 12:00pm
Manilla Office will close on Thursday 15 December 2011 at 12:00pm
Nundle Office will close on Thursday 15 December 2011 at 12:00pm
Tamworth Office will close on Thursday 15 December 2011 at 12:00pm

The following services will remain open to the public during normal operating hours for each facility:

Tamworth Airport/Kiosk, Basil Brown Drive, Tamworth
All Waste Depots which would be normally open
Recycling Centres
All Swimming Pool Complexes
Marsupial Park Endeavour Drive, Tamworth
Botanic Gardens, Piper Street, Tamworth
East Year Round Care, Tamworth Public School, Napier Street, Tamworth
South Year Round Care, Hillvue Public School, Tamworth
Community Centre, Darling Street, Tamworth
South Library, Robert Street, Tamworth
Library/Regional Gallery, Peel Street, Tamworth
Tamworth Sports Dome

For Emergency please phone 1300 733 625

BARRABA FLOOD STUDIES – COMMUNITY INFORMATION SESSION

Tamworth Regional Council has engaged consultants to carry out the Barraba Flood Study, to define flooding in Barraba and inform Council's planning for the management of flooding.

Residents who have questions about the study, or who have been affected by flooding previously, are invited to a Community Information Session being held at 6.00pm, 15 December at the Barraba Council Chambers.

Should you have any enquiries about the information session or the flood study, please contact William Ash, Senior Engineer, on 6767 5738 or 0417 964 972.

MANILLA FLOOD STUDIES – COMMUNITY INFORMATION SESSION

Tamworth Regional Council has engaged consultants to carry out the Manilla Flood Study, to define flooding in Manilla and inform Council's planning for the management of flooding.

Residents who have questions about the study, or who have been affected by flooding previously, are invited to a Community Information Session being held at 6.00pm, 14 December at the Manilla Town Hall.

Should you have any enquiries about the information session or the flood study, please contact William Ash, Senior Engineer, on 6767 5738 o
0417 964 972.

EXHIBITION OF A DEVELOPMENT APPLICATION

Notice is hereby given that a Development Application has been submitted to Council by Hibbards Pty Limited - Tamworth for Constructio of a Single Storey Detached Dual Occupancy and Torrens Title Subdivision into two lots on Lot 134 DP 1153123, 4 Red Cedar Cove, Oxley Vale.

The application and accompanying plans will be exhibited in Council's Customer Services Section, Ray Walsh House, Peel Street, Tamworth, between 8.30am and 5.00pm, Monday to Friday, for a period of 14 days from Monday, 12 December 2011.

If you wish to advise Council of your views on the proposal, you should prepare a written submission, to be made prior to 5.00pm on Tuesday, 3 January 2012. Please Note: The exhibition period has been extended due to its coincidence with the festive season and Council offices being closed from Friday 23 December 2011 to Monday 2 January 2012 inclusive. The issues you raise will be included in the evaluation of the development application, along with the other matters Council must consider. Any submissions **must** include disclosure of any reportable political contribution or gift made in the previous two years.

It should be noted that you may request that your name and address not be disclosed (by stating prominently "OBJECTION IN CONFIDENCE" on your submission) for reason that disclosure would result in detriment to you, however, Council may be obliged to release details of your complaint excluding your personal information under the Government Information (Public Access) Act 2009 even if these words are used in the submission. Further, submissions that do not contain the author's name and address may not be considered as Council will be unable to validate their authenticity.

EXHIBITION OF A DEVELOPMENT APPLICATION

Notice is hereby given that a Development Application has been submitted to Council by Ms S Moore for the establishment of a Function Centre in the existing Wine Cellar on Lot 200 DP 1040669, 80 Wyndham Close, Daruka.

The application and accompanying plans will be exhibited in Council's Customer Services Section, Ray Walsh House, Peel Street, Tamworth, between 8.30am and 5.00pm, Monday to Friday from Monday, 12 December 2011.

If you wish to advise Council of your views on the proposal, you should prepare a written submission, to be made prior to 5.00pm on Monday, 9 January 2012. Please note, the exhibition period has been extended as Council offices will be closed for the Christmas New Year period from 26 December 2011 to 2 January 2012.

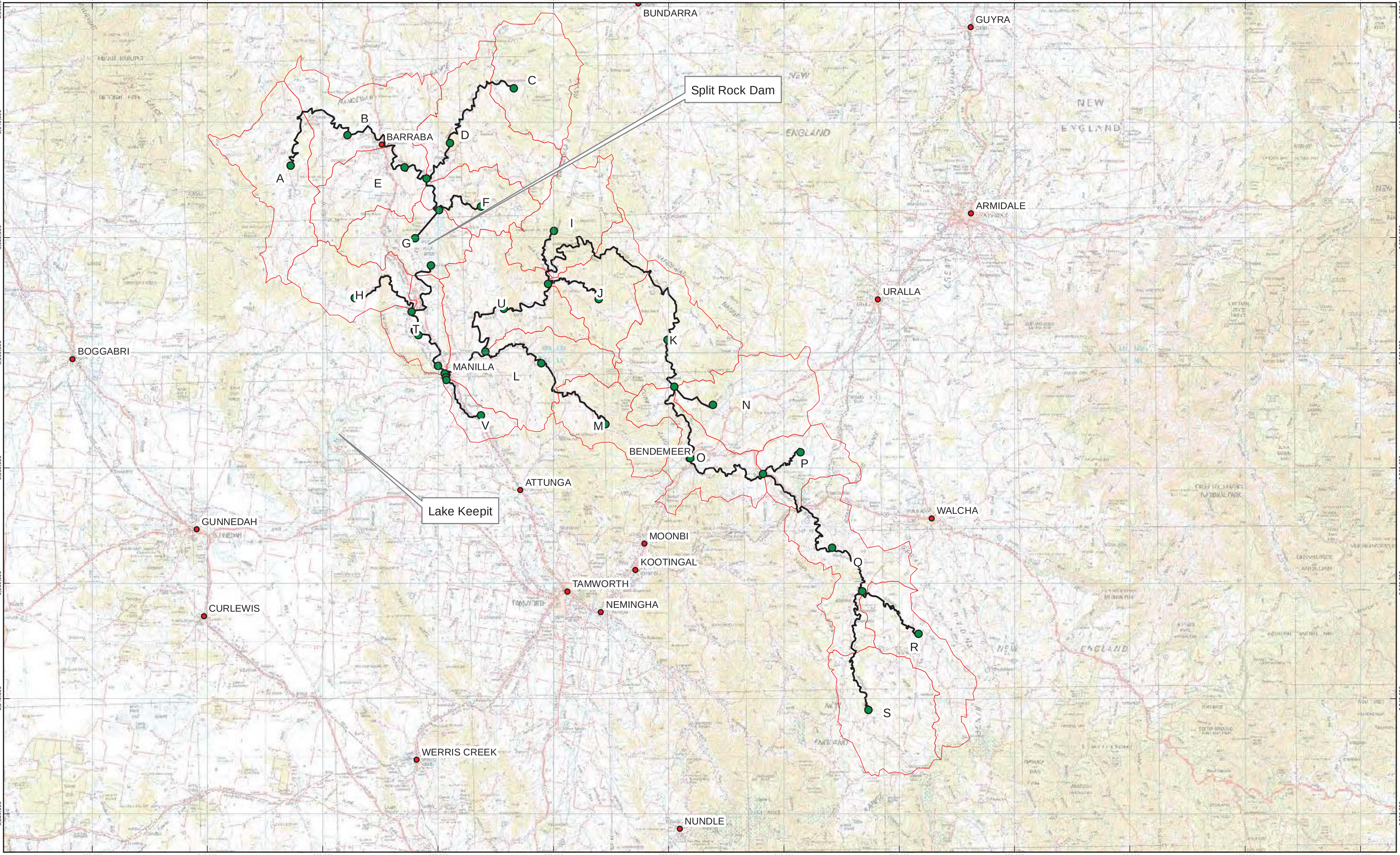
The issues you raise will be included in the evaluation of the development application, along with the other matters Council must consider. Any submissions must include disclosure of any reportable political contribution or gift made in the previous two years.

It should be noted that you may request that your name and address not be disclosed (by stating prominently "OBJECTION IN CONFIDENCE" on your submission) for reason that disclosure would result in detriment to you, however, Council may be obliged to release details of your complaint excluding your personal information under the Government

Northern Daily Leader 10 Dec 11

Appendix D

Hydrological Data (RORB)



1:600,000

0 1.5 3 6 9 12 15

Kilometres (at A3)

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

LEGEND

- RORB Nodes
- RORB Reaches
- RORB SubAreas

Tamworth Regional Council
Manilla and Barraba Flood Study

Job Number	22-15815/16
Revision	A
Date	17 Jan 2012

RORB Model Catchments

Figure D.1

G:\14\0102799\FINAL TEMPLATES\Rev 001\ArcGIS\GHD-A3-LANDSCAPE.mxt

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by: C Pappin

10 Bond Street Sydney NSW 2000 Australia T 61 2 9239 7000 F61 2 9239 7199 E sydmail@ghd.com.au W www.ghd.com.au

```
Manilla - 1
C RORB_GE 6.15
C WARNING - DO NOT EDIT THIS FILE OUTSIDE RORB TO ENSURE BOTH GRAPHICAL AND
CATCHMENT DATA ARE COMPATIBLE WITH EACH OTHER
C THIS FILE CANNOT BE OPENED IN EARLIER VERSIONS OF RORB GE - CURRENT
VERSION IS v6.15
C
C Manilla - 1
C
C #FILE COMMENTS
C   2
C File created using MiRORB version 1.1
C Original CATG file created on 9/01/2012 at 13:41:39
C
C #SUB-AREA AREA COMMENTS
C   1
C Sub-area areas in km2
C
C #IMPERVIOUS FRACTION COMMENTS
C   0
C
C #BACKGROUND IMAGE
C  T  F G:\22\15815\Tech\RORB\MANILLA 2012.12.11\MANILLA.wmf
C
C #NODES
C     36
C      1         28.658         76.977          1.000 1 0     2 A
302.925          0.050  0  0
C
C      2         32.664         80.584          1.000 1 0     5 B
286.801          0.050  0  0
C
C      3         44.440         86.087          1.000 1 0     4 D
318.750          0.050  0  0
C
C      4         39.915         79.656          1.000 1 0    23 E
223.710          0.050  0  0
C
C      5         36.716         76.791          1.000 1 0    23 C
263.621          0.050  0  0
C
C      6         42.116         72.152          1.000 1 0    33 F
159.620          0.050  0  0
C
C      7         37.467         68.406          1.000 1 0    33 G
197.882          0.050  0  0
C
C      8         33.185         61.391          1.000 1 0    34 H
186.251          0.050  0  0
C
C      9         47.280         69.282          1.000 1 0    29 Q
245.543          0.050  0  0
C
C     10         50.448         61.234          1.000 1 0    29 R
213.004          0.050  0  0
C
C     11         55.307         56.426          1.000 1 0    29 P
293.431          0.050  0  0
C
C     12         46.395         53.674          1.000 1 0    30 U
```

```
283.554          0.050  0  0
C
C     13         50.924         46.493          1.000 1 0    12 T
200.163          0.050  0  0
C
C     14         58.526         48.768          1.000 1 0    28 O
296.263          0.050  0  0
C
C     15         56.930         42.484          1.000 1 0    28 N
222.554          0.050  0  0
C
C     16         64.719         43.186          1.000 1 0    32 M
147.063          0.050  0  0
C
C     17         66.945         31.941          1.000 1 0    32 L
297.055          0.050  0  0
C
C     18         73.054         21.771          1.000 1 0    31 K
229.875          0.050  0  0
C
C     19         69.511         12.824          1.000 1 0    31 J
317.994          0.050  0  0
C
C     20         37.682         56.988          1.000 1 0    25 I
132.507          0.050  0  0
C
C     21         43.737         60.091          1.000 1 0    30 S
326.950          0.050  0  0
C
C     22         38.570         65.218          1.000 0 0    34 G1
0.000          0.000  0  1
C
C outlet node for storage
C     23         38.263         75.470          1.000 0 0    33 F1
0.000          0.000  0  1
C
C confluence of ironbark creek, manilla river
C     24         39.547         52.473          1.000 0 0    27 T1
0.000          0.000  0  1
C
C confluence at manilla
C     25         39.074         53.360          1.000 0 0    24 T2
0.000          0.000 70  1
C BRABRI
C Upstream Manilla Junction - Manilla River
C     26         40.741         53.193          1.000 0 0    24 U1
0.000          0.000 70  1
C NORTH CUERINDI
C Upstream Manilla Junction - Namoi River
C     27         39.626         52.013          1.000 0 0    36 V2
0.000          0.000 70  1
C RAILWAY
C Outlet node
C     28         55.788         50.916          1.000 0 0    11 O1
0.000          0.000  0  1
C
C confluence carlisles gully - mcdonald river
C     29         46.857         63.029          1.000 0 0    21 U2
0.000          0.000  0  1
C
```

```
C confluence Namoi River- Red Jack Mountain
C     30         42.434         55.071          1.000 0 0    26 U3
0.000          0.000  0  1
C
C Halls Creek - Namoi River Confluence
C     31         69.083         26.805          1.000 0 0    17 R1
0.000          0.000  0  0
C
C     32         62.071         40.650          1.000 0 0    15 P1
0.000          0.000  0  0
C
C     33         39.155         71.739          1.000 0 0    22 G2
0.000          0.000 70  0
C BLKSPRNG
C     34         37.218         59.749          1.000 0 0    20 T4
0.000          0.000  0  0
C
C     35         42.121         47.551          1.000 1 0    36 V
65.513          0.000  0  0
C
C     36         39.676         51.712          1.000 0 1     0 V1
0.000          0.000  0  1
C CREEK DS RAILWAY
C Outlet node
C
C #REACHES
C     34
C      1 A-B                     1     2              0 1 0         28.962
0.581    45  0
C          28.831         28.688         28.557         28.653
28.844         28.926         29.166         28.803         28.751
28.874         29.178         28.911         29.025         29.163
29.370         29.327         29.405         29.283         29.134
29.130         29.319         29.414         29.490         29.844
30.048         30.137         30.172         30.250         30.361
30.806         31.021         31.214         31.666         31.733
31.617         31.484         31.561         31.782         31.710
31.928         32.096         32.208         32.220         32.339
32.744
C          77.594         77.637         77.978         78.060
77.951         78.237         78.496         78.456         78.833
79.417         79.678         79.987         80.255         80.747
81.067         81.702         82.444         82.622         82.515
82.719         82.807         83.047         83.363         83.326
83.691         83.734         83.120         83.255         83.448
83.569         83.434         83.107         82.731         82.520
82.295         82.039         81.906         82.026         81.528
81.383         81.832         81.783         81.540         81.388
81.455
C      2 B-C                     2     5              0 1 0         20.324
0.000    31  0
C          33.218         33.408         33.750         34.096
34.352         34.401         34.573         34.663         34.767
34.925         35.171         35.277         35.277         35.277
35.375         35.776         36.002         35.858         35.820
35.916         36.144         35.997         35.866         35.916
35.758         35.922         36.047         36.112         36.292
36.468         36.644
C          80.733         81.012         80.951         81.692
81.305         80.937         80.760         80.160         80.016
```

```
80.050         80.635         80.473         80.091         79.335
79.232         79.395         79.360         79.109         78.801
78.413         78.074         77.950         77.786         77.486
77.198         76.585         76.599         76.845         77.049
77.022         77.008
C      3 C-F1                   5    23              0 1 0          8.452
0.000    14  0
C          36.628         36.734         36.865         36.865
36.960         37.281         37.413         37.479         37.576
37.724         37.882         37.605         37.839         38.017
C          76.558         76.367         76.408         76.667
76.809         77.088         77.008         76.558         76.353
76.449         76.329         75.552         75.382         75.819
C      4 D-E                    3     4              0 1 0         24.967
0.467    44  0
C          44.231         44.004         43.797         43.537
43.363         43.187         43.093         42.905         42.808
42.676         42.502         42.529         42.463         42.357
42.038         41.890         41.931         41.776         41.776
41.657         41.563         41.596         41.672         41.465
41.481         41.334         41.129         40.908         40.818
40.841         40.818         40.651         40.573         40.597
40.541         40.294         40.433         40.651         40.316
40.447         40.204         39.951         39.806         39.975
C          86.377         86.408         86.896         87.015
86.664         86.578         86.609         86.841         86.773
86.637         86.918         86.637         86.378         86.117
86.473         86.201         85.860         85.600         85.068
84.878         84.850         84.223         83.980         84.086
83.623         83.473         83.650         83.432         83.023
82.619         82.422         82.425         82.477         82.177
81.933         81.863         81.769         81.672         81.357
80.749         80.922         80.677         80.142         79.967
C      5 E-F1                   4    23              0 1 0         10.501
0.000    19  0
C          39.803         39.861         39.806         39.588
39.574         39.769         39.558         39.427         39.515
39.386         39.247         39.124         38.961         38.757
38.780         38.666         38.559         38.567         38.551
C          79.381         79.122         78.952         78.515
78.235         77.898         77.867         77.616         77.300
77.199         77.403         77.103         76.766         77.033
76.258         76.012         75.835         75.576         75.453
C      6 T2-T1                 25    24              0 1 0          1.917
0.000     5  0
C          39.075         39.172         39.414         39.491
39.504
C          53.273         53.109         52.979         52.754
52.602
C      7 U1-T1                 26    24              0 1 0          3.294
0.000     5  0
C          40.688         40.385         39.988         39.715
39.642
C          53.126         52.876         52.679         52.754
52.712
C      8 T1-V2                 24    27              0 1 0          0.706
0.000     1  0
C          39.586
C          52.243
C      9 T-T2                  20    25              0 1 0          9.559
```

```
0.000    27  0
C          37.682         37.682         37.682         37.682
37.682         37.682         37.682         37.682         37.682
37.682         37.682         37.682         37.682         37.682
37.890         38.432         38.555         38.456         38.619
38.857         39.224         39.218         38.811         38.723
38.824         38.974         39.074
C          56.988         56.988         56.988         56.988
56.988         56.988         56.988         56.988         56.988
56.988         56.988         56.988         56.988         56.988
57.131         57.014         56.500         56.238         55.957
56.064         55.133         54.755         54.319         53.989
53.725         53.601         53.360
C     10 H-T4                   8    34               0 1 0         19.558
2.633    43  0
C          33.239         33.442         33.505         33.645
33.622         33.744         33.913         34.099         34.320
34.483         34.634         34.645         34.901         34.994
34.960         34.936         35.061         35.197         35.309
35.526         35.720         35.679         35.769         35.611
35.675         35.797         35.820         36.036         36.184
36.153         36.415         36.609         36.703         36.762
36.748         36.821         36.888         36.914         36.915
36.987         37.073         37.124         37.310
C          61.613         61.688         61.755         61.628
61.440         61.342         61.493         61.842         62.017
62.288         62.288         62.618         62.734         62.845
63.102         63.471         63.883         63.815         63.965
64.010         63.785         63.604         63.371         63.063
62.958         62.908         62.346         62.071         62.123
61.717         61.514         61.446         61.371         61.198
61.033         60.989         61.025         60.892         60.695
60.589         60.567         60.853         60.717
C     11 G1-T4                 22    34               0 1 0         15.918
0.000    24  0
C          38.426         38.531         38.432         37.844
37.529         37.461         37.659         37.881         38.178
38.368         38.530         38.584         38.431         38.287
38.174         37.971         37.831         37.836         37.917
37.998         37.980         38.237         38.030         37.592
C          65.040         64.556         64.413         64.528
64.288         64.071         63.625         63.529         63.002
62.807         62.762         62.220         61.905         61.897
61.815         61.935         61.709         61.409         61.288
60.905         60.552         60.311         60.003         59.965
C     12 J-R1                  19    31               0 1 0         31.414
0.334    97  0
C          69.564         69.437         69.381         69.311
69.353         69.388         69.332         69.318         69.304
69.247         69.381         69.367         69.325         69.254
69.085         68.965         68.909         68.902         68.930
68.980         68.895         68.768         68.775         68.642
68.487         68.458         68.501         68.501         68.444
68.416         68.409         68.501         68.487         68.465
68.312         68.267         68.407         68.379         68.321
68.398         68.342         68.240         68.164         68.206
68.303         68.276         68.488         68.484         68.571
68.627         68.527         68.409         68.296         68.332
68.395         68.564         68.613         68.501         68.550
68.479         68.430         68.444         68.374         68.366
```

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68.529          68.634          68.550          68.571          68.627
68.691          68.881          68.895          68.958          68.860
68.733          68.634          68.592          68.564          68.515
68.488          68.571          68.684          68.761          68.733
68.627          68.578          68.620          68.637          68.564
68.493          68.507          68.599          68.574          68.613
68.782          68.838          68.937
C           13.123          13.370          13.252          13.370
13.487          13.605          13.769          13.921          14.074
14.215          14.438          14.684          14.766          14.872
14.919          14.966          15.036          15.236          15.353
15.494          15.588          15.717          15.870          16.280
16.292          16.327          16.445          16.609          16.926
17.055          17.172          17.372          17.618          17.752
17.627          17.778          17.815          18.055          18.078
18.454          18.671          18.477          18.514          18.668
18.755          18.928          19.168          19.409          19.484
19.766          19.820          19.989          20.142          20.541
20.811          21.022          21.280          21.468          21.761
21.961          22.184          22.407          22.653          22.747
22.817          22.794          23.005          23.275          23.428
23.592          23.522          23.768          23.956          24.132
23.944          24.050          24.097          24.355          24.578
24.716          24.813          24.625          24.648          25.012
25.212          25.235          25.364          25.468          25.529
25.588          25.763          25.928          26.287          26.338
26.526          26.432          26.679
C      13 K-R1                     18     31              0 1 0          19.506
0.761     48  0
C           72.965          72.796          72.726          72.648
72.747          72.740          72.606          72.409          72.331
72.275          72.198          72.240          72.141          71.958
71.853          71.923          71.916          71.810          71.768
71.648          71.543          71.719          71.662          71.515
71.451          71.367          71.254          71.059          71.198
71.092          70.956          70.856          70.739          70.726
70.698          70.641          70.578          70.590          70.465
70.240          70.085          69.888          69.712          69.599
69.514          69.381          69.268          69.106
C           21.889          21.796          21.901          22.089
22.253          22.394          22.500          22.629          22.746
22.394          22.476          22.676          22.793          22.922
23.063          23.204          23.404          23.404          23.709
23.979          24.237          24.213          24.460          24.448
24.612          24.577          25.105          25.039          24.777
24.718          25.129          25.325          25.355          25.129
25.000          25.047          25.223          25.603          25.763
26.021          26.197          26.244          26.303          26.397
26.631          26.502          26.103          26.350
C      14 O-O1                     14     28              0 1 0           8.788
0.000     11  0
C           58.444          58.148          57.697          57.514
57.373          57.035          56.796          56.472          56.260
56.190          56.035
C           48.439          48.627          48.979          49.355
49.707          49.379          49.473          49.613          49.989
50.153          50.435
C      15 N-O1                     15     28              0 1 0          17.884
0.000     46  0
C           56.959          56.982          57.028          57.050
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57.156         57.171         57.073         56.906         56.831
56.785         56.853         56.861         56.748         56.808
56.838         56.861         56.944         56.952         56.884
56.800         56.800         56.724         56.619         56.580
56.429         56.245         56.103         55.990         55.920
55.974         55.906         55.740         55.690         55.732
55.776         55.712         55.702         55.580         55.247
55.126         55.144         55.338         55.406         55.541
55.686         55.762
C          42.721         42.936         43.087         43.378
43.504         43.693         43.895         43.971         44.085
44.299         44.539         44.691         44.885         45.133
45.335         45.499         45.600         45.878         46.105
46.357         46.660         46.812         46.873         47.128
47.582         47.625         47.506         47.456         47.580
47.734         47.923         48.264         48.445         48.617
48.700         48.780         48.870         48.971         48.883
48.996         49.211         49.317         49.700         49.903
49.893         50.208
C     16 T-U                    13     12              0 1 0          22.067
1.029    43  0
C          50.912         50.992         50.918         50.827
50.822         50.867         50.782         50.606         50.527
50.533         50.431         50.317         50.232         50.125
50.011         49.575         49.416         49.116         49.065
48.934         48.781         48.747         48.577         48.521
48.209         48.237         47.914         47.869         47.897
47.534         47.319         47.251         47.155         47.104
47.166         47.387         47.330         47.308         47.075
46.837         46.729         46.718         46.661
C          46.716         46.877         47.028         46.972
47.028         47.198         47.302         47.501         47.482
47.246         47.189         47.633         47.718         48.048
48.086         48.644         49.022         49.201         49.664
50.004         49.976         50.382         50.259         50.051
50.231         49.938         49.749         49.985         50.231
50.231         50.326         50.552         50.401         50.562
50.864         51.478         51.676         51.931         52.678
53.235         53.329         53.651         53.717
C     17 U-U3                   12     30              0 1 0          16.003
0.000    34  0
C          46.304         45.930         45.998         45.624
45.409         45.375         45.329         45.397         45.261
45.125         45.069         45.159         45.080         44.887
44.740         44.536         44.524         44.354         44.298
44.173         44.094         44.003         43.878         43.697
43.425         43.346         43.198         43.198         42.915
42.869         42.801         42.688         42.575         42.563
C          54.161         54.029         54.444         54.841
54.709         54.935         55.049         55.389         55.616
55.502         55.672         55.880         55.918         55.956
55.937         55.956         55.786         55.710         55.994
55.880         55.918         55.748         55.729         55.408
55.276         54.841         54.841         54.615         54.445
54.558         54.350         54.634         54.709         55.031
C     18 R-U2                   10     29              0 1 0          15.125
3.366    49  0
C          50.334         50.283         50.323         50.289
50.215         50.192         50.226         50.130         50.102
50.028         49.982         49.858         49.790         49.625
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49.625         49.484         49.376         49.342         49.370
49.404         49.291         49.132         49.132         49.013
48.883         48.781         48.605         48.469         48.424
48.299         48.327         48.180         48.106         48.061
48.072         47.942         47.908         47.846         47.766
47.647         47.670         47.591         47.245         47.273
47.177         47.103         47.143         47.149         47.052
C          61.272         61.405         61.594         61.764
61.839         61.971         62.217         62.293         62.434
62.293         62.500         62.397         62.264         62.236
62.519         62.623         62.699         62.841         62.982
63.143         63.152         63.266         63.171         63.162
63.304         63.389         63.332         63.247         63.153
63.039         63.398         63.304         63.398         63.521
63.663         63.710         63.559         63.540         63.719
63.682         63.512         63.474         63.380         63.181
63.172         63.219         63.361         63.436         63.408
C     19 U2-S                   29    21               0 1 0          15.291
0.000    30  0
C          47.029         46.781         46.609         46.582
46.663         46.808         46.763         46.718         46.524
46.627         46.542         46.325         46.127         45.930
45.775         45.635         45.459         44.954         44.873
44.895         44.990         44.918         44.587         44.435
44.381         44.300         44.372         44.345         44.191
44.047
C          62.715         62.158         62.151         61.993
61.707         61.610         61.301         61.241         61.076
60.625         60.505         60.550         60.738         60.886
60.452         60.332         60.309         60.768         60.716
60.272         59.926         59.813         59.977         59.941
59.814         59.994         60.047         60.159         60.197
60.024
C     20 S-U3                   21    30               0 1 0          17.908
0.000    31  0
C          43.379         43.243         43.028         42.994
42.643         42.139         42.116         42.044         41.968
41.962         41.872         41.724         41.656         41.683
41.634         41.611         41.535         41.543         41.498
41.861         41.968         42.044         42.042         41.991
42.127         42.297         42.495         42.654         42.615
42.501         42.291
C          60.167         60.396         60.188         59.621
59.470         59.453         59.190         59.152         59.280
59.583         59.735         59.735         59.527         59.265
59.025         58.784         58.559         58.375         57.978
58.053         57.624         57.235         56.967         56.306
56.164         56.249         56.646         56.674         56.387
55.767         55.456
C     21 U3-U1                  30    26               0 1 0           6.574
0.000    16  0
C          42.456         42.274         42.110         42.002
41.895         41.668         41.566         41.481         41.481
41.299         41.203         41.180         40.857         40.741
40.741         40.741
C          54.794         54.539         54.511         54.766
54.955         55.002         54.917         54.672         54.417
54.048         53.727         53.548         53.312         53.193
53.193         53.193
C     22 O-U2                    9    29               0 1 0          13.166
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1.451    28  0
C          47.041         46.961         47.007         46.831
46.667         46.633         46.610         46.474         46.633
46.542         46.519         46.406         46.565         46.599
46.463         46.570         46.655         46.718         46.627
46.650         46.871         46.842         46.950         46.695
46.740         46.905         46.882         46.781
C          68.877         68.518         68.272         68.282
68.140         67.895         67.536         67.271         67.082
66.988         66.705         66.478         66.289         66.081
65.911         65.845         65.987         65.807         65.628
65.439         65.193         64.825         64.589         64.438
64.116         63.937         63.408         63.233
C     23 O1-K                    28    11              0 1 0         11.485
0.000    17  0
C          55.249         55.353         55.609         55.921
55.774         55.787         55.579         55.554         55.652
55.603         55.237         55.176         55.298         55.188
55.298         55.188         55.298
C          51.844         52.017         51.976         52.404
52.566         52.913         53.014         53.238         53.462
53.666         53.992         54.480         54.643         54.969
55.233         55.742         55.987
C     24 P-U2                    11    29              0 1 0         58.472
1.335   123  0
C          55.473         55.523         55.397         55.685
55.807         55.725         55.708         56.015         56.116
55.982         55.807         55.785         55.757         55.909
55.921         55.835         55.860         55.395         55.310
55.067         55.004         54.885         54.918         54.797
54.715         54.639         54.565         54.406         54.247
54.242         54.180         54.100         54.036         53.978
54.125         54.064         53.935         53.741         53.624
53.538         53.425         53.282         53.187         53.028
52.818         52.359         52.239         52.182         52.135
52.020         51.924         51.932         51.806         51.730
51.688         51.747         51.755         51.675         51.530
51.449         51.242         50.985         50.900         50.863
50.570         50.558         50.130         50.106         49.984
50.057         49.974         49.898         49.762         49.667
49.568         49.577         49.519         49.434         49.379
49.311         49.165         49.077         48.860         48.903
48.959         48.959         49.040         49.040         48.901
48.607         48.486         48.346         48.238         48.134
48.035         47.931         47.678         47.570         47.457
47.507         47.737         47.904         47.931         48.021
48.084         48.093         47.976         47.728         47.406
47.247         47.076         47.101         47.394         47.479
47.430         47.247         47.088         46.950         46.695
46.740         46.905         46.882         46.835
C          56.887         57.187         57.654         57.759
58.052         58.287         58.443         58.488         58.613
59.020         58.924         59.142         59.533         59.794
60.588         60.791         60.954         61.789         62.583
62.127         61.809         61.911         62.097         62.542
62.713         62.750         62.787         62.909         63.214
63.382         63.474         63.784         63.998         64.191
64.558         64.639         64.450         64.495         64.415
64.668         64.713         64.924         64.989         65.097
65.128         65.790         65.871         66.044         66.247
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66.264        66.394        66.555        66.563        66.655
66.856        67.034        67.205        67.202        67.370
67.429        67.124        67.103        66.839        66.594
66.493        66.045        66.371        66.717        66.839
67.165        67.398        67.918        67.946        68.142
68.162        67.909        67.714        67.694        67.751
68.142        68.549        68.623        68.529        68.380
68.187        67.901        67.706        67.465        67.473
67.300        67.563        67.616        67.466        67.496
67.646        67.684        67.225        67.240        67.150
66.789        66.721        66.834        66.466        66.376
66.225        65.962        65.947        66.143        66.269
65.944        65.822        65.374        65.007        64.681
64.437        64.478        64.682        64.589        64.438
64.116        63.937        63.408        63.193
C      25 F1-G2                  23    33               0 1 0          8.170
0.000    10  0
C          38.246        38.681        38.836        38.709
38.844        38.794        38.971        38.939        38.734
38.844
C          74.645        74.634        74.328        73.880
73.480        72.843        72.608        72.290        71.994
71.721
C      26 G-G2                    7    33               0 1 0          6.423
0.000     1  0
C          38.311
C          70.072
C      27 R1-L                   31    17               0 1 0         13.182
0.000    87  0
C          69.112        69.101        68.987        68.904
68.867        68.855        68.883        68.929        68.951
68.985        68.993        68.970        68.955        68.962
69.082        69.201        69.232        69.247        69.244
69.225        69.145        69.097        69.072        69.094
69.129        69.129        69.116        69.083        69.043
69.016        68.994        68.995        68.989        68.981
68.966        68.923        68.889        68.890        68.901
68.923        68.941        68.946        68.941        68.923
68.883        68.839        68.786        68.735        68.692
68.672        68.674        68.697        68.703        68.655
68.618        68.465        68.469        68.422        68.395
68.383        68.383        68.372        68.340        68.304
68.283        68.217        68.153        68.146        68.094
68.079        68.018        67.976        67.926        67.879
67.817        67.789        67.774        67.742        67.700
67.647        67.601        67.543        67.460        67.375
67.246        67.163        67.137
C          26.844        26.934        26.999        27.048
27.087        27.159        27.226        27.285        27.312
27.424        27.521        27.566        27.615        27.687
27.842        27.856        27.881        27.919        27.975
28.045        28.087        28.132        28.173        28.218
28.285        28.366        28.411        28.438        28.438
28.483        28.578        28.657        28.744        28.800
28.870        28.915        28.956        28.996        29.055
29.091        29.122        29.192        29.250        29.311
29.374        29.424        29.484        29.536        29.567
29.608        29.657        29.693        29.741        29.808
29.864        30.035        30.343        30.429        30.440
30.413        30.366        30.330        30.339        30.380
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30.420        30.994        31.081        31.176        31.270
31.362        31.455        31.506        31.547        31.590
31.599        31.551        31.488        31.423        31.392
31.394        31.457        31.529        31.565        31.583
31.520        31.554        31.626
C     28 L-P1                  17    32              0 1 0         28.839
0.000   133  0
C          66.893        66.874        66.866        66.855
66.825        66.791        66.613        66.544        66.535
66.531        66.465        66.423        66.378        66.330
66.132        66.082        66.002        65.961        65.928
65.871        65.852        65.843        65.789        65.816
65.775        65.822        65.957        65.965        65.965
65.943        65.903        65.832        65.781        65.763
65.766        65.828        65.959        66.046        66.103
66.149        66.206        66.238        66.261        66.183
66.094        66.029        65.978        65.945        65.891
65.856        65.802        65.799        65.956        66.069
66.080        66.077        66.021        65.910        65.856
65.824        65.764        65.710        65.702        65.740
65.802        65.888        65.967        65.932        65.829
65.764        65.716        65.573        65.570        65.508
65.451        65.305        65.260        65.103        64.789
64.708        64.677        64.694        64.734        64.725
64.652        64.554        64.497        64.489        64.428
64.474        64.434        64.336        64.339        64.371
64.371        64.342        64.274        64.288        64.299
64.220        64.115        64.056        64.002        63.975
63.953        63.880        63.824        63.794        63.721
63.662        63.581        63.527        63.494        63.456
63.388        63.295        63.249        62.947        62.917
62.929        62.929        62.919        62.878        62.810
62.726        62.667        62.460        62.360        62.316
62.282        62.262        62.184        62.130
C          31.934        31.889        31.786        31.693
31.597        31.527        31.480        31.581        31.718
31.790        31.905        31.932        31.907        31.853
31.828        31.786        31.700        31.667        31.669
31.707        31.790        31.878        32.026        32.186
32.337        32.434        32.519        32.604        32.660
32.661        32.621        32.637        32.699        32.787
32.899        33.062        33.149        33.385        33.383
33.322        33.270        33.268        33.315        33.484
33.596        33.713        33.749        33.749        33.844
33.898        33.949        34.078        34.415        34.536
34.586        34.631        34.671        34.698        34.712
34.698        34.743        34.739        34.865        34.923
34.928        35.045        35.189        35.346        35.445
35.495        35.495        35.657        35.850        35.958
35.976        36.151        36.318        36.507        36.800
36.703        36.609        36.502        36.422        36.328
36.281        36.131        36.145        36.399        36.572
36.799        37.015        37.222        37.344        37.402
37.470        37.569        37.668        37.839        37.951
38.059        38.037        38.068        38.144        38.257
38.347        38.383        38.365        38.432        38.500
38.522        38.500        38.576        38.815        38.977
39.161        39.358        39.407        39.388        39.438
39.639        39.639        39.851        40.044        40.162
40.230        40.344        40.443        40.401        40.428
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40.488          40.579          40.648          40.644
C     29 M-P1                      16    32              0 1 0         12.190
2.029    91  0
C          64.669          64.660          64.656          64.656
64.637          64.606          64.592          64.560          64.492
64.410          64.328          64.296          64.296          64.301
64.301          64.287          64.241          64.200          64.191
64.191          64.178          64.155          64.114          64.078
64.014          63.968          63.991          64.009          64.059
64.073          64.091          64.041          63.996          63.914
63.918          63.946          63.946          63.923          63.905
63.868          63.850          63.836          63.809          63.786
63.755          63.750          63.750          63.736          63.700
63.673          63.659          63.663          63.659          63.627
63.577          63.536          63.500          63.468          63.486
63.486          63.427          63.377          63.286          63.277
63.268          63.195          63.136          63.054          62.999
62.958          62.922          62.890          62.849          62.822
62.808          62.776          62.721          62.676          62.699
62.653          62.608          62.535          62.498          62.453
62.394          62.344          62.294          62.271          62.193
62.143          62.093
C          43.292          43.398          43.489          43.543
43.611          43.641          43.550          43.444          43.353
43.262          43.156          43.110          43.019          42.936
42.868          42.822          42.799          42.784          42.761
42.708          42.663          42.579          42.542          42.504
42.481          42.451          42.390          42.329          42.299
42.246          42.193          42.177          42.170          42.147
42.011          41.942          41.897          41.813          41.753
41.730          41.753          41.791          41.829          41.859
41.844          41.806          41.745          41.700          41.662
41.677          41.730          41.813          41.889          41.942
41.950          41.897          41.844          41.783          41.738
41.715          41.707          41.685          41.571          41.518
41.465          41.374          41.343          41.245          41.169
41.116          41.017          40.941          40.941          40.994
41.116          41.199          41.305          41.419          41.533
41.571          41.548          41.525          41.457          41.442
41.427          41.328          41.230          41.154          40.987
40.919          40.896
C     30 P1-N                      32    15              0 1 0         21.785
0.000   126  0
C          62.030          61.975          61.952          61.934
61.932          61.927          61.884          61.834          61.779
61.752          61.718          61.627          61.543          61.470
61.324          61.245          61.217          61.185          61.154
61.076          61.058          61.028          60.994          60.933
60.794          60.824          60.810          60.890          60.867
60.846          60.853          60.814          60.801          60.753
60.596          60.431          60.409          60.398          60.389
60.368          60.342          60.290          60.263          60.190
60.052          60.004          59.999          60.017          60.057
60.091          60.134          60.133          60.114          60.059
59.944          59.910          59.875          59.851          59.833
59.798          59.759          59.706          59.664          59.612
59.572          59.542          59.532          59.531          59.526
59.521          59.506          59.473          59.438          59.416
59.394          59.386          59.389          59.382          59.368
59.346          59.303          59.247          59.207          59.163
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59.142        59.129        59.128        59.111        59.087
59.060        59.036        58.995        58.963        58.946
58.907        58.879        58.854        58.810        58.773
58.744        58.728        58.656        58.605        58.562
58.292        58.139        58.012        57.905        57.882
57.750        57.646        57.564        57.436        57.436
57.354        57.345        57.259        57.266        57.238
57.197        57.193        57.170        57.031        56.977
56.949        56.930
C           40.577      40.547      40.513      40.316
40.191        40.138        40.085        40.081        40.141
40.282        40.316        40.267        40.111        40.062
39.935        39.859        39.848        39.874        39.950
40.083        40.087        40.018        40.056        40.170
40.265        40.360        40.458        40.599        40.697
40.758        40.856        41.031        41.088        41.213
41.262        41.472        41.531        41.673        41.709
41.734        41.709        41.629        41.597        41.599
41.749        41.681        41.599        41.538        41.468
41.349        41.172        41.085        41.043        40.987
40.943        40.902        40.804        40.733        40.669
40.629        40.618        40.622        40.661        40.680
40.661        40.637        40.589        40.542        40.504
40.436        40.415        40.405        40.406        40.459
40.523        40.574        40.625        40.680        40.718
40.775        40.817        40.833        40.860        40.924
40.987        41.064        41.137        41.197        41.258
41.311        41.339        41.326        41.243        41.188
41.059        40.958        40.888        40.894        40.892
40.917        40.974        41.184        41.239        41.349
41.343        41.306        41.268        40.962        40.765
40.655        40.777        40.777        40.906        41.004
41.103        41.228        41.440        41.565        41.641
41.687        41.770        41.816        41.886        41.924
42.023        42.484
C     31 F-G2              6    33              0 1 0          12.680
1.992    68  0
C           42.011      41.861      41.834      41.734
41.697        41.656        41.615        41.524        41.388
41.319        41.160        41.128        41.107        41.068
41.065        41.063        41.041        40.980        40.919
40.868        40.776        40.756        40.745        40.714
40.711        40.680        40.679        40.642        40.521
40.429        40.343        40.257        40.213        40.170
40.157        40.142        40.111        40.086        40.087
40.075        40.055        40.016        39.983        39.972
40.006        40.047        40.074        40.071        40.027
40.021        40.074        40.039        39.978        39.873
39.881        39.837        39.837        39.775        39.714
39.690        39.559        39.484        39.418        39.358
39.285        39.220        39.234        39.208
C           72.198      72.115      71.933      71.887
71.826        71.864        71.948        71.986        72.206
72.426        72.486        72.555        72.571        72.529
72.470        72.421        72.402        72.425        72.449
72.497        72.637        72.736        72.882        72.958
73.096        73.140        73.335        73.396        73.331
73.420        73.420        73.470        73.475        73.456
73.379        73.324        73.280        73.246        73.182
73.121        73.051        73.034        73.024        72.973
```

```
72.848         72.717         72.618         72.467         72.432
72.373         72.155         72.151         72.170         72.081
71.958         71.920         71.774         71.817         71.889
71.952         72.062         72.049         72.089         72.166
72.284         72.204         72.022         71.817
C     32 T4-T                   34    20               0 1 0          6.266
0.000    20  0
C          37.159         37.195         37.245         37.363
37.481         37.586         37.636         37.645         37.604
37.522         37.441         37.391         37.359         37.268
37.268         37.186         37.186         37.263         37.368
37.591
C          59.522         59.371         59.303         59.287
59.250         59.060         58.826         58.606         58.477
58.424         58.424         58.341         58.250         58.212
58.008         57.720         57.463         57.251         57.114
57.092
C     33 V3-V1                  35    36               0 1 1         11.010
1.143    31  0
C          41.973         41.868         41.749         41.590
41.508         41.248         41.202         41.170         41.047
40.960         40.919         40.824         40.646         40.678
40.623         40.623         40.436         40.450         40.286
40.272         40.240         40.250         40.214         40.109
40.045         39.995         39.936         39.849         39.769
39.724         39.676
C          47.620         47.567         47.445         47.422
47.339         47.399         47.491         47.673         47.810
47.931         48.144         48.243         48.456         48.707
48.805         48.927         49.064         49.353         49.505
50.006         50.166         51.024         50.979         51.287
51.382         51.298         51.355         51.488         51.480
51.686         51.712
C     34 V2-V1                  27    36               0 1 0          0.460
0.000     1  0
C          39.676
C          51.712
C
C #STORAGES
C      1
C      1 SPLIT ROCK DAM         33    22          39.020         69.943
1.000  3          0.000     2  1  0  0  0  0
C         449.000         96.500
C         462.890        484.000
C           2.000          0.000          0.000     0
C           0.000          0.000  1          0.000          0.000
0.000     0
C     34
C               397.00              398.00              400.00
402.00              404.00              406.00              408.00
410.00              412.00              414.00              416.00
418.00              420.00              422.00              424.00
426.00              428.00              430.00              432.00
434.00              436.00              438.00              440.00
442.00              444.00              446.00              448.00
450.00              452.00              454.00              456.00
458.00              460.00              462.90
C                 0.00            24000.00           197000.00
514000.00          1060000.00          1890000.00          3160000.00
5240000.00          8440000.00          12800000.00          18400000.00
```

```
25600000.00         34700000.00         45500000.00         57900000.00
72000000.00         88000000.00        106000000.00        127000000.00
150000000.00        175000000.00        202000000.00        232000000.00
264000000.00        299000000.00        336000000.00        376000000.00
419000000.00        465000000.00        515000000.00        568000000.00
625000000.00        685000000.00        790000000.00
C
C #INFLOW/OUTFLOW
C      0
C
C END RORB_GE
C
C File created using MiRORB version 1.1
C Original CATG file created on 9/01/2012 at 13:41:39
1
1, 19.506,  -99                                   ,Reach 13 node 18
Sub-area K, Reach K-R1 - Generate rainfall excess h'graph and route
downstream
3                                                 ,
Store running hydrograph
1, 31.414,  -99                                   ,Reach 12 node 19
Sub-area J, Reach J-R1 - Generate rainfall excess h'graph and route
downstream
4                                                 ,
Add running h'graph to last stored h'graph
5, 13.182,  -99                                   ,Reach 27
Reach R1-L - Route running h'graph downstream
2, 28.839,  -99                                   ,Reach 28 node 17
Sub-area L, Reach L-P1 - Generate rainfall excess h'graph, add to running
h'graph, and route downstream
3                                                 ,
Store running hydrograph
1, 12.190,  -99                                   ,Reach 29 node 16
Sub-area M, Reach M-P1 - Generate rainfall excess h'graph and route
downstream
4                                                 ,
Add running h'graph to last stored h'graph
5, 21.785,  -99                                   ,Reach 30
Reach P1-N - Route running h'graph downstream
2, 17.884,  -99                                   ,Reach 15 node 15
Sub-area N, Reach N-O1 - Generate rainfall excess h'graph, add to running
h'graph, and route downstream
3                                                 ,
Store running hydrograph
1, 8.788,  -99                                    ,Reach 14 node 14
Sub-area O, Reach O-O1 - Generate rainfall excess h'graph and route
downstream
4                                                 ,
Add running h'graph to last stored h'graph
5, 11.485,  -99                                   ,Reach 23
Reach O1-K - Route running h'graph downstream
2, 58.472,  -99                                   ,Reach 24 node 11
Sub-area P, Reach P-U2 - Generate rainfall excess h'graph, add to running
h'graph, and route downstream
3                                                 ,
Store running hydrograph
1, 13.166,  -99                                   ,Reach 22 node 9
Sub-area Q, Reach O-U2 - Generate rainfall excess h'graph and route
downstream
4                                                 ,
```

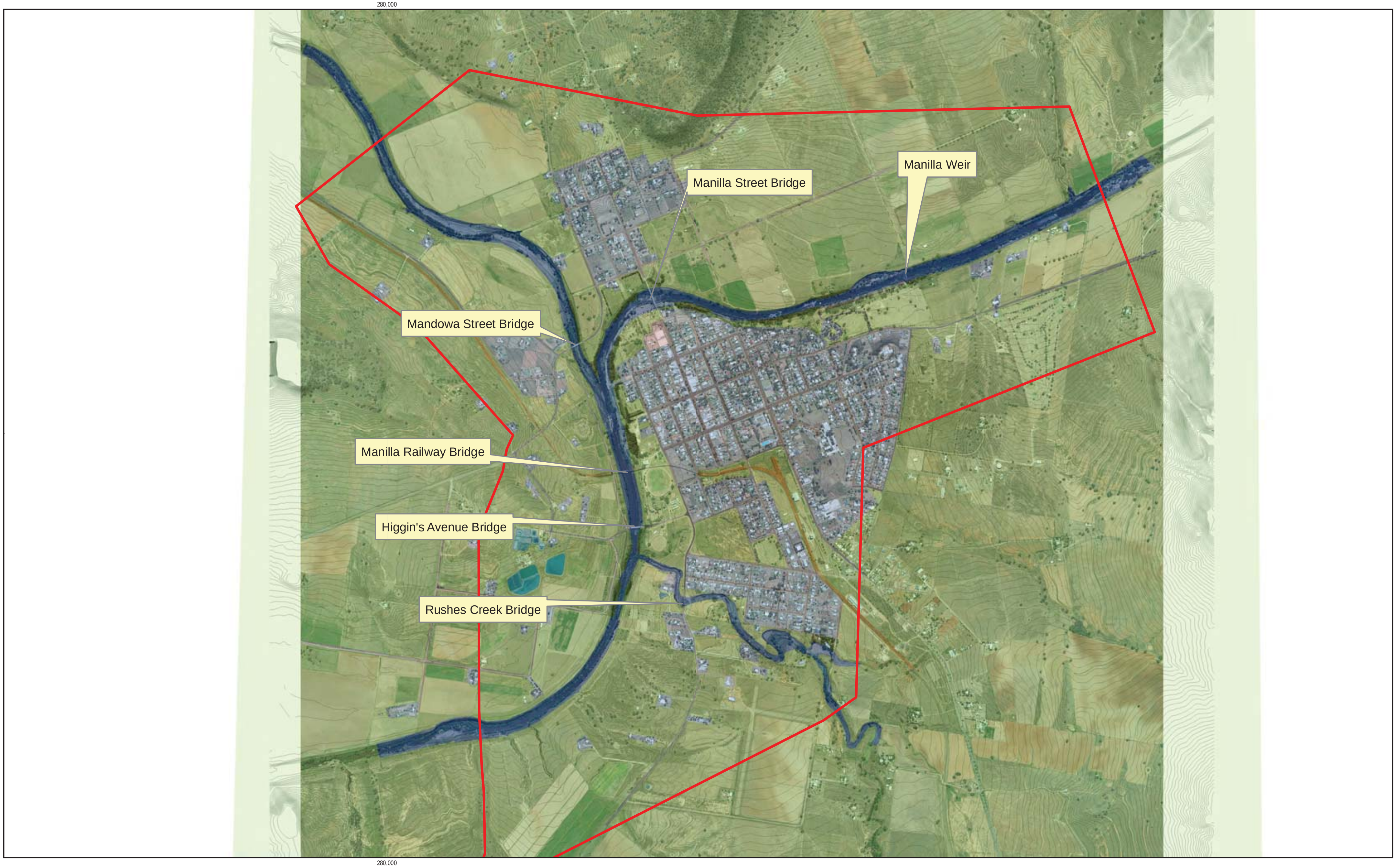
```
Add running h'graph to last stored h'graph
3                                                  ,
Store running hydrograph
1, 15.125,  -99                                    ,Reach 18 node 10
Sub-area R, Reach R-U2 - Generate rainfall excess h'graph and route
downstream
4                                                  ,
Add running h'graph to last stored h'graph
5, 15.291,  -99                                    ,Reach 19
Reach U2-S - Route running h'graph downstream
2, 17.908,  -99                                    ,Reach 20 node 21
Sub-area S, Reach S-U3 - Generate rainfall excess h'graph, add to running
h'graph, and route downstream
3                                                  ,
Store running hydrograph
1, 22.067,  -99                                    ,Reach 16 node 13
Sub-area T, Reach T-U - Generate rainfall excess h'graph and route
downstream
2, 16.003,  -99                                    ,Reach 17 node 12
Sub-area U, Reach U-U3 - Generate rainfall excess h'graph, add to running
h'graph, and route downstream
4                                                  ,
Add running h'graph to last stored h'graph
5, 6.574,  -99                                     ,Reach 21
Reach U3-U1 - Route running h'graph downstream
C Upstream Manilla Junction - Namoi River
7                                                  ,
PRINT
NORTH CUERINDI
5, 3.294,  -99                                     ,Reach 7
Reach U1-T1 - Route running h'graph downstream
3                                                  ,
Store running hydrograph
1, 28.962,  -99                                    ,Reach 1 node 1
Sub-area A, Reach A-B - Generate rainfall excess h'graph and route
downstream
2, 20.324,  -99                                    ,Reach 2 node 2
Sub-area B, Reach B-C - Generate rainfall excess h'graph, add to running
h'graph, and route downstream
2, 8.452,  -99                                     ,Reach 3 node 5
Sub-area C, Reach C-F1 - Generate rainfall excess h'graph, add to running
h'graph, and route downstream
3                                                  ,
Store running hydrograph
1, 24.967,  -99                                    ,Reach 4 node 3
Sub-area D, Reach D-E - Generate rainfall excess h'graph and route
downstream
2, 10.501,  -99                                    ,Reach 5 node 4
Sub-area E, Reach E-F1 - Generate rainfall excess h'graph, add to running
h'graph, and route downstream
4                                                  ,
Add running h'graph to last stored h'graph
5, 8.170,  -99                                     ,Reach 25
Reach F1-G2 - Route running h'graph downstream
3                                                  ,
Store running hydrograph
1, 12.680,  -99                                    ,Reach 31 node 6
Sub-area F, Reach F-G2 - Generate rainfall excess h'graph and route
downstream
4                                                  ,
```

```
Add running h'graph to last stored h'graph
3                                                  ,
Store running hydrograph
1, 6.423,  -99                                     ,Reach 26 node 7
Sub-area G, Reach G-G2 - Generate rainfall excess h'graph and route
downstream
4                                                  ,
Add running h'graph to last stored h'graph
7                                                  ,
PRINT
BLKSPRNG
16                                                 ,
Storage
SPLIT ROCK DAM
3, .000, 2, Spillway data (2 values x 2 spillways)
 449.000,   96.500,
 462.890,  484.000,
2.00,  -99
C Elevation-storage relationship
1, 34, Elevation-storage table (2 values x 34 lines)
           397.000,              0.000,
           398.000,          24000.000,
           400.000,         197000.000,
           402.000,         514000.000,
           404.000,        1060000.000,
           406.000,        1890000.000,
           408.000,        3160000.000,
           410.000,        5240000.000,
           412.000,        8440000.000,
           414.000,       12800000.000,
           416.000,       18400000.000,
           418.000,       25600000.000,
           420.000,       34700000.000,
           422.000,       45500000.000,
           424.000,       57900000.000,
           426.000,       72000000.000,
           428.000,       88000000.000,
           430.000,      106000000.000,
           432.000,      127000000.000,
           434.000,      150000000.000,
           436.000,      175000000.000,
           438.000,      202000000.000,
           440.000,      232000000.000,
           442.000,      264000000.000,
           444.000,      299000000.000,
           446.000,      336000000.000,
           448.000,      376000000.000,
           450.000,      419000000.000,
           452.000,      465000000.000,
           454.000,      515000000.000,
           456.000,      568000000.000,
           458.000,      625000000.000,
           460.000,      685000000.000,
           462.900,      790000000.000,
 -99
5, 15.918,  -99                                    ,Reach 11
Reach G1-T4 - Route running h'graph downstream
3                                                  ,
Store running hydrograph
1, 19.558,  -99                                    ,Reach 10 node 8
```

```
Sub-area H, Reach H-T4 - Generate rainfall excess h'graph and route
downstream
4                                                    ,
Add running h'graph to last stored h'graph
5, 6.266,  -99                                       ,Reach 32
Reach T4-T - Route running h'graph downstream
2, 9.559,  -99                                       ,Reach 9 node 20
Sub-area I, Reach T-T2 - Generate rainfall excess h'graph, add to running
h'graph, and route downstream
C Upstream Manilla Junction - Manilla River
7                                                    ,
PRINT
BRABRI
5, 1.917,  -99                                       ,Reach 6
Reach T2-T1 - Route running h'graph downstream
4                                                    ,
Add running h'graph to last stored h'graph
5, .706,  -99                                        ,Reach 8
Reach T1-V2 - Route running h'graph downstream
C Outlet node
7                                                    ,
PRINT
RAILWAY
5, .460,  -99                                        ,Reach 34
Reach V2-V1 - Route running h'graph downstream
3                                                    ,
Store running hydrograph
11, 11.010,  -99                                     ,Reach 33 node 35
Sub-area V, Reach V3-V1 - Generate rainfall excess h'graph and route
downstream
4                                                    ,
Add running h'graph to last stored h'graph
0
C Sub-area areas in km2
 229.875,  317.994,  297.055,  147.063,  222.554,
 296.263,  293.431,  245.543,  213.004,  326.950,
 200.163,  283.554,  302.925,  286.801,  263.621,
 318.750,  223.710,  159.620,  197.882,  186.251,
 132.507,   65.513,
 -99
C Impervious Fraction Data
 1 ,
   0.050,    0.050,    0.050,    0.050,    0.050,
   0.050,    0.050,    0.050,    0.050,    0.050,
   0.050,    0.050,    0.050,    0.050,    0.050,
   0.050,    0.050,    0.050,    0.050,    0.050,
   0.050,    0.000,
 -99
```

Appendix E

Hydraulic Data (TUFLOW)



1:20,000

200 100 0 200 400

Meters

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

LEGEND

TOPO Contours (1m)

2D Code Boundary

Roughness Layer

MATERIAL

Roads

Rail

Default, mostly grass

Some trees

Water bodies

Creek, waterways

Residential

Commercial

Tamworth Regional Council
Manilla and Barraba Flood Study

TUFLOW Model

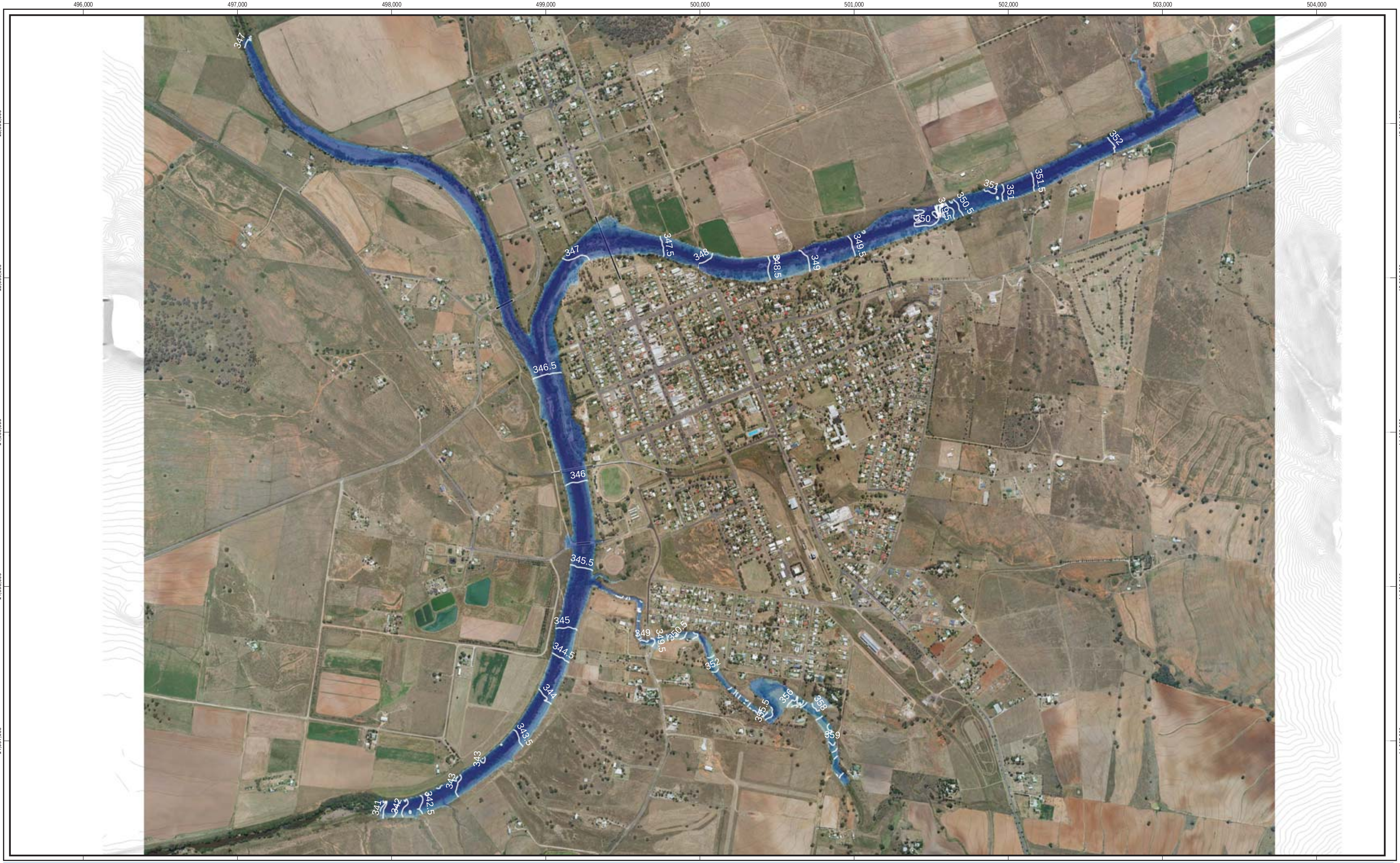
Job Number	22-15815/16
Revision	A
Date	02.02.2012

Figure E.1

10 Bond Street Sydney NSW 2000 Australia **T** 61 2 9239 7000 **F** 61 2 9239 7199 **E** sydmail@ghd.com.au **W** www.ghd.com.au

Appendix F

Design Flood Results and Mapping



1:15,000

0 75 150 300 450 600
Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 56

Flood Extent and Depth (m)
- 0.16 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 3.0
- 3.0 - 5.0
- 5.0 - 10.0
- 10.0 - 20.0

Flood Level Contours (mAHD)
Topo Contours (1m)

GHD
CLIENTS|PEOPLE|PERFORMANCE

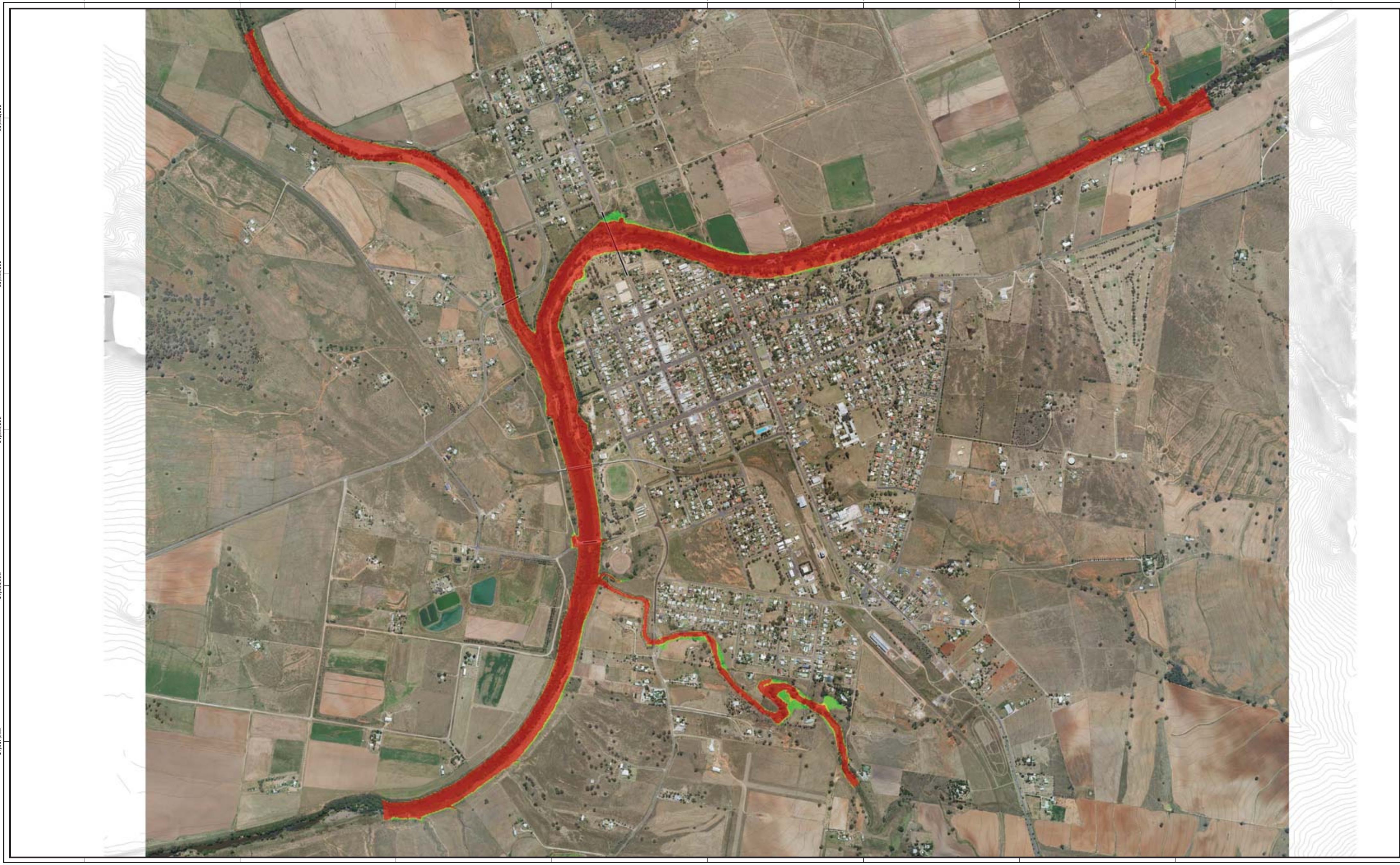
Tamworth Regional Council
Manilla Flood Study

Flood Map
20% AEP Flood Event

Job Number	22-15815
Revision	A
Date	01.02.2012

Figure F.1.1

230 Harbour Drive Coffs Harbour NSW 2450 Australia T 61 2 6652 5600 F 61 2 6652 5601 E cfsmail@ghd.com.au W www.ghd.com.au



1:15,000

0 75 150 300 450 600
Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 56

O

Flood Hazard
- 1 - Low Hazard
- 2 - Intermediate Hazard
- 3 - High Hazard
- Topo Contours (1m)

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Tamworth Regional Council
Manilla Flood Study

Flood Hazard Map
20% AEP Flood Event

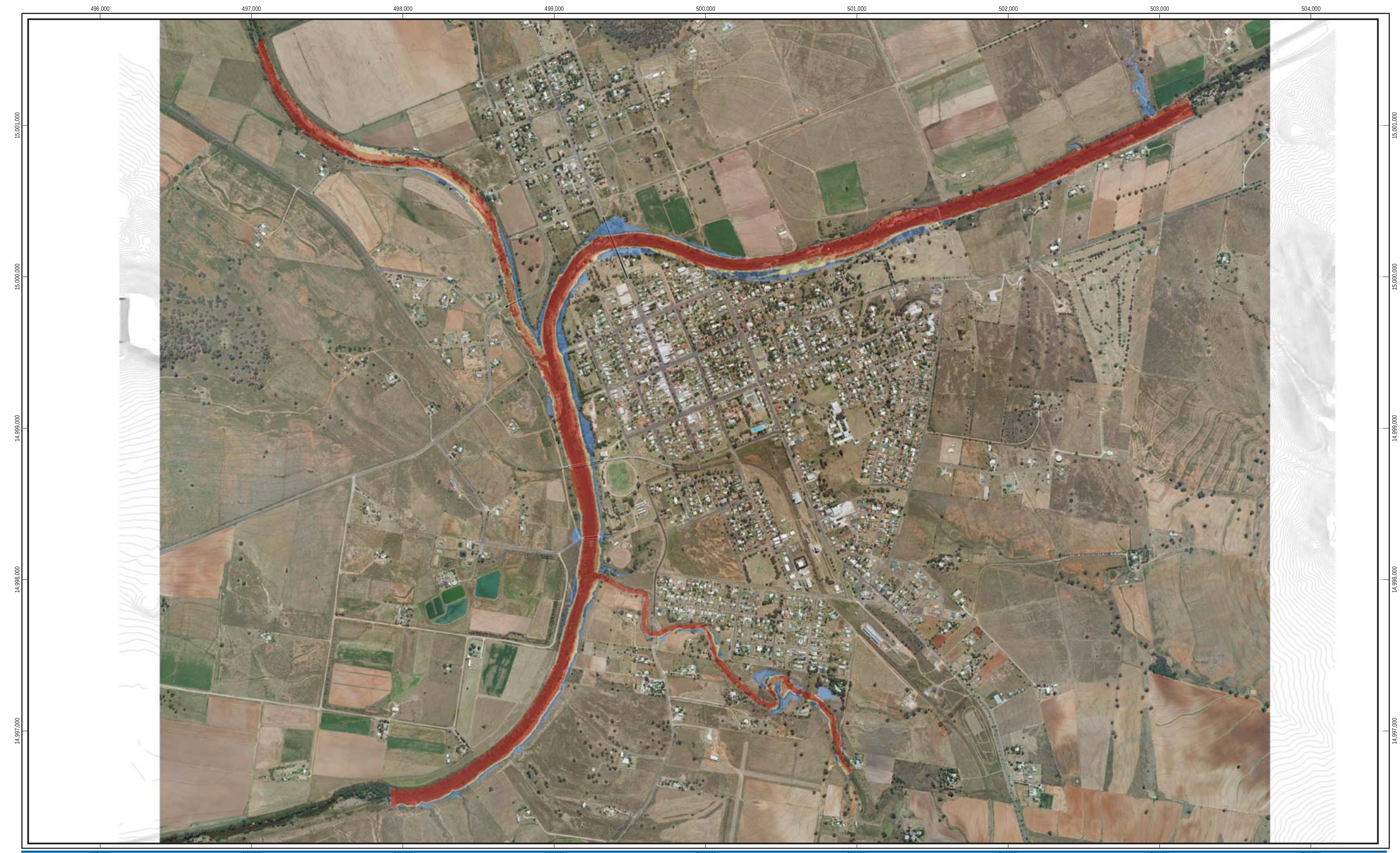
Job Number	22-15815
Revision	A
Date	01.02.2012

Figure F.1.2

N:\AU\Melbourne\Apps Resources\Local\ESRI\ArcGIS\Libraries_Templates\New_Templates_Rev3\Libraries_Templates\GHD-A3-LANDSCAPE TECH.mxt

230 Harbour Drive Coffs Harbour NSW 2450 Australia T 61 2 6652 5600 F 61 2 6652 5601 E cfsmail@ghd.com.au W www.ghd.com.au

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:



1:15,000

0 75 150 300 450 600

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 56

Peak Flood Velocity (m3/s)

- 0 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- Greater than 2
- Topo Contours (1m)

CLIENTS | PEOPLE | PERFORMANCE

Tamworth Regional Council
Manilla Flood Study

Flood Velocity Map
20% AEP Flood Event

Job Number	22-15815
Revision	A
Date	01.02.2012

Figure F.1.3

N:\AU\Melbourne\Apps Resources\Local\ESRI\ArcGIS\Libraries_Templates\New_Templates_Rev3\Libraries_Templates\GHD-A3-LANDSCAPE TECH.mxt

230 Harbour Drive Coffs Harbour NSW 2450 Australia T 61 2 6652 5600 F 61 2 6652 5601 E cfsmail@ghd.com.au W www.ghd.com.au

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:

1:15,000

0 75 150 300 450 600

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 56

Flood Extent and Depth (m)

- 0.16 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 3.0
- 3.0 - 5.0
- 5.0 - 10.0
- 10.0 - 20.0

Flood Level Contours (mAHD)

Topo Contours (1m)

CLIENTS|PEOPLE|PERFORMANCE

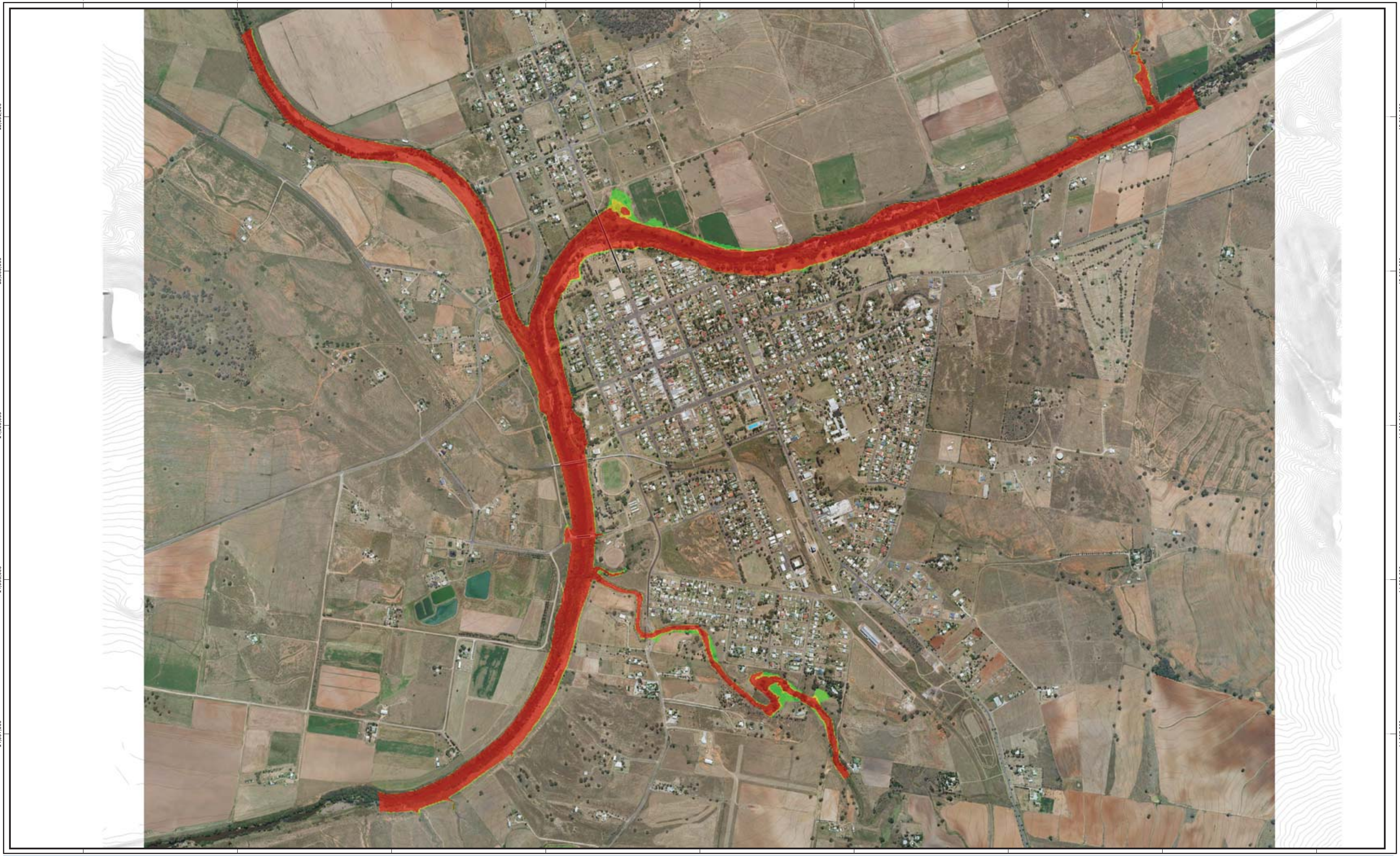
Tamworth Regional Council
Manilla Flood Study

Flood Map
10% AEP Flood Event

Job Number	22-15815
Revision	A
Date	01.02.2012

Figure F.2.1

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:



1:15,000

0 75 150 300 450 600

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 56

O

Flood Hazard

- 1 - Low Hazard
- 2 - Intermediate Hazard
- 3 - High Hazard
- Topo Contours (1m)

CLIENTS | PEOPLE | PERFORMANCE

Tamworth Regional Council
Manilla Flood Study

Flood Hazard Map
10% AEP Flood Event

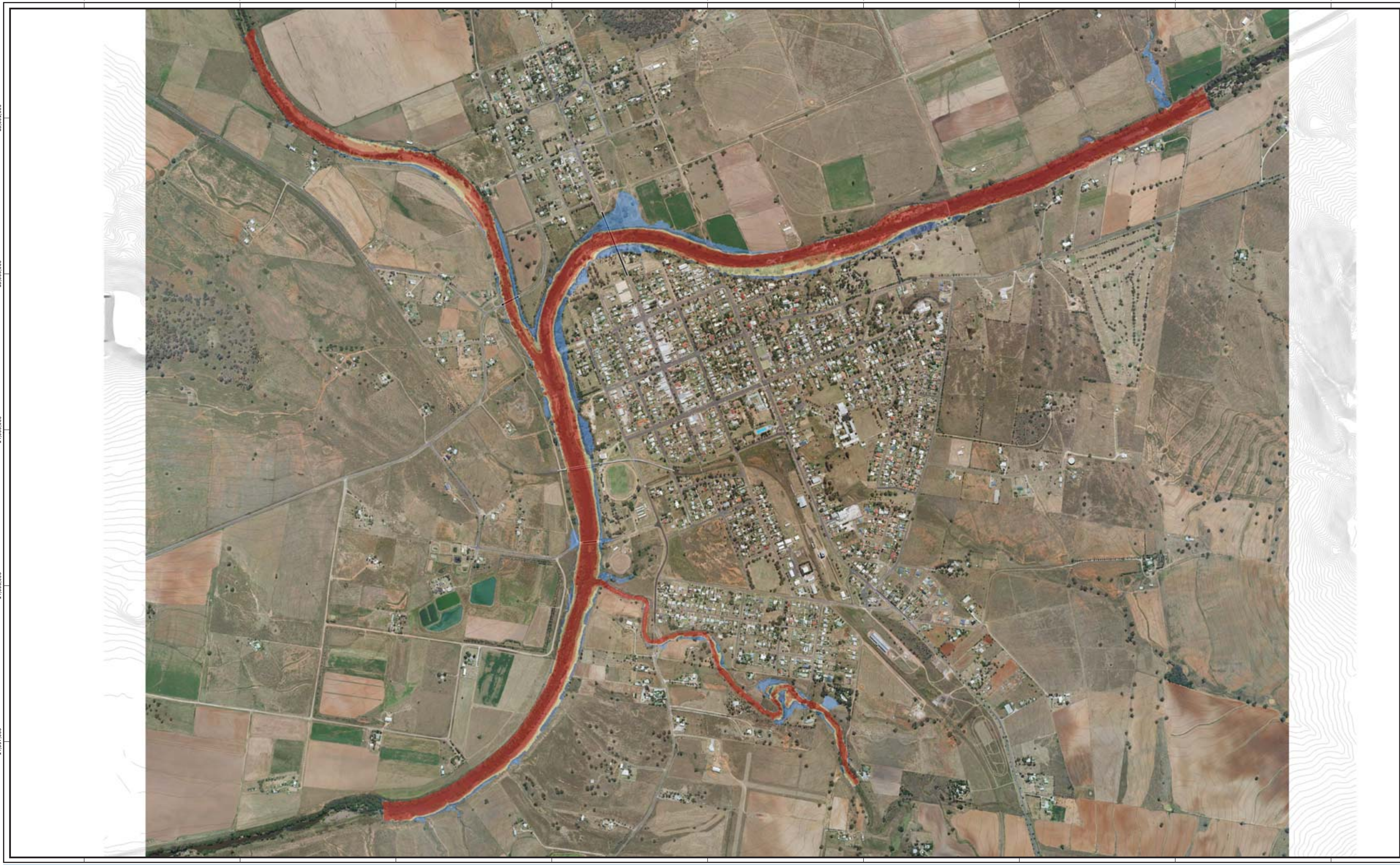
Job Number	22-15815
Revision	A
Date	01.02.2012

Figure F.2.1

230 Harbour Drive Coffs Harbour NSW 2450 Australia **T** 61 2 6652 5600 **F** 61 2 6652 5601 **E** cfsmail@ghd.com.au **W** www.ghd.com.au

N:\AU\Melbourne\Apps Resources\Local\ESRI\ArcGIS\Libraries_Templates\New_Templates_Rev3\Libraries_Templates\GHD-A3-LANDSCAPE TECH.mxt

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:



1:15,000

0 75 150 300 450 600

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 56

O

Peak Flood Velocity (m/s)

- 0 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- Greater than 2
- Topo Contours (1m)

GHD

CLIENTS | PEOPLE | PERFORMANCE

Tamworth Regional Council
Manilla Flood Study

Flood Velocity Map 10% AEP Flood Event

Job Number	22-15815
Revision	A
Date	01.02.2012

Figure F.2.1

230 Harbour Drive Coffs Harbour NSW 2450 Australia **T** 61 2 6652 5600 **F** 61 2 6652 5601 **E** cfsmail@ghd.com.au **W** www.ghd.com.au

N:\AU\Melbourne\Apps Resources\Local\ESRI\ArcGIS\Libraries_Templates\New_Templates_Rev3\Libraries_Templates\GHD-A3-LANDSCAPE TECH.mxt

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:

1:15,000

0 75 150 300 450 600

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 56

Flood Extent and Depth (m)

- 0.16 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 3.0
- 3.0 - 5.0
- 5.0 - 10.0
- 10.0 - 20.0

Flood Level Contours (mAHD)

Topo Contours (1m)

GHD

CLIENTS|PEOPLE|PERFORMANCE

Tamworth Regional Council
Manilla Flood Study

Flood Map
5% AEP Flood Event

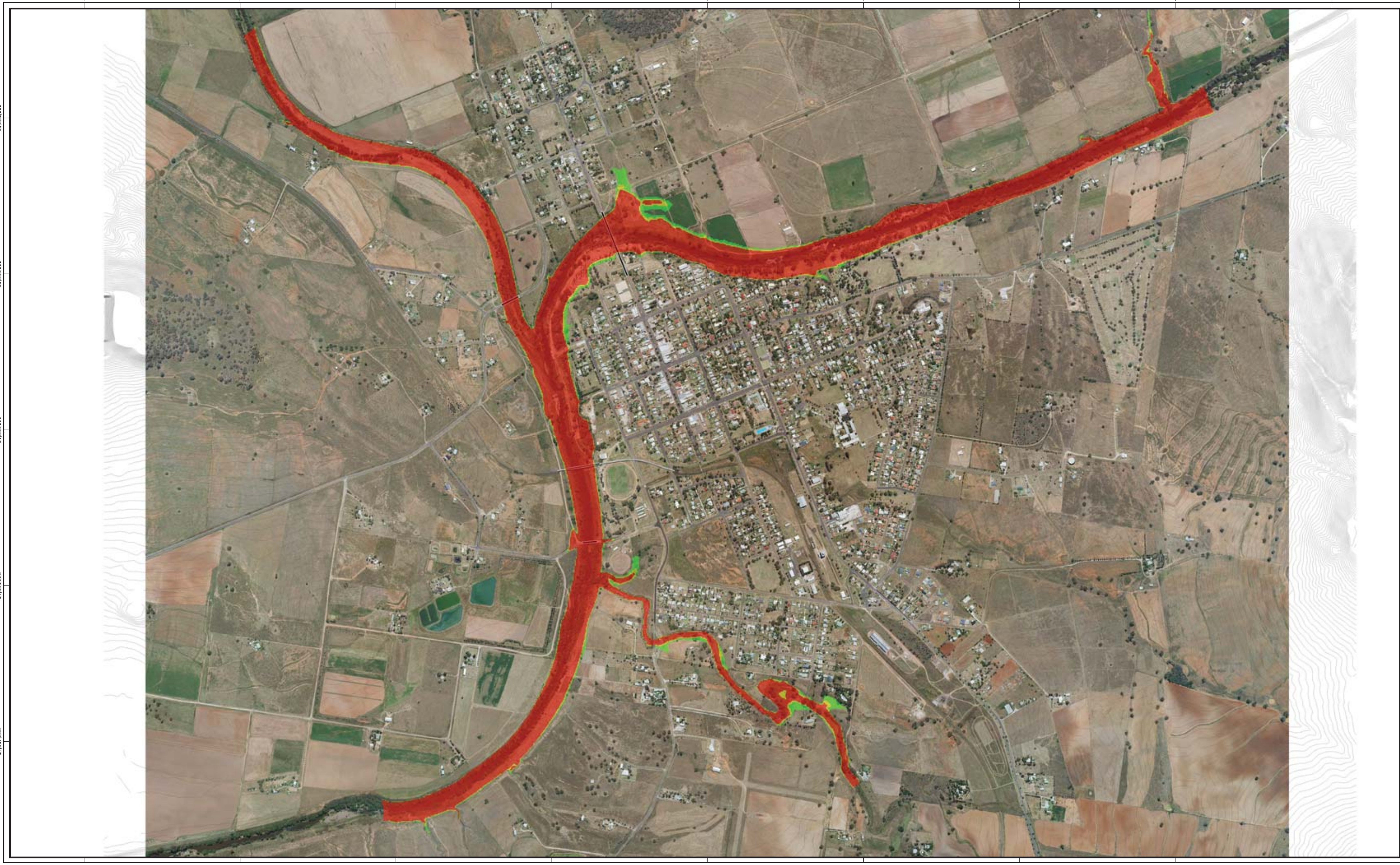
Job Number	22-15815
Revision	A
Date	01.02.2012

Figure F.3.1

N:\AU\Melbourne\Apps Resources\Local\ESRI\ArcGIS\Libraries_Templates\New_Templates_Rev3\Libraries_Templates\GHD-A3-LANDSCAPE TECH.mxt

230 Harbour Drive Coffs Harbour NSW 2450 Australia T 61 2 6652 5600 F 61 2 6652 5601 E cfsmail@ghd.com.au W www.ghd.com.au

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:



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0 75 150 300 450 600

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 56

Flood Hazard

1 - Low Hazard

2 - Intermediate Hazard

3 - High Hazard

Topo Contours (1m)

CLIENTS | PEOPLE | PERFORMANCE

Tamworth Regional Council
Manilla Flood Study

Flood Hazard Map
5% AEP Flood Event

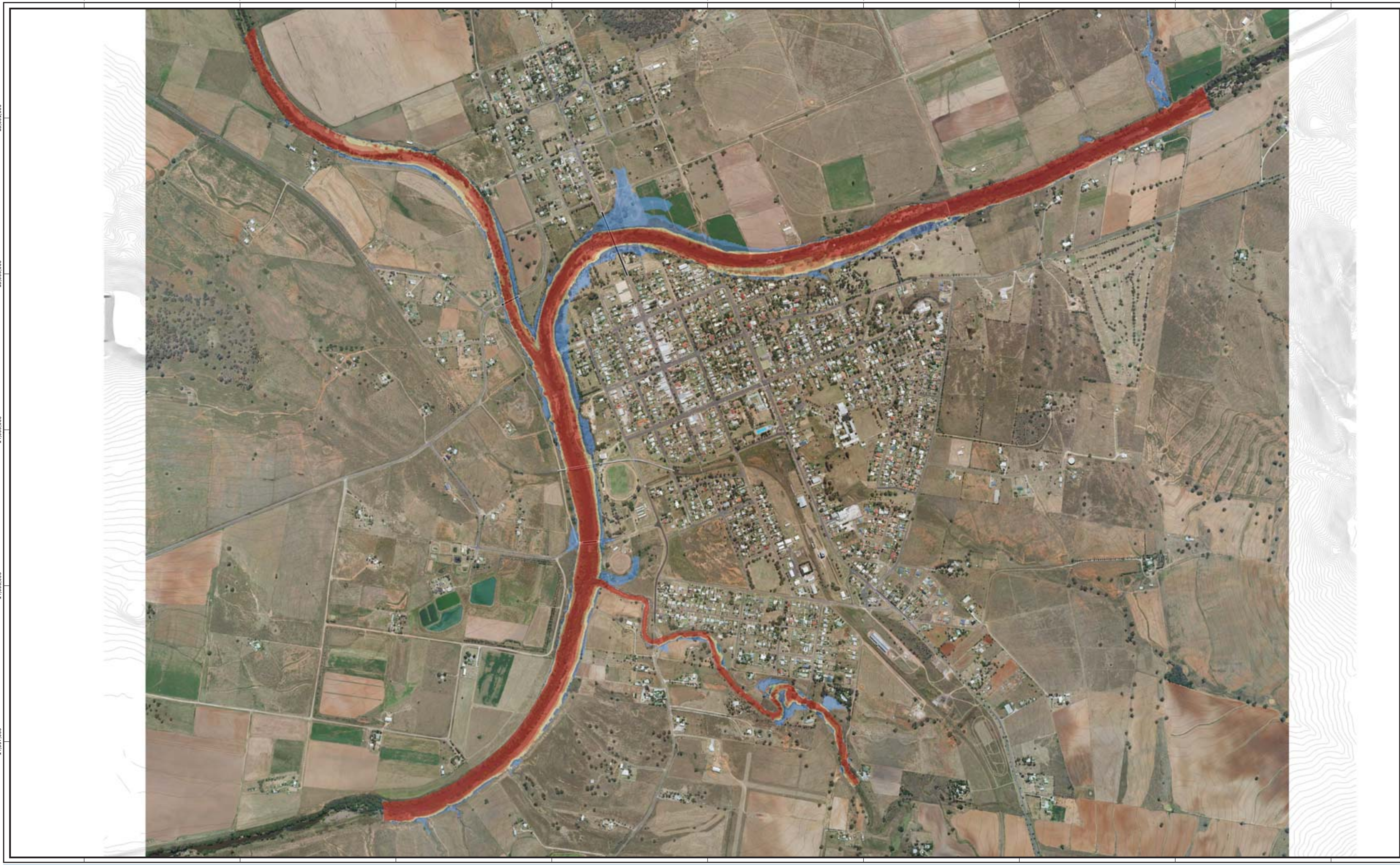
Job Number	22-15815
Revision	A
Date	01.02.2012

Figure F.3.2

N:\AU\Melbourne\Apps Resources\Local\ESRI\ArcGIS\Libraries_Templates\New_Templates_Rev3\Libraries_Templates\GHD-A3-LANDSCAPE TECH.mxt

230 Harbour Drive Coffs Harbour NSW 2450 Australia **T** 61 2 6652 5600 **F** 61 2 6652 5601 **E** cfsmail@ghd.com.au **W** www.ghd.com.au

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:



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0 75 150 300 450 600

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 56

O

manilla_20yr_18hr_v_Max.asc

- 0 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- Greater than 2
- Topo Contours (1m)

GHD

CLIENTS | PEOPLE | PERFORMANCE

Tamworth Regional Council
Manilla Flood Study

Flood Velocity Map
5% AEP Flood Event

Job Number	22-15815
Revision	A
Date	01.02.2012

Figure F.3.3

N:\AU\Melbourne\Apps Resources\Local\ESRI\ArcGIS\Libraries_Templates\New_Templates_Rev3\Libraries_Templates\GHD-A3-LANDSCAPE TECH.mxt

230 Harbour Drive Coffs Harbour NSW 2450 Australia **T** 61 2 6652 5600 **F** 61 2 6652 5601 **E** cfsmail@ghd.com.au **W** www.ghd.com.au

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:

1:15,000

0 75 150 300 450 600

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 56

O

Flood Extent and Depth (m)

- 0.16 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 3.0
- 3.0 - 5.0
- 5.0 - 10.0
- 10.0 - 20.0

Flood Level Contour (mAHD)

Topo Contours (1m)

GHD

CLIENTS | PEOPLE | PERFORMANCE

Tamworth Regional Council
Manilla Flood Study

Flood Map
2% AEP Flood Event

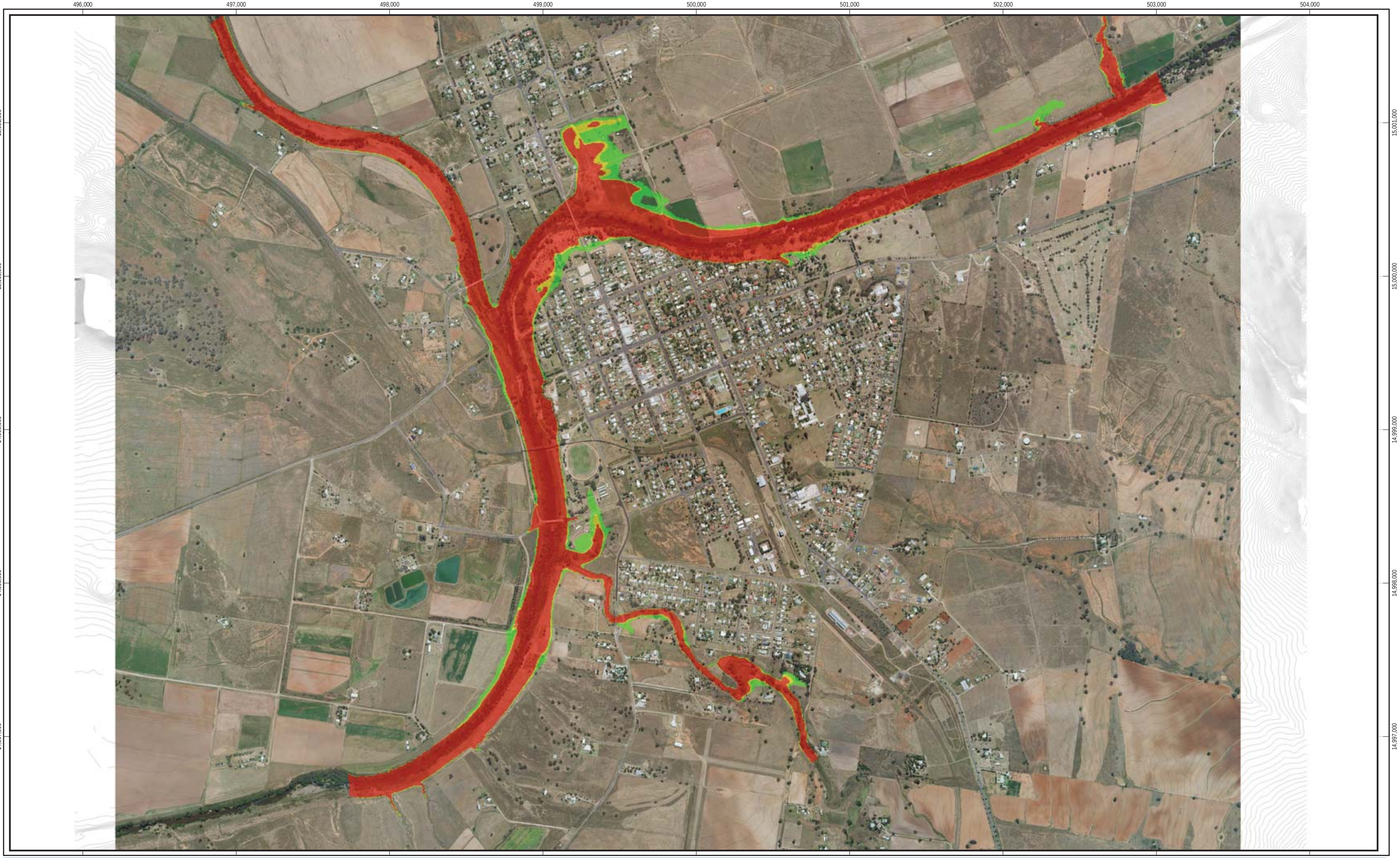
Job Number	22-15815
Revision	A
Date	01.02.2012

Figure F.4.1

230 Harbour Drive Coffs Harbour NSW 2450 Australia T 61 2 6652 5600 F 61 2 6652 5601 E cfsmail@ghd.com.au W www.ghd.com.au

N:\AU\Melbourne\Apps Resources\Local\ESRI\ArcGIS\Libraries_Templates\New_Templates_Rev3\Libraries_Templates\GHD-A3-LANDSCAPE TECH.mxt

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:



1:15,000

0 75 150 300 450 600
Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 56

Flood Hazard

- 1 - Low Hazard
- 2 - Intermediate Hazard
- 3 - High Hazard
- Topo Contours (1m)

CLIENTS | PEOPLE | PERFORMANCE

Tamworth Regional Council
Manilla Flood Study

Flood Hazard Map
2% AEP Flood Event

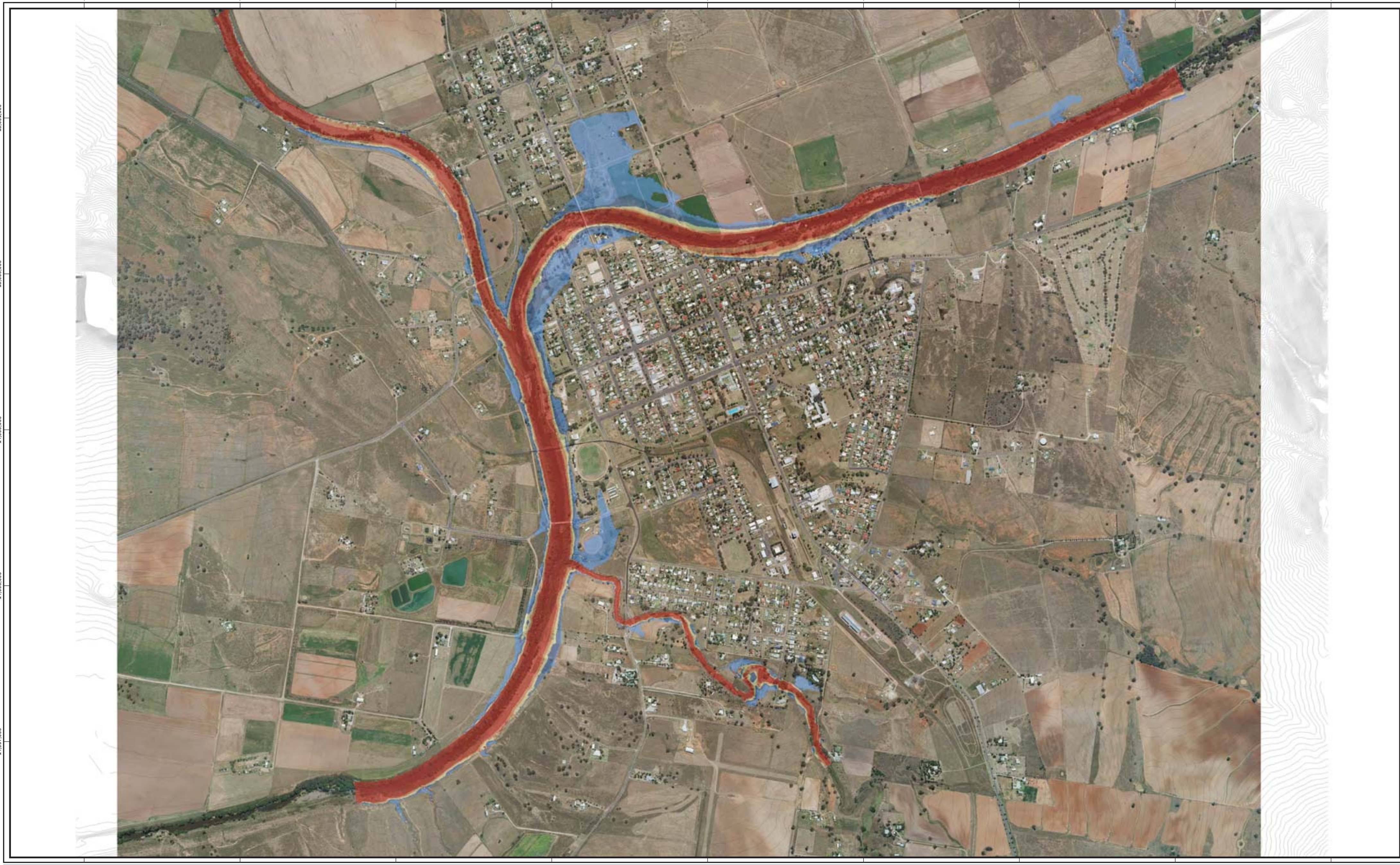
Job Number	22-15815
Revision	A
Date	01.02.2012

Figure F.4.1

230 Harbour Drive Coffs Harbour NSW 2450 Australia T 61 2 6652 5600 F 61 2 6652 5601 E cfsmail@ghd.com.au W www.ghd.com.au

N:\AU\Melbourne\Apps Resources\Local\ESRI\ArcGIS\Libraries_Templates\New_Templates_Rev3\Libraries_Templates\GHD-A3-LANDSCAPE TECH.mxt

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:



1:15,000

0 75 150 300 450 600

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 56

Peak Flood Velocity (m/s)

- 0 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- Greater than 2
- Topo Contours (1m)

GHD
CLIENTS | PEOPLE | PERFORMANCE

Tamworth Regional Council
Manilla Flood Study

Flood Velocity Map
2% AEP Flood Event

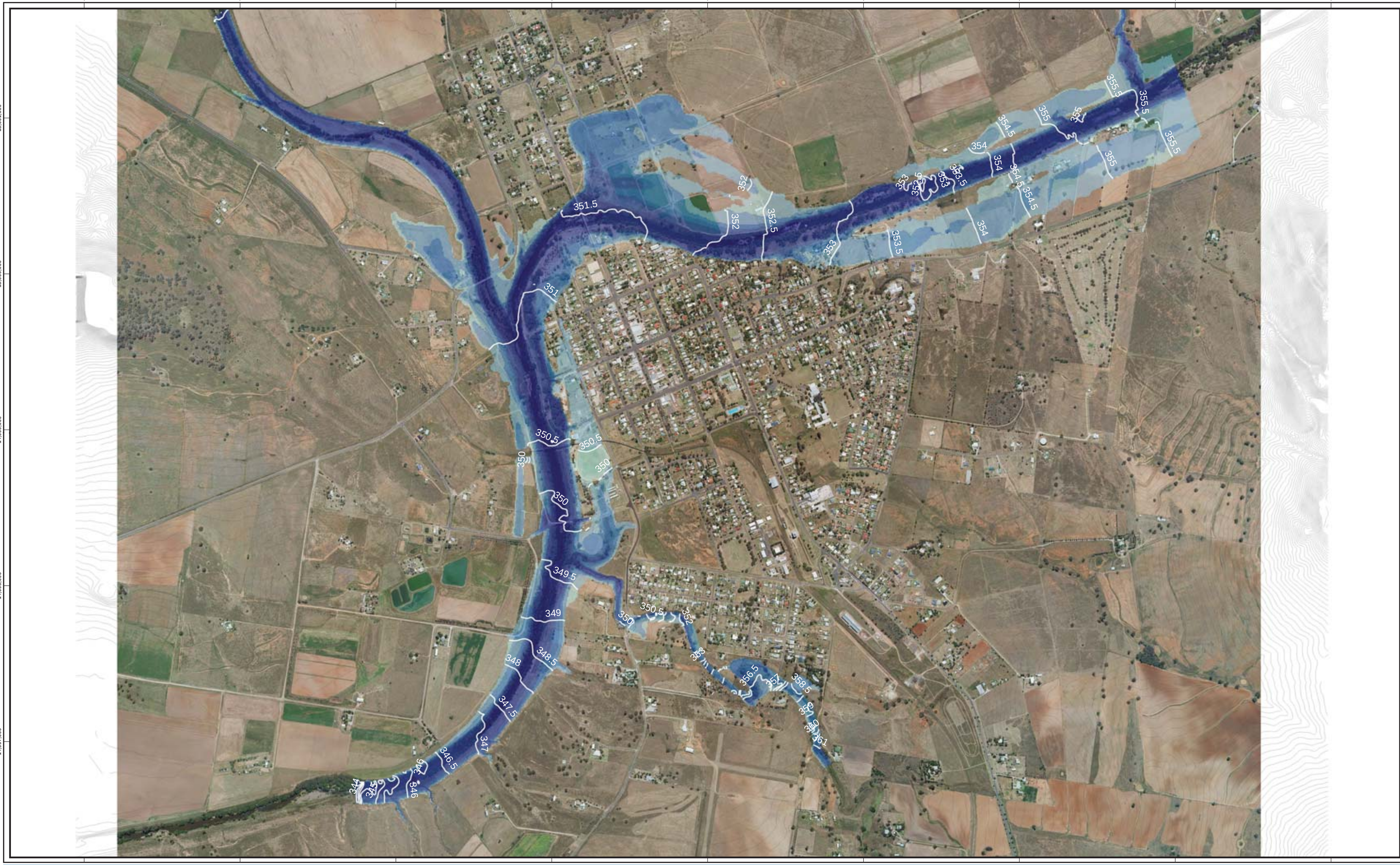
Job Number	22-15815
Revision	A
Date	01.02.2012

Figure F.4.1

230 Harbour Drive Coffs Harbour NSW 2450 Australia T 61 2 6652 5600 F 61 2 6652 5601 E cfsmail@ghd.com.au W www.ghd.com.au

N:\AU\Melbourne\Apps Resources\Local\ESRI\ArcGIS\Libraries_Templates\New_Templates_Rev3\Libraries_Templates\GHD-A3-LANDSCAPE TECH.mxt

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:



1:15,000

0 75 150 300 450 600

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 56

O

Flood Extent and Depth (m)

- 0.16 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 3.0
- 3.0 - 5.0
- 5.0 - 10.0
- 10.0 - 20.0
- Flood Level Contours (mAHD)
- Topo Contours (1m)

GHD
CLIENTS|PEOPLE|PERFORMANCE

Tamworth Regional Council
Manilla Flood Study

Flood Map
1% AEP Flood Event

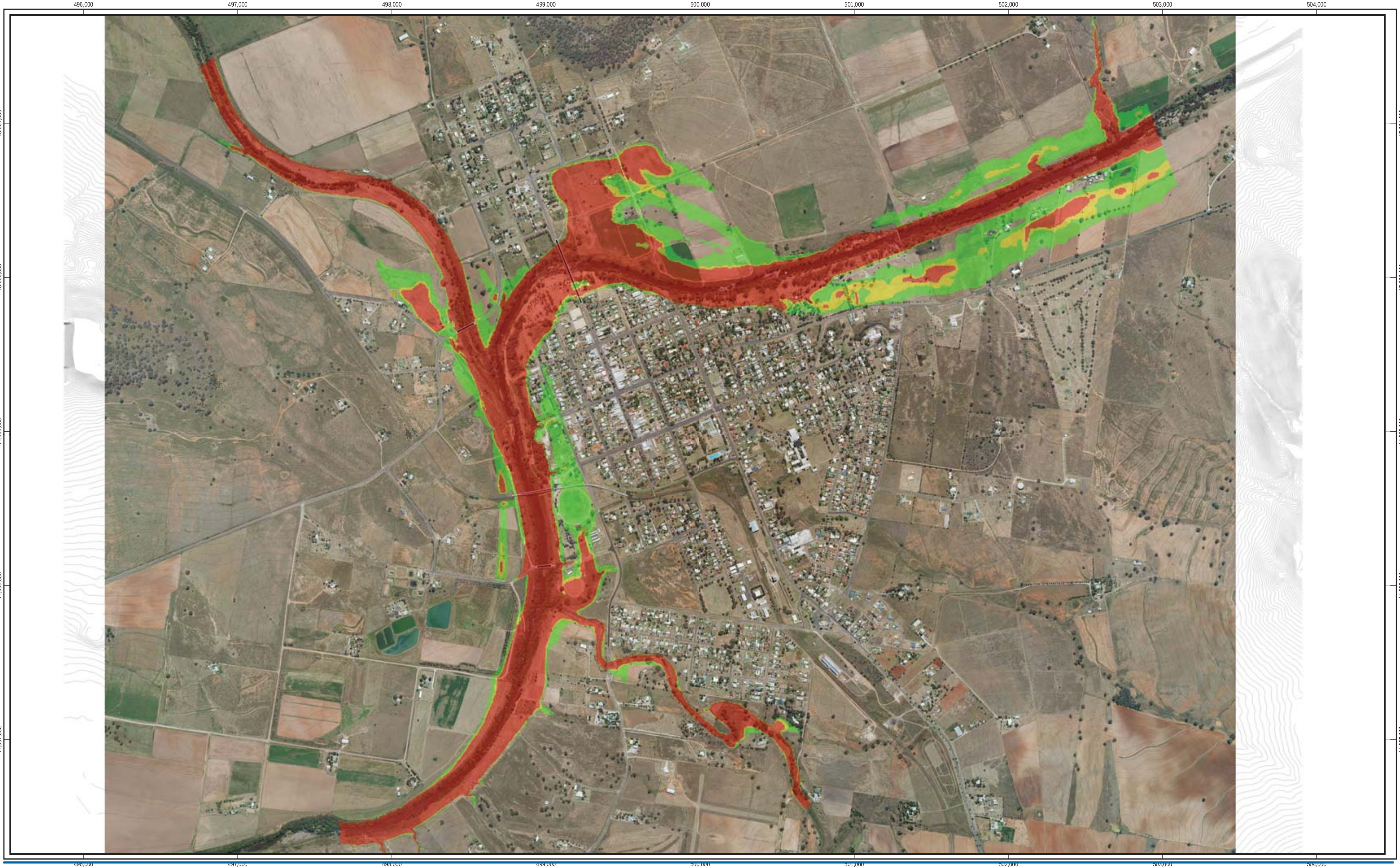
Job Number	22-15815
Revision	A
Date	01.02.2012

Figure F.5.1

230 Harbour Drive Coffs Harbour NSW 2450 Australia **T** 61 2 6652 5600 **F** 61 2 6652 5601 **E** cfsmail@ghd.com.au **W** www.ghd.com.au

N:\AU\Melbourne\Apps Resources\Local\ESRI\ArcGIS\Libraries_Templates\New_Templates_Rev3\Libraries_Templates\GHD-A3-LANDSCAPE TECH.mxt

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:



1:15,000

0 75 150 300 450 600

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 56

Manilla 100yr Flood Hazard Mapping

- 1 - Low Hazard
- 2 - Intermediate Hazard
- 3 - High Hazard
- Topo Contours (1m)

GHD CLIENTS | PEOPLE | PERFORMANCE

Tamworth Regional Council
Manilla Flood Study

Flood Hazard Map
1% AEP Flood Event

Job Number	22-15815
Revision	A
Date	01.02.2012

Figure F.5.2

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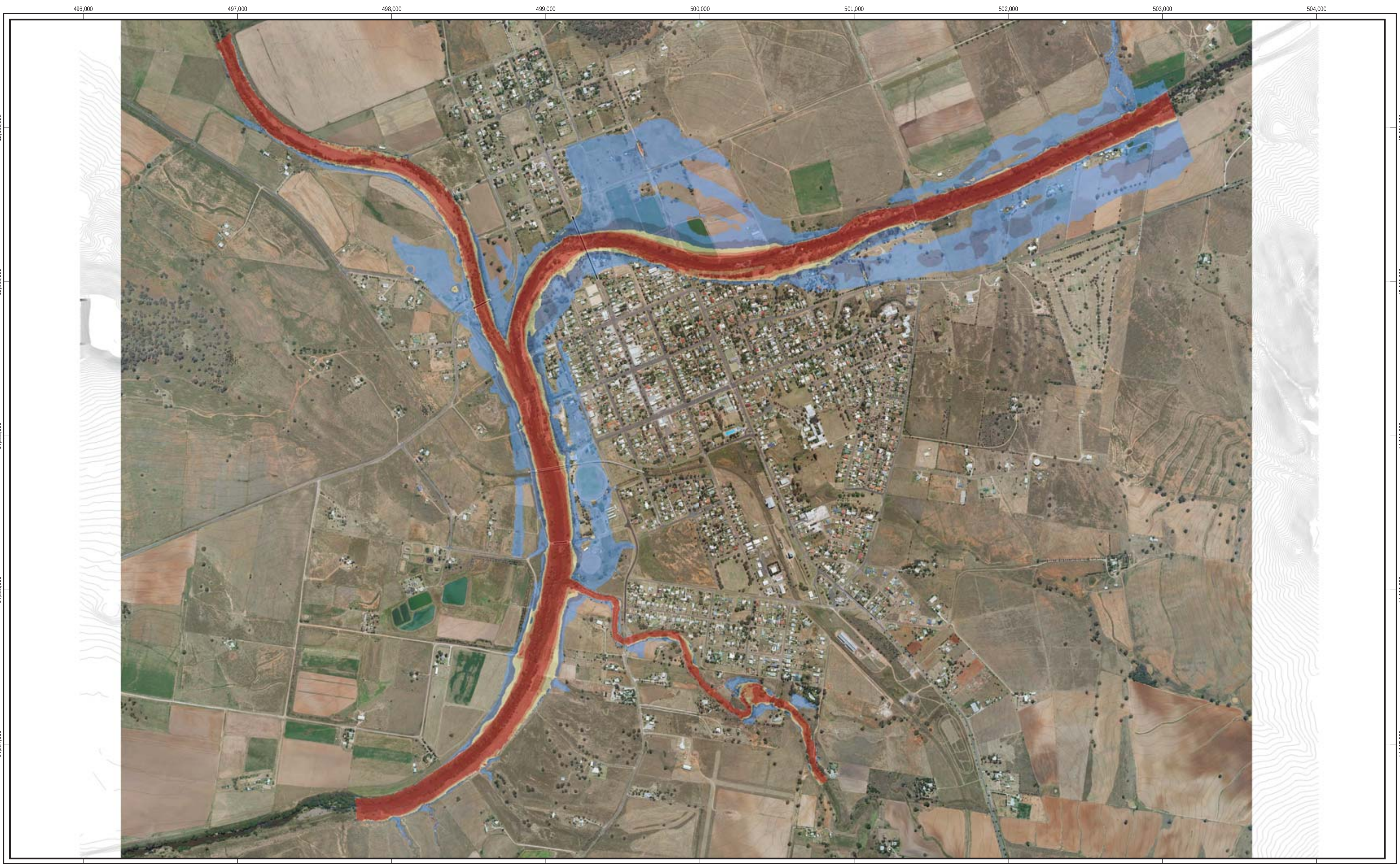
230 Harbour Drive Coffs Harbour NSW 2450 Australia T 61 2 6652 5600 F 61 2 6652 5601 E cfsmail@ghd.com.au W www.ghd.com

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:



1:15,000

0 75 150 300 450 600
Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 56

Manilla 100yr Peak Velocity (m3/s)
- 0 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- Greater than 2

Topo Contours (1m)

CLIENTS | PEOPLE | PERFORMANCE

Tamworth Regional Council
Manilla Flood Study

Flood Velocity Map
1% AEP Flood Event

Job Number	22-15815
Revision	A
Date	01.02.2012

Figure F.5.3

230 Harbour Drive Coffs Harbour NSW 2450 Australia T 61 2 6652 5600 F 61 2 6652 5601 E cfsmail@ghd.com.au W www.ghd.com

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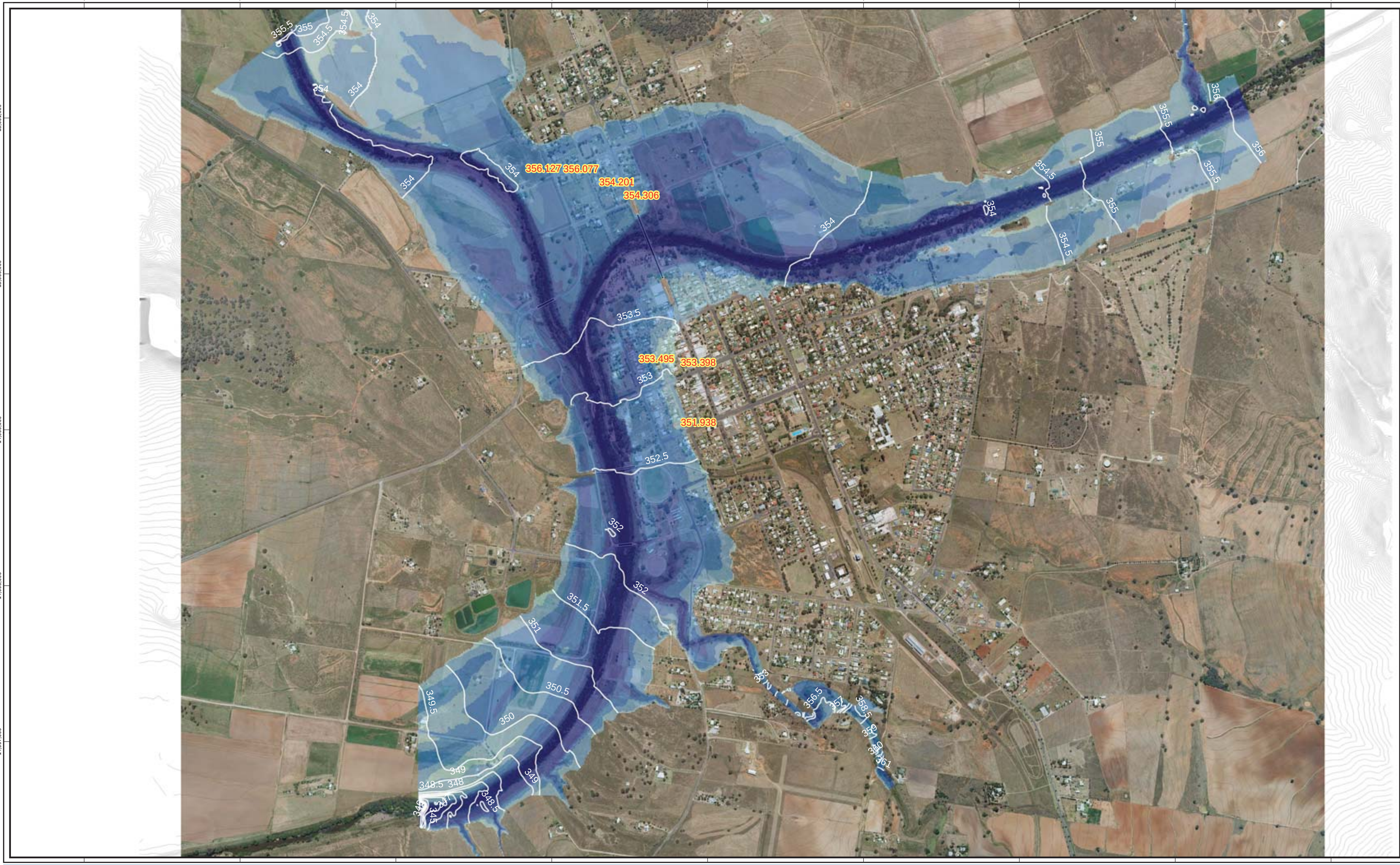
Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:



1:15,000

0 75 150 300 450 600

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 56

Flood Extent and Depth (m)

- 0.16 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 3.0
- 3.0 - 5.0
- 5.0 - 10
- 10.0 - 20

Flood Level Contours (mAHD)

Topo Contours (1m)

1964 Flood Markers (mAHD)

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Tamworth Regional Council
Manilla Flood Study

Pre-Dam Flood Map
1% AEP Flood Event

Job Number	22-15815
Revision	A
Date	30.02.2012

Figure F.5.4

230 Harbour Drive Coffs Harbour NSW 2450 Australia T 61 2 6652 5600 F 61 2 6652 5601 E cfsmail@ghd.com.au W www.ghd.com.au

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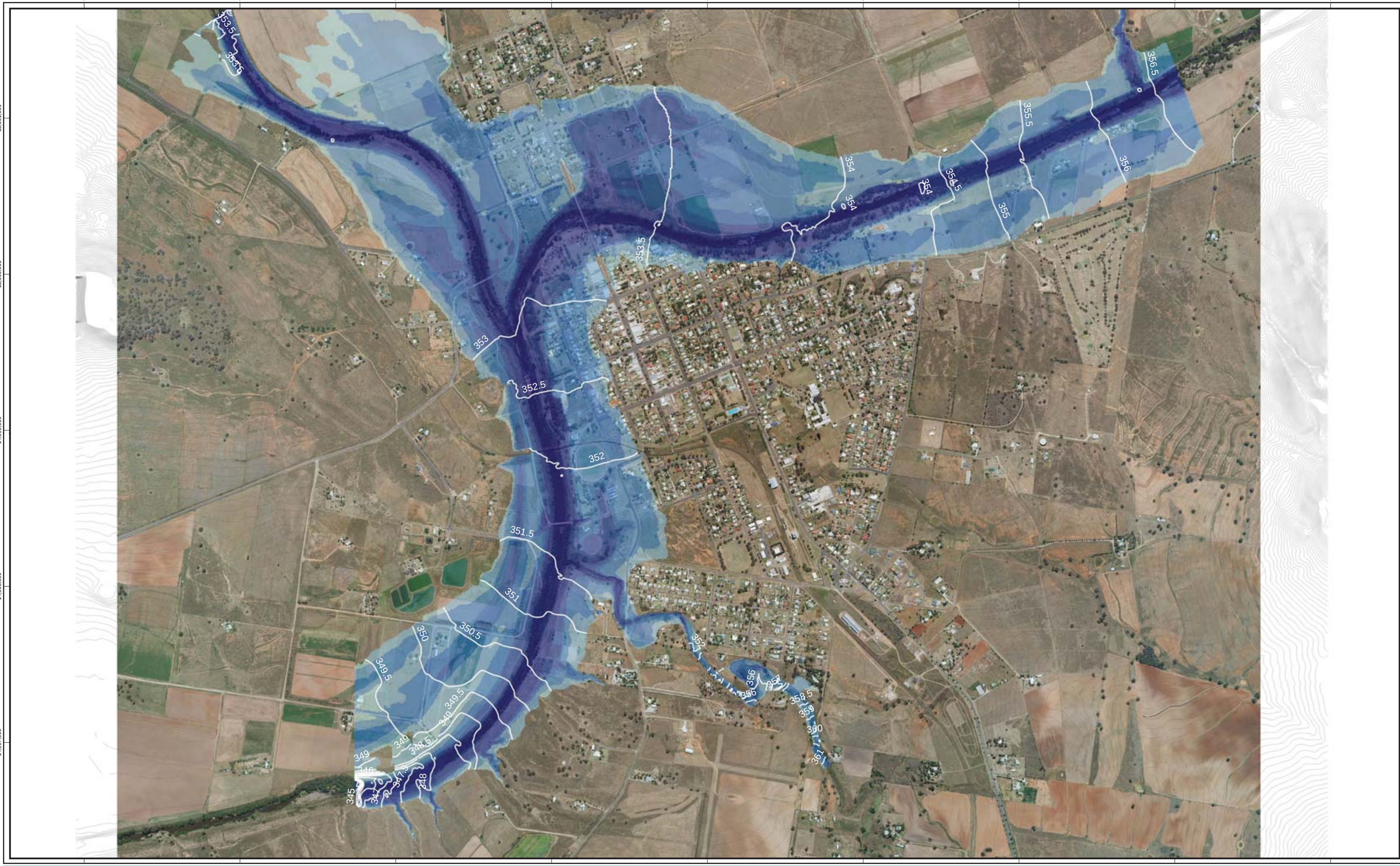
Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:



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0 75 150 300 450 600

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 56

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Flood Extent and Depth (m)

- 0.16 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 3.0
- 3.0 - 5.0
- 5.0 - 10.0
- 10.0 - 20.0

Flood Level Contours (mAHD)

Topo Contours (1m)

GHD

CLIENTS | PEOPLE | PERFORMANCE

Tamworth Regional Council
Manilla Flood Study

Flood Map
0.5% AEP Flood Event

Job Number	22-15815
Revision	A
Date	02.02.2012

Figure F.6.1

230 Harbour Drive Coffs Harbour NSW 2450 Australia T 61 2 6652 5600 F 61 2 6652 5601 E cfsmail@ghd.com.au W www.ghd.com.au

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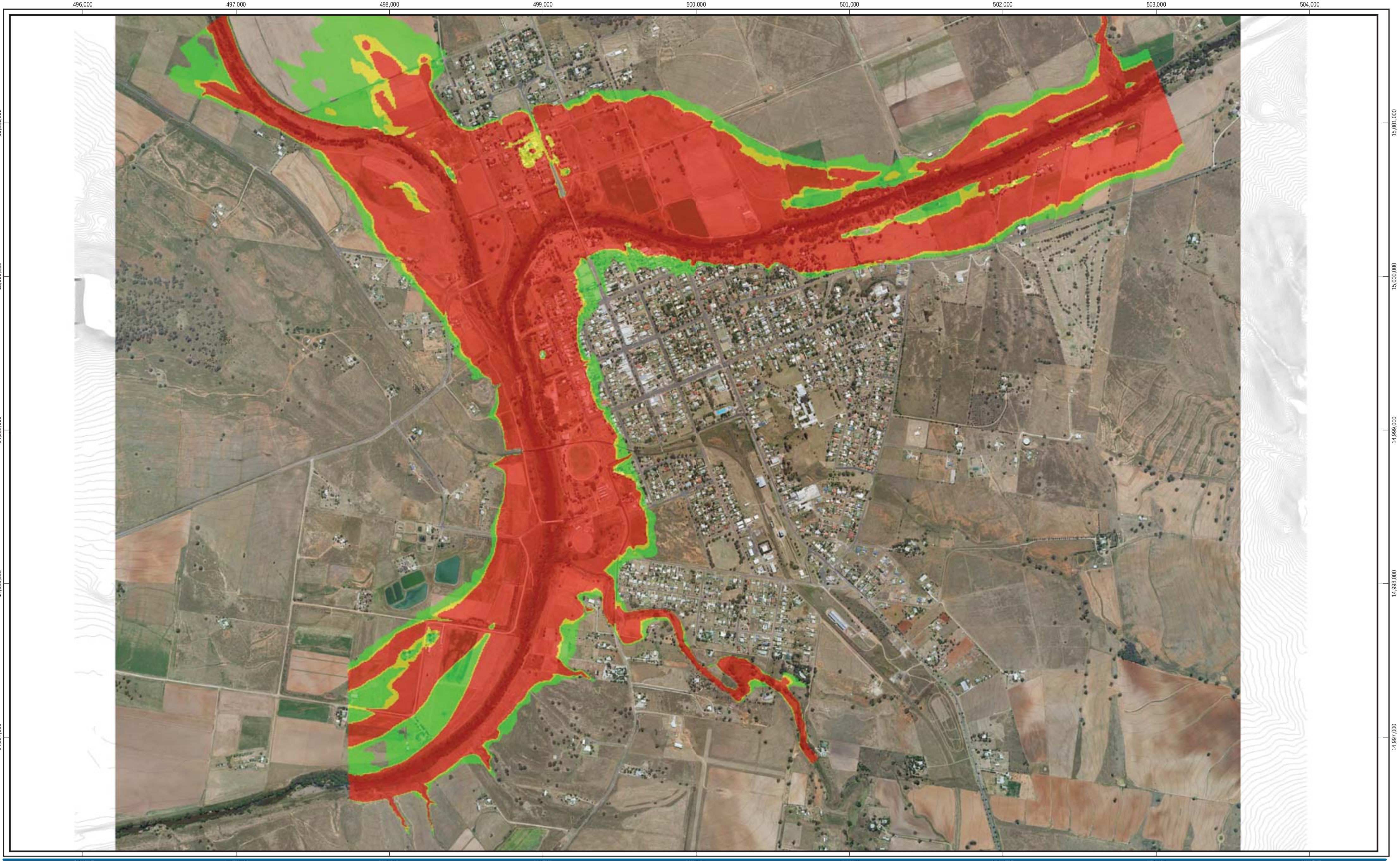
Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:



1:15,000

0 75 150 300 450 600

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 56

Flood Hazard

- 1 - Low Hazard
- 2 - Intermediate Hazard
- 3 - High Hazard
- Topo Contours (1m)

CLIENTS | PEOPLE | PERFORMANCE

Tamworth Regional Council
Manilla Flood Study

Flood Hazard Map
0.5% AEP Flood Event

Job Number	22-15815
Revision	A
Date	02.02.2012

Figure F.6.2

230 Harbour Drive Coffs Harbour NSW 2450 Australia **T** 61 2 6652 5600 **F** 61 2 6652 5601 **E** cfsmail@ghd.com.au **W** www.ghd.com.au

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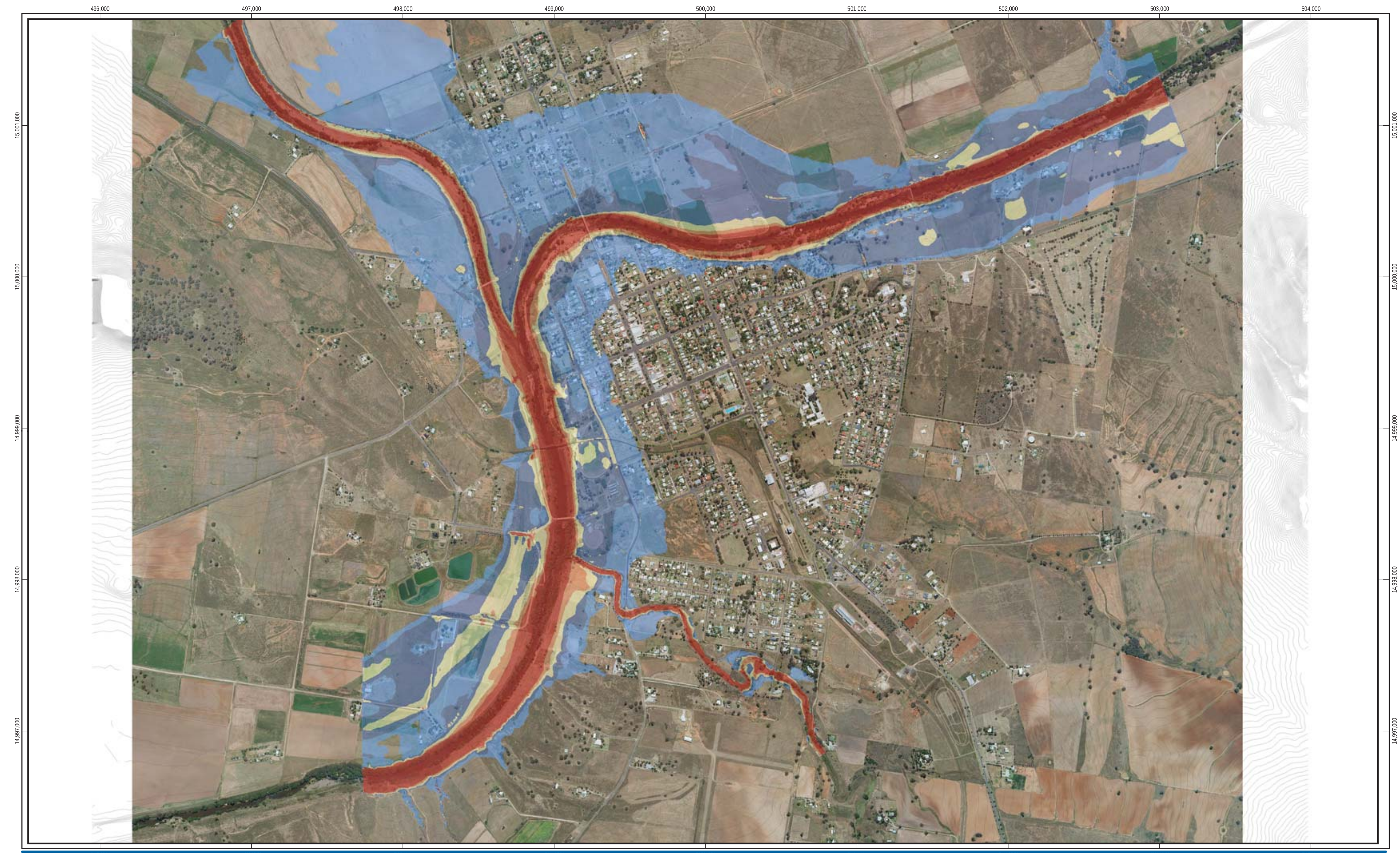
Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:



1:15,000

0 75 150 300 450 600

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 56

Flood Peak Velocity (m/s)

- 0 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- Greater than 2
- Topo Contours (1m)

CLIENTS | PEOPLE | PERFORMANCE

Tamworth Regional Council
Manilla Flood Study

Flood Velocity Map
0.5% AEP Flood Event

Job Number	22-15815
Revision	A
Date	02.02.2012

Figure F.6.3

230 Harbour Drive Coffs Harbour NSW 2450 Australia T 61 2 6652 5600 F 61 2 6652 5601 E cfsmail@ghd.com.au W www.ghd.com.au

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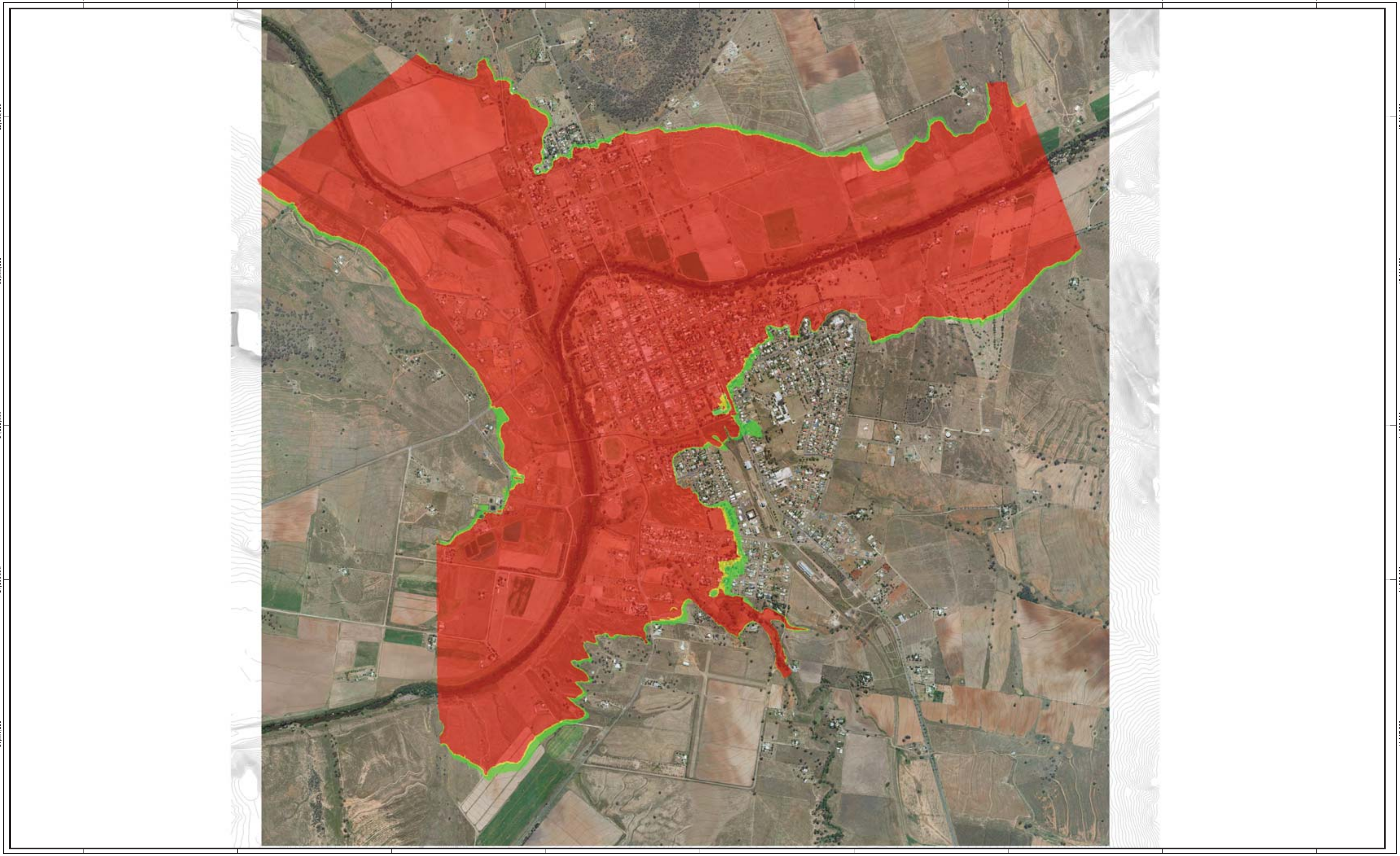
Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:



1:20,000

0 75 150 300 450 600

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 56

Flood Hazard

- 1 - Low Hazard
- 2 - Intermediate Hazard
- 3 - High Hazard
- Topo Contours (1m)

CLIENTS | PEOPLE | PERFORMANCE

Tamworth Regional Council
Manilla Flood Study

Flood Hazard Map
PMF Flood Event

Job Number	22-15815
Revision	A
Date	02.02.2012

Figure F.7.2

230 Harbour Drive Coffs Harbour NSW 2450 Australia T 61 2 6652 5600 F 61 2 6652 5601 E cfsmail@ghd.com.au W www.ghd.com.au

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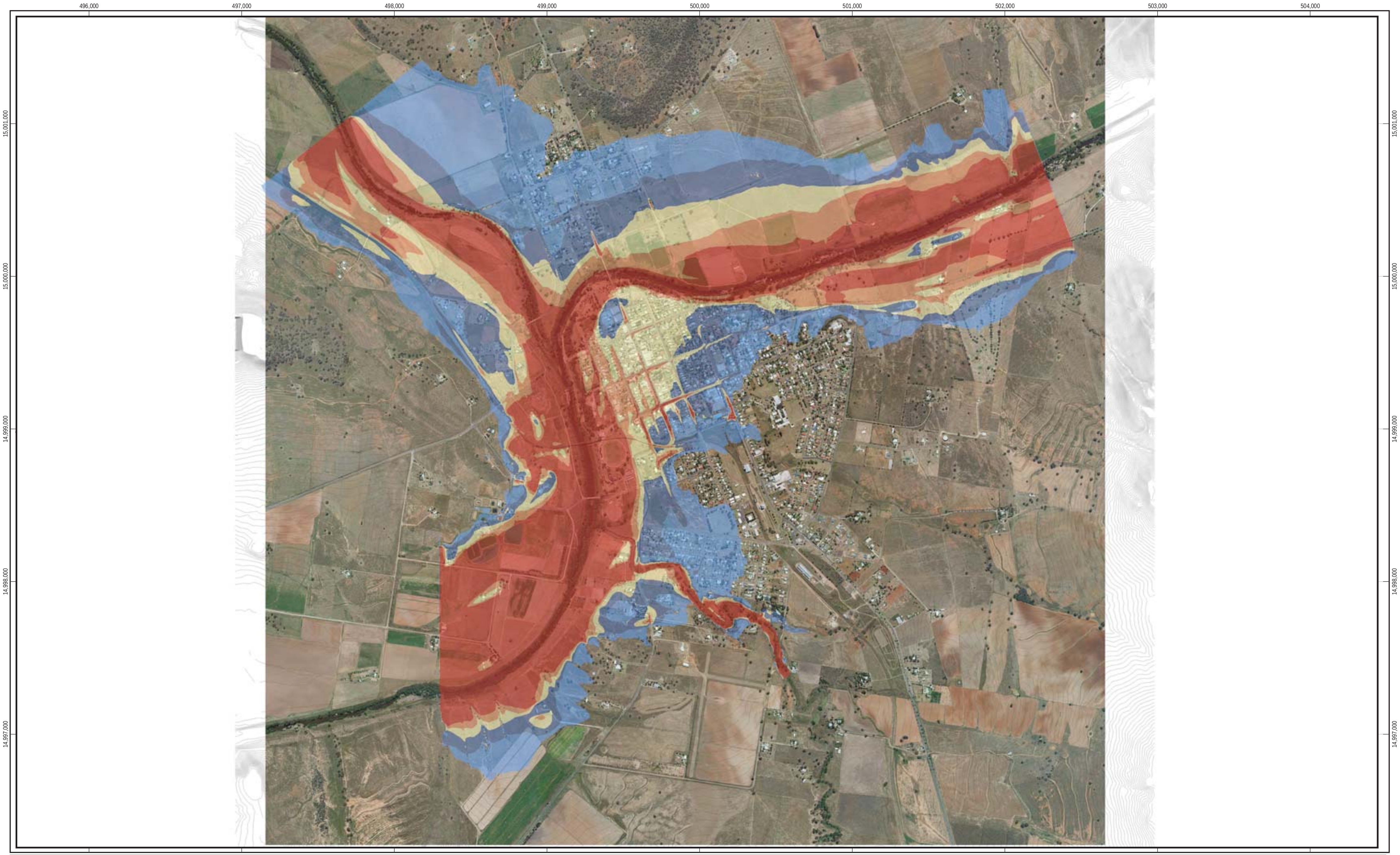
Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:



1:20,000

0 75 150 300 450 600

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 56

Flood Peak Velocity (m/s)

- 0 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- Greater than 2
- Topo Contours (1m)

GHD

CLIENTS | PEOPLE | PERFORMANCE

Tamworth Regional Council
Manilla Flood Study

Flood Velocity Map
PMF Flood Event

Job Number	22-15815
Revision	A
Date	02.02.2012

Figure F.7.3

230 Harbour Drive Coffs Harbour NSW 2450 Australia T 61 2 6652 5600 F 61 2 6652 5601 E cfsmail@ghd.com.au W www.ghd.com.au

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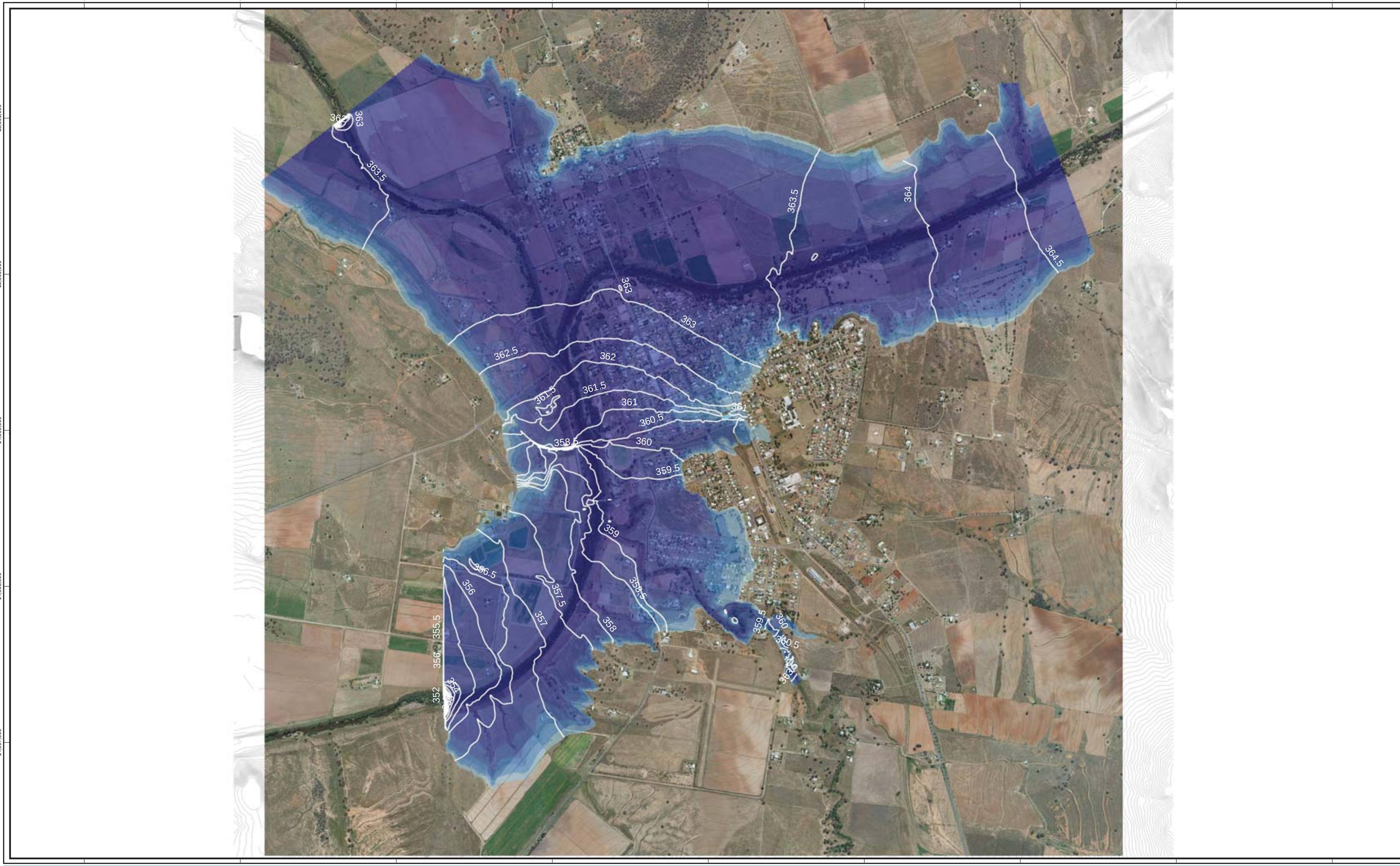
Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:



1:20,000

0 75 150 300 450 600
Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 56

Flood Extent and Depth (m)
- 0.16 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 3.0
- 3.0 - 5.0
- 5.0 - 10.0
- 10.0 - 20.0

- Flood Level Contours (mAHD)
- Topo Contours (1m)

CLIENTS | PEOPLE | PERFORMANCE

Tamworth Regional Council
Manilla Flood Study

Flood Map
PMF Flood Event

Job Number	22-15815
Revision	A
Date	02.02.2012

Figure F.7.1

N:\AU\Melbourne\Apps Resources\Local\ESRI\ArcGIS\Libraries_Templates\New_Templates_Rev3\Libraries_Templates\GHD-A3-LANDSCAPE TECH.mxt

230 Harbour Drive Coffs Harbour NSW 2450 Australia T 61 2 6652 5600 F 61 2 6652 5601 E cfsmail@ghd.com.au W www.ghd.com.au

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:

Appendix G

Sensitivity Assessments

1:15,000

0 75 150 300 450 600
Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 56

Change In Flood Depth (m)

-0.02 - 0	0.4 - 0.6	1.2 - 1.4	2.0 - 2.2
0 - 0.2	0.6 - 0.8	1.4 - 1.6	2.2 - 2.4
0.2 - 0.4	0.8 - 1	1.6 - 1.8	2.4 - 2.6
	1.0 - 1.2	1.8 - 2	Additional Innundation Area
			Topo Contours (1m)

CLIENTS | PEOPLE | PERFORMANCE

Tamworth Regional Council
Manilla Flood Study

Loss Sensitivity
1% AEP Flood Event

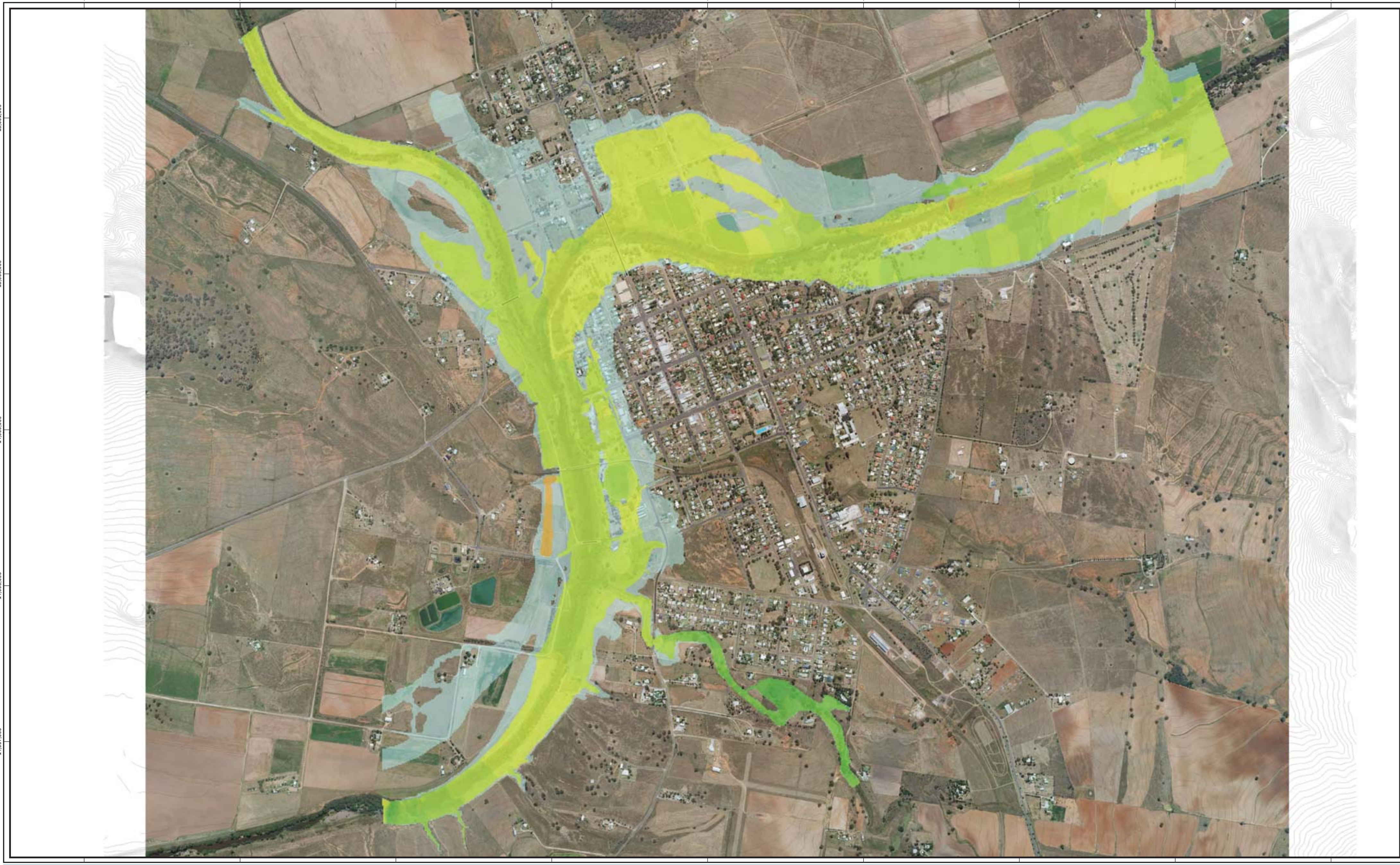
Job Number 22-15815
Revision A
Date 06.02.2012

Figure G.1

N:\AU\Melbourne\Apps Resources\Local\ESRI\ArcGIS\Libraries_Templates\New_Templates_Rev3\Libraries_Templates\GHD-A3-LANDSCAPE TECH.mxt

230 Harbour Drive Coffs Harbour NSW 2450 Australia **T** 61 2 6652 5600 **F** 61 2 6652 5601 **E** cfsmail@ghd.com.au **W** www.ghd.com.au

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:



1:15,000

0 75 150 300 450 600

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 56

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Change In Flood Depth (m)			
-0.02 - 0	0.4 - 0.6	1.2 - 1.4	2.0 - 2.2
0 - 0.2	0.6 - 0.8	1.4 - 1.6	2.2 - 2.4
0.2 - 0.4	0.8 - 1	1.6 - 1.8	2.4 - 2.6
	1.0 - 1.2	1.8 - 2	Additional Innundation
			Topo Contours (1m)

CLIENTS | PEOPLE | PERFORMANCE

Tamworth Regional Council
Manilla Flood Study

Mannings n Sensitivity
1% AEP Flood Event

Job Number 22-15815
Revision A
Date 06.02.2012

Figure G.2

230 Harbour Drive Coffs Harbour NSW 2450 Australia T 61 2 6652 5600 F 61 2 6652 5601 E cfsmail@ghd.com.au W www.ghd.com.au

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Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:

1:15,000

0 75 150 300 450 600

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 56

Change in Flood Depth (m)

- >-1
- -1.0 - -0.5
- -0.5 - -0.4
- -0.4 - -0.3
- -0.3 - -0.2
- -0.2 - -0.1
- -0.1 - -0.01
- -0.01 - -0.005
- -0.005 - -0.0025
- -0.0025 - -0.001
- -0.001 - +0.001
- +0.001 - +0.0025
- +0.0025 - +0.005
- +0.005 - +0.01
- +0.01 - +0.05
- +0.05 - +0.1
- +0.1 - +0.2
- +0.2 - +0.3
- +0.3 - +0.4
- +0.4 - +0.5
- +0.5 - +1
- Additional Innundation Area
- Topo Contours (1m)

CLIENTS | PEOPLE | PERFORMANCE

Tamworth Regional Council
Manilla Flood Study

Blockage Sensitivity 1% AEP Flood Event

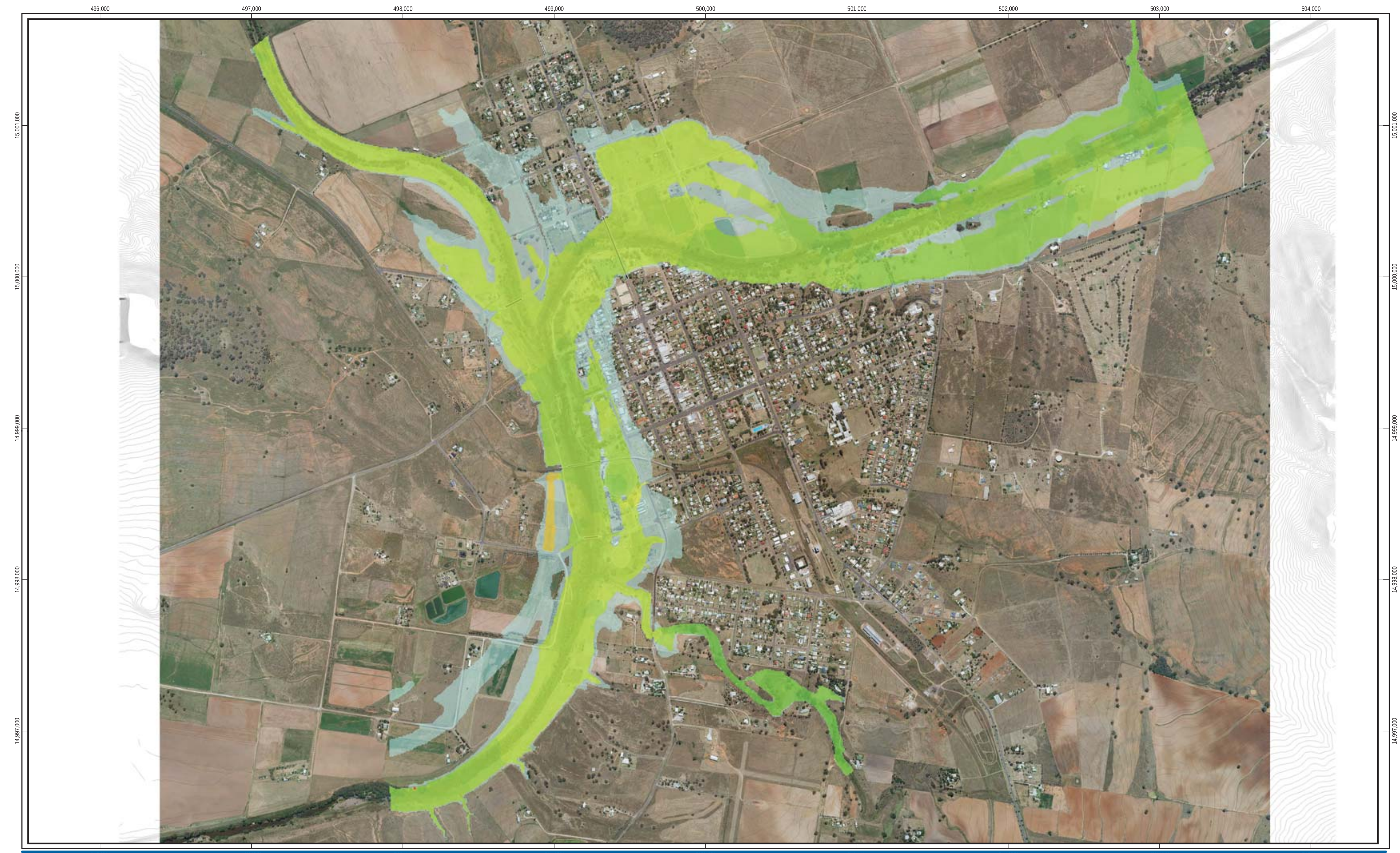
Job Number	22-15815
Revision	A
Date	23.02.2012

Figure G.3

N:\AU\Melbourne\Apps Resources\Local\ESRI\ArcGIS\Libraries_Templates\New_Templates_Rev3\Libraries_Templates\GHD-A3-LANDSCAPE TECH.mxt

230 Harbour Drive Coffs Harbour NSW 2450 Australia T 61 2 6652 5600 F 61 2 6652 5601 E cfsmail@ghd.com.au W www.ghd.com.au

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:



1:15,000

0 75 150 300 450 600
Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 56

Change In Flood Level (m)

- -0.02 - 0
- 0 - 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1
- 1.0 - 1.2
- 1.2 - 1.4
- 1.4 - 1.6
- 1.6 - 1.8
- 1.8 - 2
- 2.0 - 2.2
- 2.2 - 2.4
- 2.4 - 2.6
- Additional innundation
- Topo Contours (1m)

GHD
CLIENTS | PEOPLE | PERFORMANCE

Tamworth Regional Council
Manilla Flood Study

Climate Change Sensitivity (10%) 1% AEP Flood Event

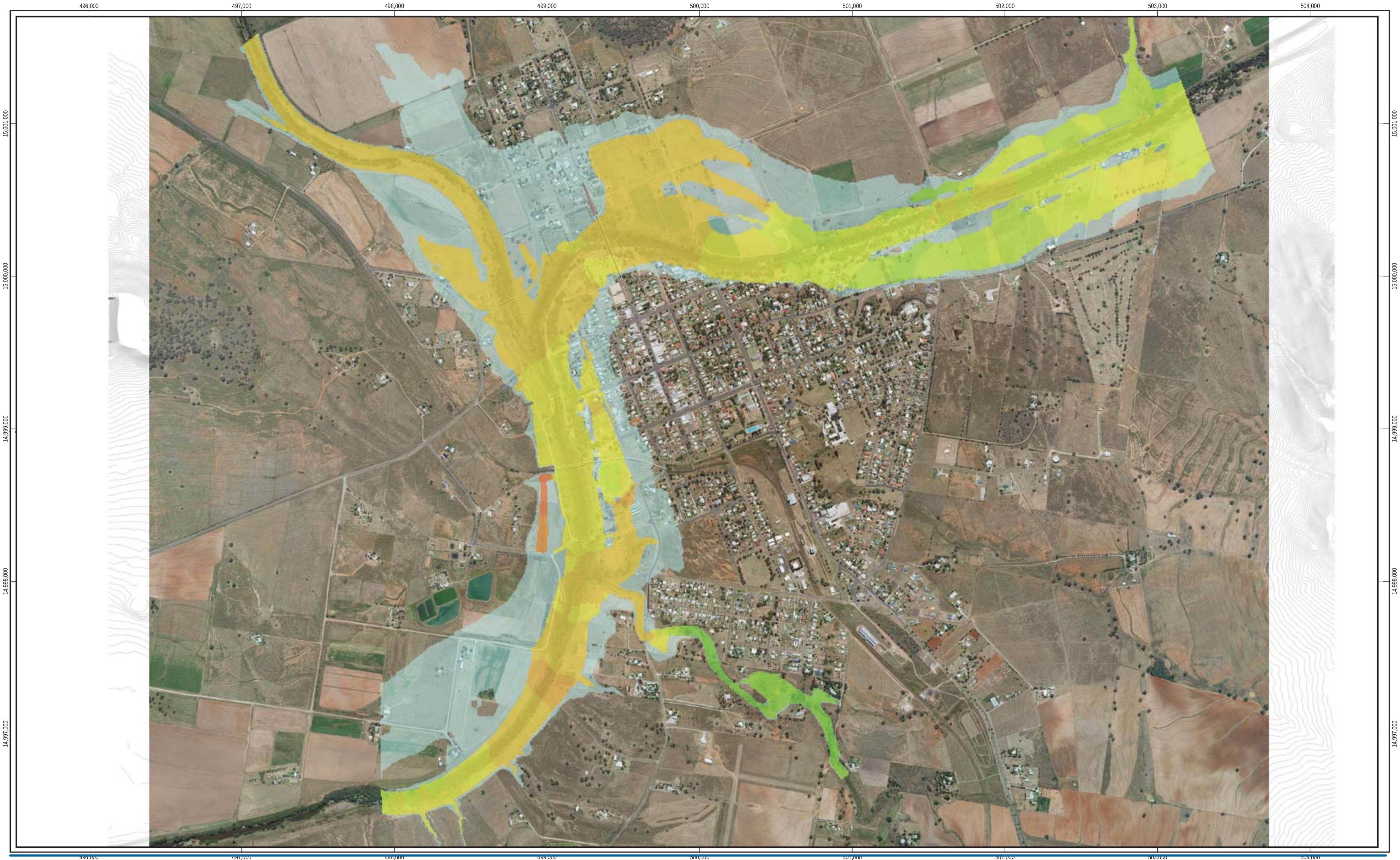
Job Number	22-15815
Revision	A
Date	06.02.2012

Figure G.4

230 Harbour Drive Coffs Harbour NSW 2450 Australia T 61 2 6652 5600 F 61 2 6652 5601 E cfsmail@ghd.com.au W www.ghd.com.au

N:\AU\Melbourne\Apps Resources\Local\ESRI\ArcGIS\Libraries_Templates\New_Templates_Rev3\Libraries_Templates\GHD-A3-LANDSCAPE TECH.mxt

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:



1:15,000

0 75 150 300 450 600

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 56

O

Change in Flood Depth (m)

-0.02 - 0	0.4 - 0.6	1.2 - 1.4	2.0 - 2.2
0 - 0.2	0.6 - 0.8	1.4 - 1.6	2.2 - 2.4
0.2 - 0.4	0.8 - 1	1.6 - 1.8	2.4 - 2.6
	1.0 - 1.2	1.8 - 2	Additional Innundation Area
			Topo Contours (1m)

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Tamworth Regional Council
Manilla Flood Study

Climate Change Sensitivity (20%) 1% AEP Flood Event

Job Number	22-15815
Revision	A
Date	06.02.2012

Figure G.5

N:\AU\Melbourne\Apps Resources\Local\ESRI\ArcGIS\Libraries_Templates\New_Templates_Rev3\Libraries_Templates\GHD-A3-LANDSCAPE TECH.mxt

230 Harbour Drive Coffs Harbour NSW 2450 Australia T 61 2 6652 5600 F 61 2 6652 5601 E cfsmail@ghd.com.au W www.ghd.com.au

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:

1:15,000

0 75 150 300 450 600

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 56

O

Change in Flood Depth (m)

-0.02 - 0	0.4 - 0.6	1.2 - 1.4	2.0 - 2.2
0 - 0.2	0.6 - 0.8	1.4 - 1.6	2.2 - 2.4
0.2 - 0.4	0.8 - 1	1.6 - 1.8	2.4 - 2.6
	1.0 - 1.2	1.8 - 2	Additional Innundation Area
			Topo Contours (1m)

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Tamworth Regional Council
Manilla Flood Study

Climate Change Sensitivity (30%) 1% AEP Flood Event

Job Number 22-15815
Revision A
Date 06.02.2012

Figure G.6

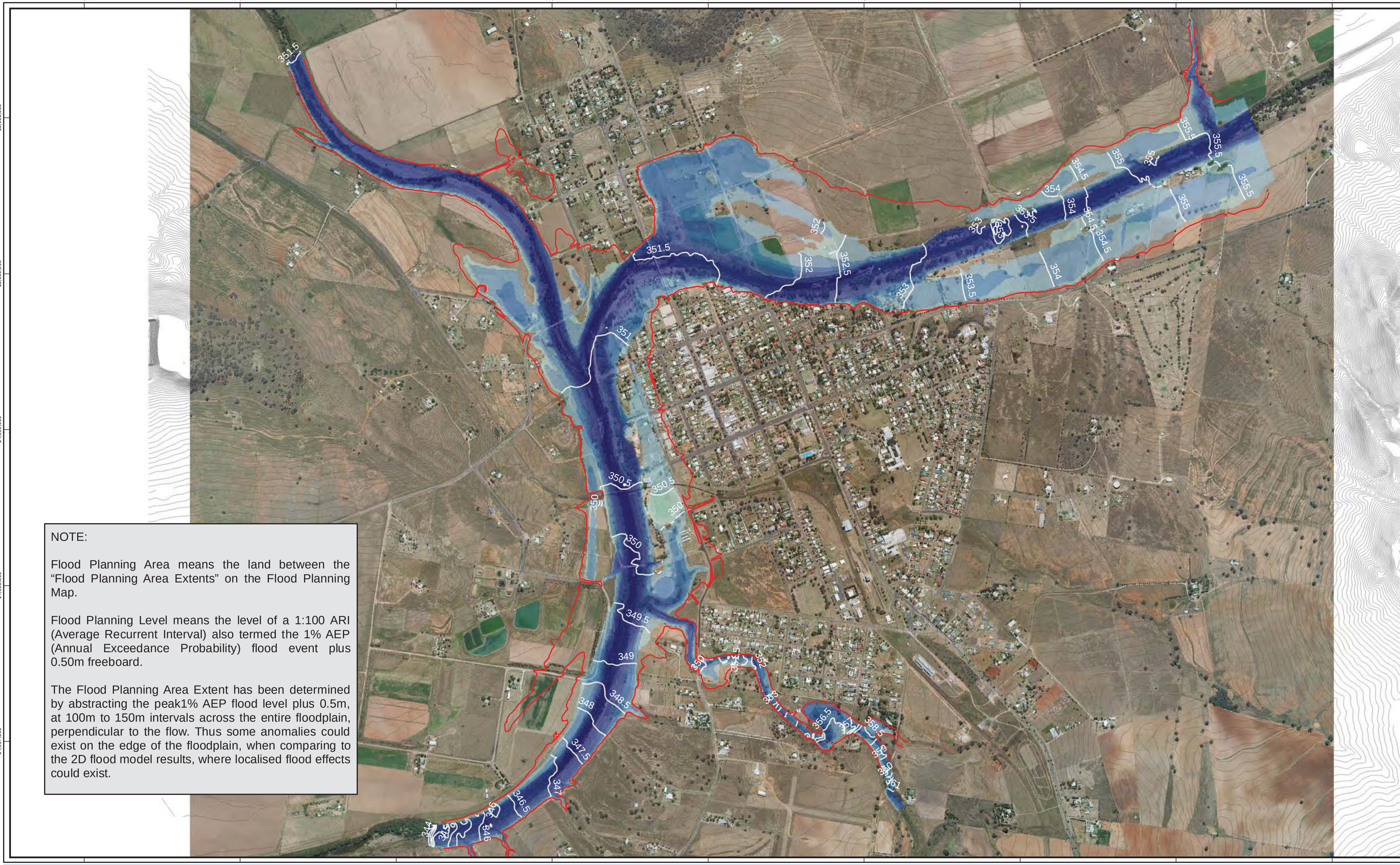
N:\AU\Melbourne\Apps Resources\Local\ESRI\ArcGIS\Libraries_Templates\New_Templates_Rev3\Libraries_Templates\GHD-A3-LANDSCAPE TECH.mxt

230 Harbour Drive Coffs Harbour NSW 2450 Australia T 61 2 6652 5600 F 61 2 6652 5601 E cfsmail@ghd.com.au W www.ghd.com.au

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:

Appendix H

Flood Planning Map



NOTE:

Flood Planning Area means the land between the "Flood Planning Area Extents" on the Flood Planning Map.

Flood Planning Level means the level of a 1:100 ARI (Average Recurrent Interval) also termed the 1% AEP (Annual Exceedance Probability) flood event plus 0.50m freeboard.

The Flood Planning Area Extent has been determined by abstracting the peak1% AEP flood level plus 0.5m, at 100m to 150m intervals across the entire floodplain, perpendicular to the flow. Thus some anomalies could exist on the edge of the floodplain, when comparing to the 2D flood model results, where localised flood effects could exist.

1:15,000

0 75 150 300 450 600

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 56

Legend:

Flood Extent and Depth (m)

- 0.1 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 3.0
- 3.0 - 5.0
- 5.0 - 10.0
- 10.0 - 20.0
- Flood Level Contours (mAHD)
- Flood Planning Area Extents
- Topo Contours (1m)

GHD

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Tamworth Regional Council
Manilla Flood Study

Flood Planing Map
100-Year Flood Event

Job Number	22-15815
Revision	A
Date	09.05.2012

Figure H.1

230 Harbour Drive Coffs Harbour NSW 2450 Australia T 61 2 6652 5600 F 61 2 6652 5601 E cfsmail@ghd.com.au W www.ghd.com.au

N:\AU\Melbourne\Apps Resources\Local\ESRI\ArcGIS\Libraries_Templates\New_Templates_Rev3\Libraries_Templates\GHD-A3-LANDSCAPE TECH.mxt

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:

Appendix I

QA Documentation

Baxter Geo Consulting Pty Ltd
Surveying - Development Planning & Co-ordination
ACN: 103 579 335 ABN : 63 323 316 716

2/13 Hill Street
TAMWORTH NSW 2340

please address all correspondence to
PO Box 1402 TAMWORTH NSW 2340

Ph 02 6766 6499
Fax 02 6766 6599
Mob: 0418 401 802

general: okbaxter@baxtergeo.com
writers email: peter@baxtergeo.com

Our Ref: 0486
File Location: Z:\0486 Manilla Flood Study\Doc\0486-120130 GHD Manilla Quality Doc.docx

Your Ref: Manilla Flood Study

30th January 2012.

The General Manager
Tamworth Regional Council
P.O. Box 555
TAMWORTH NSW 2340

Dear Sir,

Re: Quality Control Manilla Flood Study – Joint Venture Aerometrex, Baxter Geo & GHD

Survey Control

Establish Survey Control

A SCIMS search was undertaken on 5th September 2011 to locate reliable Survey Control in the town of Manilla. PM142521 each being of Class A Order 1 Horizontal and Class B Order 2 Vertical was chosen as the control station for all survey work.

A GNSS base station and eccentric check station were established on the SCIMS co-ordinates and the primary control measured using two rovers, each on a range pole with bi-pod set at different heights. This methodology provides an independent check on heights. Measurements were made to PM 12834 (Class A Order 1 Horizontal – Class LC Order L3 Vertical), PM74722 (Class A Order 1 Horizontal – Class B Order 2 Vertical), PM117815 (Class A Order 1 Horizontal – Class B Order 2 Vertical), and PM151659 (Class A Order 1 Horizontal – Class B Order 2 Vertical). There was good agreement with the SCIMS data base and our initial calibration survey.

Mark	Mean Ovsevation			SCIMS					
	Easting	Northing	AHD	Easting	Northing	AHD	dE	dN	dH
PM142521	280223.213	6596881.885	359.132	280223.213	6596881.885	359.132			
PM 151659	280375.589	6595596.884	370.549	280375.579	6595596.879	370.552	-0.009	-0.005	0.003
PM12834	281739.410	6597226.378	352.586	281739.407	6597226.383	352.600	-0.003	0.005	0.014
PM 74722	282919.498	6595107.700	371.796	282919.504	6595107.704	371.776	0.006	0.004	-0.020
PM 117815	281795.090	6594655.660	357.603	281795.078	6594655.671	357.628	-0.012	0.011	0.026

The largest difference shown at PM117815 is over a distance of 2725.23m and represents an accuracy of 1:170,327 in distance and 1:104,815 in height.

Eccentric Control Station

The co-ordinates of the eccentric control station were documented and on each subsequent survey a check measurement was taken to the eccentric station at the beginning and end of each day. The check co-ordinates were compared to establish no errors were made in setting up the base station each day and that the base station had not been disturbed or tampered with during the days observations.

Establish Photo Control

Aerometrex required photo control points to be established in six areas. An RTK survey was undertaken with two rovers set at different heights. A minimum of two control points (each determined by observations using two rovers) were taken in each of the six areas. This gave a redundancy of 100% for Aerometrex.

Establish Quality Control

During the control survey a GNSS rover was fixed to the top of the car and random measurements at an approximate interval of 50m spacing.

Control Data was forwarded to Aerometrex for processing.

Processed Photogrammetric Data

Aerometrex supplied digital data which was read into AutoCAD Civil 3D. The data was processed and a Digital Terrain Model created.

Checking and Quality Control

The random heights were placed in the model and a data set of heights on the DTM for those points calculated. A total of 208 points were analysed. Of these points 133 points agreed to better than 0.15m. A further 57 points were in the range 0.15m to 0.3m The remaining points were analysed visually to determine why larger difference were calculated. It is our conclusion the larger differences are due to the location of the check points being inappropriate, eg on the crown of a dirt road etc.

It is our opinion the data supplied by Aerometrex and the subsequent DTM is superior to what could be achieved by conventional ground survey. The anomalies mentioned above are not considered significant in the overall accuracy of the DTM for the purpose calculating water levels over a large area. A large number of points with a lower accuracy (X, Y, Z) and breaklines lines will provide a more superior DTM than a low number with highly accurate points (X, Y, Z). It is our opinion the aerial photography and the subsequent DTM are suitable for the purpose.

Additional Information

Additional survey data was required to be collected by ground survey. This data included existing flood heights and bridges. This data was collected by GNSS and total station measurements. The Leica TPS 1200 instrument used to collect the data allows all total station measurements to be collected in MGA 56 in the same file as the GNSS data. Each total station setup was compared to control points in the GNSS data base at the beginning of each observation epoch.

A separate file containing the 3D models bridges was created and supplied to GHD.

Supply of data to GHD

The electronic data was supplied by FTP to GHD.

Floor Level Survey

A data set containing the 1:100 and PMF flood lines was provided to Baxter Geo by GHD. This data was loaded into the model and a series of field sheets produced to identify the floor levels required to be measured.

Floor levels were determined using GNSS and a laser level. The system was checked prior to field survey to ensure accuracy. The initial check showed what we believe to be a collimation error in the laser level. A new laser level was obtained and a further field check undertaken to confirm accuracy. This check proved satisfactory and the field survey was then undertaken using the previous GNSS control station and the eccentric control station. During the course of the floor level survey, measurements were taken to known points and the values of the GNSS / laser level survey compared. All results showed good agreement. We are of the opinion our levels determined by this method are good to 0.05m or better.

The greatest source of uncertainty in determining the floor levels is picking a point on the outside of the building that is representative of the floor level inside. Our instruction was to determine the floor levels within +/- 0.1m. We are of the opinion that this criteria has been satisfactorily met.

Each measurement with the laser level was measured in metres and inches. Each value was entered into the data recorder. The observed inches were converted to metres on a handheld calculator and compared to the reading in metres entered into the data recorder before the data was stored. This methodology provided quality control in the field.

The GNSS and level observations were downloaded and converted to an Excel spreadsheet. The processed data was then read into the Civil 3D model and a visual check made against the aerial photography. This was then checked against a data file of Manilla showing the cadastral layout and street numbers supplied by Tamworth Regional Council. A number of amendments to the addressing collected in the field were required to be made to be consistent with Council's data set.

The processed floor levels were exported to an Excel spreadsheet and this was supplied to GHD as a Excel spreadsheet and a pdf print of the file.

Personnel

All surveys were undertaken by the undersigned with the assistance of Dan Whale who is a competent field assistant and a qualified town planner.

Yours faithfully

Peter J Baxter *B.Surv M.I.S(NSW) S.S.S.I.*
Registered Surveyor / Licensed Strata Managing Agent
for Baxter Geo Consulting Pty. Ltd.

GHD JFlow QA Documentation

2215816	TRC - Barraba Flood Study (T074/2011)	James McPherson	Rainer Berg	93,237	Active	28/02/2012

- DELIVERABLE: Calculations - Barraba RORB model check : Completed on 15/05/2012
  - REVIEW: Online Review - Michelle S Kan : Completed on 01/03/2012
    - CHECKSHEET: Calculations - Michelle S Kan : Completed on 01/03/2012
- DELIVERABLE: Calculations - Barraba Tuflow Model Check : Completed on 15/05/2012
  - REVIEW: Online Review - Michelle S Kan : Completed on 01/03/2012
    - CHECKSHEET: Calculations - Michelle S Kan : Completed on 01/03/2012
- DELIVERABLE: Reports - Barraba Flood Study Report : Due on 01/03/2012
  - REVIEW: Authorised Person to Sign - Rainer Berg : Completed on 15/05/2012
  - REVIEW: Authorised Person to Sign - Rainer Berg : Completed on 15/05/2012
- JOB REVIEW: 15% Job Review : Completed on 31/08/2011 by Rainer Berg
  - CHECKSHEET: 15% Job Review - by Rainer Berg due 09/09/2011 - completed on 31/08/2011
- Risk: Not meeting completion date of 28 Feb 2012 - Complete
- Risk: Package to include three studies. Will need high level of support and success will depend on availabilty of key personnel. - Complete
- Risk: Project Environmental Imapct - Complete
- Risk: Survey infomation incompatability - Complete
- SUBCONSULTANT: Aerometrex Pty Ltd - PI Current; PL Current; Registration None
- SUBCONSULTANT: Baxter Geo Consulting Pty Ltd - PI Current; PL Current; Registration None

2215815	TRC - Manilla Flood Study (T073/2011)	James McPherson	Rainer Berg	98,807	Active	28/02/2012

- DELIVERABLE: Calculations - Catchment Delineation : Completed on 15/05/2012
  - REVIEW: Signed Check to be Kept on File - Samuel L Douglas : Completed on 29/02/2012
- DELIVERABLE: Calculations - RORB model Check : Completed on 15/05/2012
  - REVIEW: Online Review - Michelle S Kan : Completed on 01/03/2012
    - CHECKSHEET: Calculations - Michelle S Kan : Completed on 01/03/2012
- DELIVERABLE: Calculations - tuflow model : Completed on 15/05/2012
  - REVIEW: Online Review - Michelle S Kan : Completed on 01/03/2012
    - CHECKSHEET: Calculations - Michelle S Kan : Completed on 01/03/2012
- DELIVERABLE: Reports - Flood Study Report : Due on 01/03/2012
  - REVIEW: Authorised Person to Sign - Rainer Berg : Completed on 15/05/2012
  - REVIEW: Authorised Person to Sign - Rainer Berg : Completed on 15/05/2012
- JOB REVIEW: 15% Job Review : Completed on 31/08/2011 by Rainer Berg
  - CHECKSHEET: 15% Job Review - by Rainer Berg due 09/09/2011 - completed on 31/08/2011
- JOB REVIEW: Project Review Group (PRG) Review : Completed on 15/05/2012 by Rainer Berg
- Risk: Environmental impact - Complete
- Risk: Not meeting completion date of 28 Feb 2012 - Complete
- Risk: Survey infomation incompatability - Complete
- SUBCONSULTANT: Aerometrex Pty Ltd - PI Current; PL Current; Registration None
- SUBCONSULTANT: Baxter Geo Consulting Pty Ltd - PI Current; PL Current; Registration None

aerometrex
ABN 94 153 103 925
Digital Mapping Specialists
www.aerometrex.com.au

Adelaide Office: 413 Magill Road, St. Morris SA 5068
Contact: Todd Dunow – Senior Account Manager
T: (08) 8361 3111 Mobile: 0419 712 897
E: todd.dunow@aerometrex.com.au

Project Reference: A3177 Manilla 2011

15 May 2012

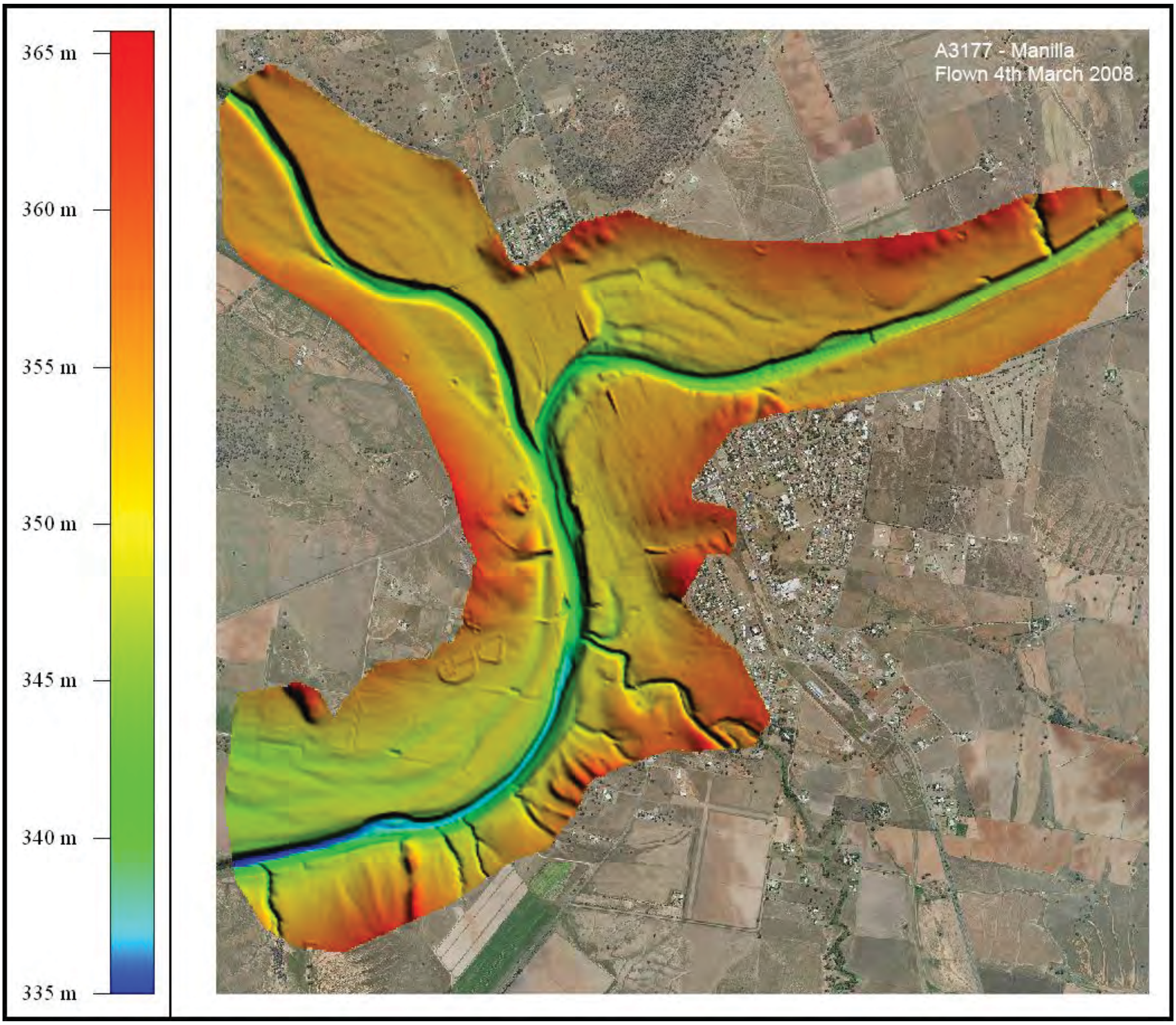
Dr. Rainer Berg
GHD
230 Harbour Drive
Coffs Harbour NSW 2450

Dear Rainer,

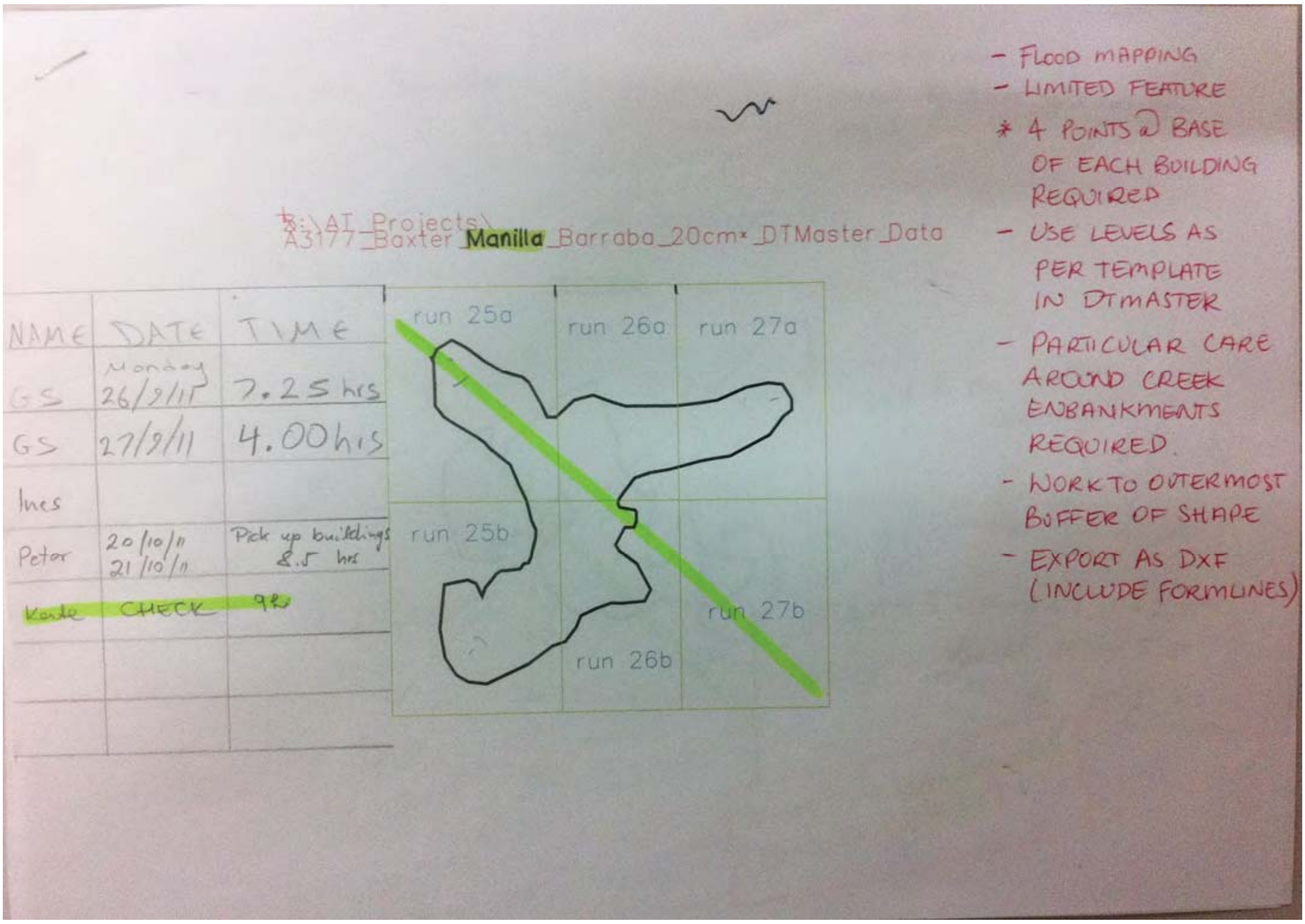
Please find below survey specifications, accuracy statements & quality control check sheets for the aerial survey Aerometrex conducted over the township of Manilla in October 2011.

Survey Reference: A3177 Manilla

Overview:

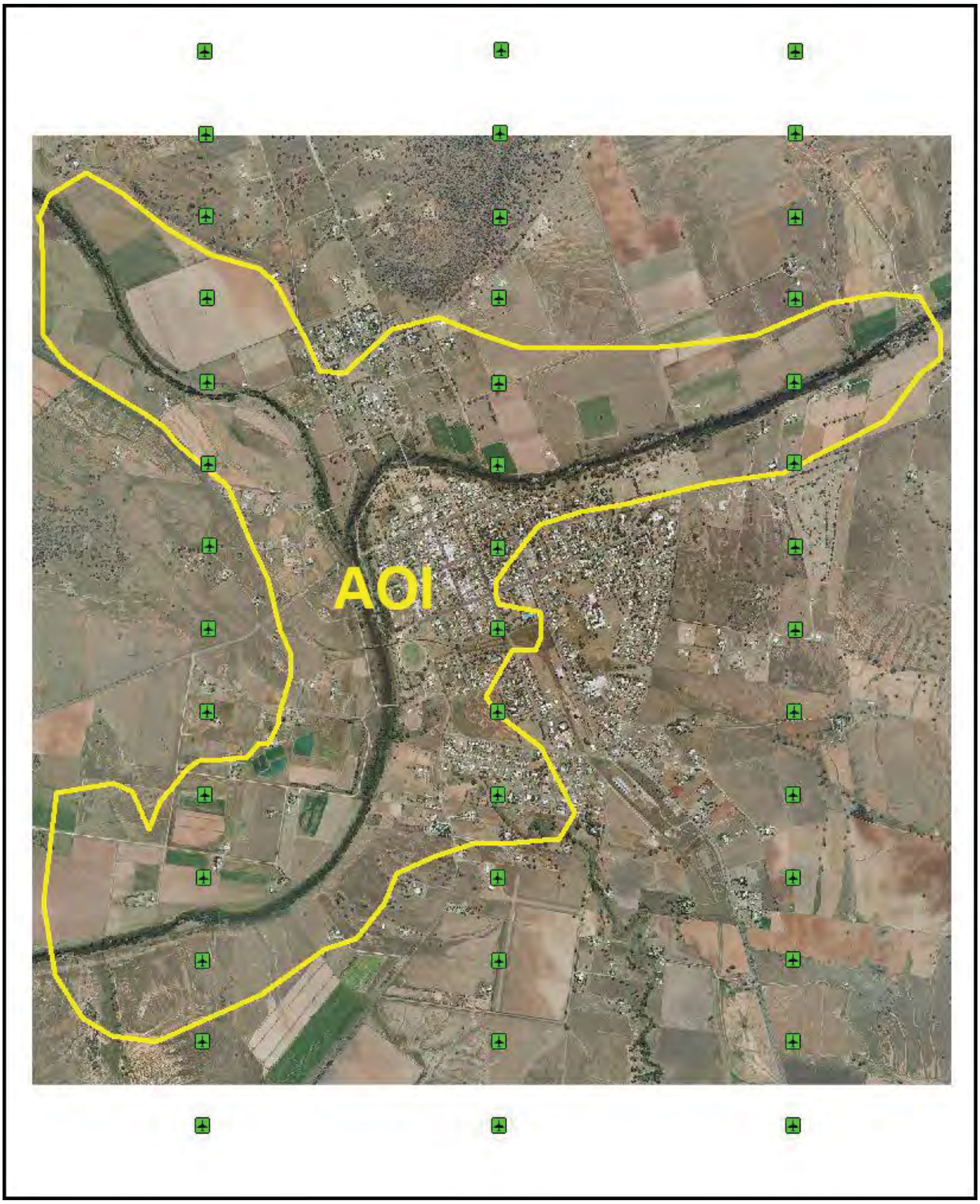


Quality Control Sheet:



Survey Details:

Flown – 5th March 2008
Plane – Conquest VH-VEW
Capture Height – Approx. 8800 Feet
Number of Runs – 3
Number of Frames - 45
Direction of Runs – North / South
Ground Sample Distance – 20cm
Forward frame overlap: 70%
Side frame overlap: 30%



Sensor Details:

Sensor – Vexcel Ultracam D, Large Format Mapping Camera – UCD-SU-1-0047
Focal Length: 105.200mm
Image Extent: (-33.75, -51.75)mm (33.75, 51.75)mm
Image Format: 7500 pixels (width) x 11500 pixels (height)
Pixel Size: 9.000 micron x 9.000 micron
PPA: X_ppa = -0.000 mm , Y_ppa = 0.180 mm
Please refer to included document "Calib-Report_0047_V10_short.pdf"

The sensor used in this survey was fully calibrated in Dec 2006.

Flight Report:

AEROmetrex Pty Ltd
ABN 19 438 552 201
Mapping Specialists
Web: www.aerometrex.com.au

AIR PHOTOGRAPHY REPORT
Times in UTC

Camera Type - Vexcel UltraCam	Calibrated FL - 105.2mm	Date - 05MAR08A	Possible Images - 1337
Capture Time Interval 3.9s	GPS Base Station Tamworth ARP	Pilot - George Scott	Navigator - John Murphy
Max Aircraft Speed 220kts	Data Download Time -	Aircraft Registration - VH-VEW	Aircraft Time - 042200 - 050203

JOB NO.	PROJECT	GSD	AMSL(ft)	RUN No.	DIRECTION	START_SU	START_Wpt	END_SU	END_Wpt	Comments
A2705	Tamworth	20	9635	26	181	78935	010	78944	001	OK
				25	001	78945	001	78985	041	OK
				24	181	78986	041	79026	001	OK
			9730	1	091	79027	001	79096	070	OK
				2	271	79097	070	79166	001	OK
				3	091	79167	001	79236	070	OK
				4	271	79237	070	79306	001	OK
				5	091	79307	001	79376	070	OK
				6	271	79377	070	79446	001	OK
				7	091	79437	001	79516	070	OK
			9665	8	271	79517	070	79586	001	OK
				9	091	79587	001	79656	070	OK
				10	271	79657	070	79726	001	OK
				11	091	79727	001	79796	070	OK
				12	271	79797	070	79866	001	OK
			9305	22	001	79867	001	79878	012	OK
				23	181	79879	012	79890	001	OK
			8815	19	181	79891	014	79904	001	OK
				20	001	79905	001	79918	014	OK
				21	181	79919	014	79932	001	OK

Survey Accuracy:

The table below defines the accuracy Aerometrex is able to quote and obtain from this survey. The highest quality equipment combined with hundreds of surveys of experience allows Aerometrex to confidently quote these accuracies. Numerous cross checking techniques are employed, additional surveys over the Manilla township were used in one checking procedure.

Aerometrex has considerable resources and time over the past 10 years in research and development proving its ability to conform to specified accuracies.

Accuracy	20cm pixel resolution

Horizontal (Point)	+/- 0.20m RMSE
Horizontal (Ortho)	+/- 0.40m RMSE
Vertical (With BGC ground survey inputs)	+/- 0.17m (68% c.i., 1σ) +/- 0.34m (95% c.i., 2σ)

The above vertical accuracies were obtained by incorporating ground control supplied by Baxter Geo Consulting.

Supplied data details:

10m spacing gridded DTM with breaklines.
10m spacing gridded DTM with breaklines converted to breakpoints every 1m.
1m Contours in dxf format.
4 DTM Points around the base of all buildings.

Please do not hesitate to contact me if any more information is required.

Yours sincerely,

Todd Dunow
Senior Account Manager
Aerometrex Pty Ltd.

aerometrex
Aerial Survey and Mapping Specialists
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GHD

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Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
EARLYDRAFT	S Douglas/R Berg	R Berg		R Berg		17/01/2012
DRAFT	S Douglas/R Berg	R Berg		R Berg		07/02/2012
FINAL DRAFT	S Douglas/R Berg	R Berg		R Berg		27/02/2012
FINAL	S Douglas/R Berg	R Berg		R Berg		25/04/2012