Cardno LawsonTreloar

Shaping the Future

PROPOSED RURAL RESIDENTIAL SUBDIVISION ON MOLONEY

March 2007
Job No. LJ8709R1_V1

SMK Irrigation Consultants Pty Ltd

Cardno Lawson Treloar Pty Ltd

ABN 55 001 882 873

Ground Floor, 9 Gardner Close

Milton Queensland 4064

PO Box 388 Toowong

Queensland 4066 Australia

Telephone: 07 3310 2455

Facsimile: 07 3369 9722

International: +61 7 3310 2455

cltqld@cardno.com.au

www.cardno.com.au

Document Control

Version	Date	Author		Reviewer		Approved	
		Name	Initials	Name	Initials	Name	Initials
1	2 May 2007	W. Turkensteen	WLT	J. McArthur	JMcA	J. McArthur	JMcA

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDICES

1. INTRODUCTION

This report has been prepared to provide hydraulic advice for a proposed rural residential subdivision on Moloney just south of Goondiwindi in New South Wales.

Cardno Lawson & Treloar (CLT) has completed this assessment for SMK Irrigation Consultants Pty Ltd.

The aim of this investigation has been to assess the Macintyre River flooding conditions at the site and to quantify the effect of the proposed development on regional flooding for the surrounding area. This flood study has been undertaken to support a Material Change of Use Application.

2. SITE DETAILS AND PROPOSED DEVELOPMENT

2.1 Site details

The site is situated in New South Wales, adjacent to the Queensland border, south of the Township of Goondiwindi. The site is bounded by the Macintyre River to the north. Access to the site is from the road between Boomi and Goondiwindi, which forms the southern boundary of the site (Refer Figure 1.1). There is also an eastern access road from Goondiwindi on the southern bank of the Macintyre River.

The proposed development is on the southern bank of the Macintyre River, which flows in a westerly direction and drains a catchment of approximately 6,900 sq.km. The Macintyre River catchment is part of the "Border Rivers" drainage basin which also includes the Weir and the Dumaresq Rivers. This system eventually drains into the Barwon River before joining the Murray Darling System.

The site ground levels generally range from RL 212m to 217m AHD (Refer to Figure 2.1).

2.2 The Proposed Development

For this proposed rural residential subdivision fill pads of 20 by 40 metres wide are proposed per lot (Refer to Figure 2.2). The height of the fill pads will be set 600 mm above the 1% AEP flood level, which is expected to be above the Probable Maximum Flood (PMF) levels, hence contributing in the safety of future residents and a minimal reliance on nearby located emergency services of the Goondiwindi Township.

2.3 Greenfield Scenario

The NSW Department of Natural Resources require that flooding characteristics also be compared against a 'no-development' or 'greenfield' floodplain scenario.

An Existing Greenfield Scenario without levee systems other than the Goondiwindi Town Levee System has therefore been compared to a Developed Greenfield Scenario containing the proposed rural development fill pads.

3. PREVIOUS STUDIES

3.1 Goondiwindi Environs Flooding Investigation

A flooding investigation of the Goondiwindi Environs has been undertaken by CLT for Waggamba Shire Council with completion in March 2007. The hydraulic model that was developed as part of this flood study has been used to investigate the proposed subdivision on Moloney.

The Goondiwindi Environs Flood Study forms part of a package of investigations being undertaken under the National Disaster Risk Management Studies Programme run by the Australian Government Department of Transport and Regional Services, with funding from the Australian and State Governments, and the local authorities of Waggamba Shire Council (WSC) and Goondiwindi Town Council.

As part of this study:

- A new two dimensional flood model of the entire Goondiwindi Environs has been developed, encompassing the existing township and its protection levee system, and future potential growth areas within 12 kilometres of the town centre;
- The flood model has been calibrated against the February 1976 and January 1996 flooding events, using recorded peak water levels at the Boggabilla and Goondiwindi Gauge, as well as observed peak water levels along the Goondiwindi town levee;
- A flood frequency analysis has been undertaken on annual floods at the Boggabilla Gauge, using 101 years of recorded heights and rated flows, to estimate peak flows for a number of design events;
- Flood maps have been provided for the following design events:
    - ‘Half of 1976’ flood (a currently used design flood);
    - AEP 5%, 2% and 1% design events using Boggabilla gauge data;
    - AEP 0.2% and 0.5% design event by extrapolating the Boggabilla gauge results; and
    - An approximate Probable Maximum Flood (PMF), based on twice the magnitude of the 1976 flood.
- Hazards and risks associated with the modelled floods have been identified;
- Mitigation options have been investigated;
- A database of flood information including depths and risk has been provided to assist Council in their planning activities for the future; and
- Emergency / evacuation planning in regards to flooding has been described to assist Waggamba Shire Council to plan future development and form a basis for disaster and rescue plans for WSC, Goondiwindi Shire Council and the Department of Emergency Services.

4. DATA USED IN THIS STUDY

Several sources of information were used in this study. These include the following:

4.1 Topographic Information

Topographic information for the hydrologic modelling was sourced from the following:

- 3D ground survey data of the site (September 2006) provided by SMK Consultants Pty Ltd
- 3D terrain information and survey provided by AAMHatch (March 2006).
- 3D ground survey data of the existing levee system (July 2006) provided by SMK Consultants Pty Ltd
- Photogrammetry carried out for the Border Rivers Floodplain Hydraulic Analysis (BRFHA) Study.

4.2 Hydraulic Model

The two dimensional SOBEK model that was built for the Goondiwindi Environs Flooding Investigation, as described in Section 3, was used to investigate flooding of the proposed subdivision at the Moloney site.

5. HYDROLOGY

The Macintyre River and floodplain flows have been estimated as part of the Goondiwindi Environs Flood Study. Relevant outcomes are described below.

5.1 Historical Flood Data Boggabilla and Goondiwindi Gauges

As part of the Goondiwindi Environs Flood Study, historical flood information was sought to gain an understanding of previous flood history and flood patterns as well as for model calibration purposes.

The major flooding events in February 1976 and January 1996 were used for calibration of the model.

Flood level and flow information associated with the Boggabilla and the Goondiwindi stream gauges, with station numbers 416002 and 416201A respectively, had previously been obtained as part of the Border River Floodplain Hydraulic Analysis.

The locations of the Boggabilla and Goondiwindi gauges are shown on Figure 1.1. The Goondiwindi gauge is located at the bridge over the Macintyre River located at the junction of Macintyre Street and McLean Street.

The Boggabilla gauge is situated approximately one kilometre downstream of the township of Boggabilla. The Boggabilla gauge was chosen as the upstream boundary of the 2D model. The historical flood data of the Boggabilla Gauge was therefore critical in calibrating the model and assessing design flows.

5.2 Historic Events of 1976 and 1996

Flood flows associated with the 1976 and 1996 Macintyre River events have been obtained from the rated stream gauging station at Boggabilla (Station Number 416002).

The rated flows indicated the following:

1976 event – 3241m^3/s

1996 event – 3308m^3/s

As the rated flows did not relate to the recorded flood levels, a joint calibration using the 2D hydraulic model was undertaken to obtain a more accurate flow rating. This calibration provided the following peak flow Boggabilla at the stream gauge. It should be noted that the location of the Boggabilla stream gauge changed between 1976 and 1996 (refer Figure 1.1)

Table 5-1 Boggabilla Peak Discharges – Historic Events

Flood	Recorded Water Level (mAHD)	Peak Discharge (m^3/s)
1976	221.27	2760
1996	220.99	2280

5.3 Design Events

The Boggabilla stream gauge has 101 years of height and rated flow records. A flood frequency analysis based on peak annual floods and using a Log Pearson III distribution was undertaken with the 1976 and 1996 flood events amended in accordance with the rating provided by the hydraulic model.

The distribution is shown in Appendix A and design event flows are presented below.

Table 5-2 Boggabilla Peak Discharges – Design Events

ARI (years)	AEP (%)	Peak Discharge (m^3/s)
2	50	576
5	20	1157
10	10	1582
20	5	1996
50	2	2526
100	***1***	***2912***
200	0.5	3284
500	0.2	3754

For the proposed subdivision on Moloney the 1% AEP event was used to quantify the effect of the proposed development on regional flooding for the surrounding area.

6. HYDRAULICS

6.1 General

The hydraulic analysis was performed with the aid of the computer program SOBEK, version 2.09.004. SOBEK is a hydrodynamic package developed by Delft Hydraulics in the Netherlands. The SOBEK model can simulate steady and unsteady hydrodynamic flow in two directions on a rectilinear grid. It is based on a robust finite difference scheme able to compute both subcritical and supercritical flow regimes.

The SOBEK model is suited for simulation of dynamic hydraulic behaviour of overland flow over initially dry land. Based on this and its supercritical solving ability the SOBEK modelling system was considered the most appropriate investigative tool.

Hydraulic analysis has been performed to investigate the impacts of the development on the surrounding floodplain and to ensure the development is set at an appropriate level to ensure 1 in 100 year flood immunity in accordance with Moree Plains Shire Council Guidelines.

The extent of the hydraulic model is shown on Figure 1.1 and closer detail of the existing topography is presented on Figure 2.1.

6.2 Hydraulic Model Construction

Model Topography

Model topography was constructed from 2006 aerial laser survey topography for Goondiwindi and its surroundings and photogrammetry carried out for the Border Rivers Floodplain Hydraulic Analysis (BRFHA) Study.

The height of the Goondiwindi Township Levee was incorporated into the model based on recent ground survey data (July 2006).

The location of levee systems in New South Wales is based on information relating to existing and approved levees. In the SOBEK model it is assumed that no overtopping of the levee systems in New South Wales occurs during extreme events up to the PMF event. However, in reality some of the levees in New South Wales may overtop during extreme events and minor overtopping may occur during the AEP 1% event. More detailed ground survey of the top of the levee banks would be required to confirm this.

A 20 metre grid was chosen for the 2D model topography giving approximately 500,000 computational points.

Greenfield Scenarios

In the Existing and Proposed Greenfield Scenarios, existing flood plain levee systems were removed from the Model Topography. The only remaining levee system is the Goondiwindi Town Levee System.

Boundary Conditions

The inflow boundary for the 1% AEP event was estimated using a flood frequency analysis (Refer to Table 5.2).

Tail water conditions in the SOBEK model were controlled by a discharge/waterlevel (Q/H) relationship at the downstream boundary of the model based on normal depth conditions.

The downstream model boundary is at a distance which will have a negligible influence on peak water levels on the proposed subdivision on Moloney.

Roughness

The spatial variation of roughness was incorporated into the model by assigning each grid element an individual Manning's 'n' roughness value.

Model roughness (Manning's n) values were chosen based on generally accepted roughness values for different landuses. The roughness values used are shown below in Table 6.1. A general Mannings 'n' value of 0.05 was adopted, mostly for the grassed / grazing floodplain areas.

Table 6-1 Typical Roughness Values Adopted

Land Use	Manning's 'n' Value
Flood Plain Trees	0.05 – 0.08
Flood Plain Cleared Land	0.05
Macintyre River	0.03
Creeks	0.04 - 0.08
Local Ponds	0.025
Built up area (buildings)	0.20
Roads	0.02

6.3 Model Calibration

Calibration was undertaken using 2 historic flood events, the major event in 1976 and 1996, as discussed in Section 5. The model was calibrated to recorded peak flood levels.

Tables 6.2 and 6.3 compare available historic data and calibrated model results for the 1996 and 1976 events respectively. The 1996 and 1976 models have been calibrated to the recorded water levels at the Boggabilla and the Goondiwindi Gauges. Also two flood marks were found at the Millers residency for the 1996 event during the 2006 levee survey. These flood marks are located on the downstream section of the model, along the Macintyre River (Refer Figure 1.1 for the location of these additional flood marks).

Table 6-2 Calibration Summary 1996 event

Location	Gauge zero (m AHD)	Recorded Depth (m)	Recorded Level (m AHD)	Modelled Level (m AHD)	Difference (m)
Gauge Boggabilla	208.48	12.513	220.99	221.01	+ 0.02
Gauge Goondiwindi	207.56	10.615	218.18	218.19	+ 0.01
Millers Flood Mark			215.73 215.75	215.70	- 0.03 - 0.05

For the 1976 event additional information was found in the report "Investigation of Flooding at Goondiwindi" prepared by the Engineering & Technical Services Division for Goondiwindi Town Council in December 1985. A recorded water level at the most upstream location of the Goondiwindi Town Levee has been used specifically for the calibration of the 1976 model (refer Figure 1.1 for location of 1976 Flood Mark).

Table 6-3 Calibration Summary 1976 event

Location	Gauge zero (m AHD)	Recorded Depth (m)	Recorded Level (m AHD)	Modelled Level (m AHD)	Difference (m)
Gauge Boggabilla	208.48	12.8	221.27	221.27	+ 0.00
Gauge Goondiwindi	207.56	10.5	218.06	218.17	+ 0.11
Upstream of Goondiwindi Levee	--	--	219.88	219.88	+ 0.00

It should be noted that the hydraulic model incorporates current (as of 2006) topography including farming levees. Some of these levees, especially in the floodplain area south of Goondiwindi, may not have existed in 1976, impacting on flow distribution within the floodplain. It is therefore considered the 1976 calibration result is reasonable taking into account this uncertainty.

6.4 Proposed Case Setup

The proposed case was constructed based on a proposed layout plan provided by SKM Irrigation Consultants Pty Ltd (Refer to the Reference Drawings). The proposed case model topography is shown on Figure 2.2.

7. STATUTORY FLOODING CRITERIA AND MODEL RESULTS

7.1 Flooding Criteria

The following flooding criteria were used to assess the hydraulic outcomes of this flooding investigation:

Flooding criteria set by Moree Plains Shire Council:
- Required fill heights – 600mm above the 1% AEP flood level;
- Flood velocities for 1% AEP flood - less than 1.0m/s;
- Maximum depths for 1% AEP flood – less than 1.5m.

Flooding criteria set by Waggamba Shire Council:
- Maximum allowable impact – less than 200 mm;
- No overtopping of the existing and accurately surveyed Goondiwindi Levee System occurs during the 1% AEP event due to the proposed development.

Flooding criteria set by DNR (NSW)
- Maximum allowable impact – less than 200 mm;
- Preferred afflux – less than 100mm;
- Afflux on affected existing properties – less than 20mm, depending on habitable floor levels;
- Maximum change in flow distribution – less than 2 to 5%;
- Maximum increase in velocities outside scour prone areas – less than 50%.

7.2 Model Results Pre-and Post Developed Case

7.2.1 Flood Levels and Flood Level Impacts

The estimated existing 1% AEP peak flood levels have been presented in Figure 3.1. The proposed case 1% AEP flood levels are shown in Figure 4.1. Proposed Case 1% AEP event peak flood level impacts are presented on Figure 4.4.

The results show that the site is inundated during the 1% AEP flood, with peak water levels ranging approximately between 216.6mAHD to RL 217.9mAHD.

The proposed development fill pads in the floodplain result in off-site impacts during the 1% AEP events of up to 50mm. These impacts are less than the allowable affluxes as described in Waggamba Shire Council and DNR guidelines.

Also, no overtopping of the existing and accurately surveyed Goondiwindi Levee System occurs during the 1% AEP event due to the proposed development.

7.2.2 Peak Water Depths and Velocities

Peak water depths and peak velocities are critical elements for the determination of flood hazard categories and for emergency evacuation.

Figures 3.2 and 4.2 provide peak water depths and flow patterns for respectively the Existing and Proposed Case 1% AEP events. Existing and Proposed Case water depths generally range between 0.5 and 1.0 metre.

Two locations show water depths over 1.5metres:

- The eastern access road from Goondiwindi on the southern bank of the Macintyre River; and
- Water depths of up to 2.0 metres occur on the proposed road in the north western corner near lots 78, 77 and 76 (refer Plan 1 in the reference figures section).

These two locations should be either raised to reduce peak water depths or emergency evacuation should be directed along alternative routes during extreme Macintyre River floods.

Peak water velocities and flow patterns are shown on Figures 3.3 and 4.3 for Existing and Proposed Case 1% AEP events. Peak velocities generally range between 0.25 and 1.0 m/s. On the site no velocities over 1 m/s are reported. Increases in velocities are in general within the 50% range.

No changes in peak flows up- and downstream of the site are reported and no significant changes occur in flow distribution.

7.3 Model Results Greenfield Scenario

7.3.1 Flood Levels and Flood Level Impacts

The 1% AEP peak water levels of the Pre- and Post-Developed Greenfield Scenarios are shown on Figures 5.1 and 6.1 respectively. Pre-Development Greenfield peak water levels range between approximately 216.6mAHD and RL 217.9mAHD.

Proposed Greenfield Case peak flood level impacts are presented on Figure 6.4 for the 1% AEP event. The proposed development fill pads in the floodplain result in off-site impacts during the 1% AEP events of up to 40mm.

7.3.2 Peak Water Depths and Velocities

Figures 5.2 and 6.2 provide peak water depths and flow patterns for the 1% AEP Existing and Proposed Greenfield Scenarios respectively. Existing and Proposed Greenfield Case water depths generally range between 0.5 and 1.0 metre.

Two locations show water depths over 1.5metres:

- The eastern access road from Goondiwindi on the southern bank of the Macintyre River; and
- Water depths of up to 2.0 metres occur on the proposed road in the north western corner near lots 78, 77 and 76 (refer Plan 1 in the reference figures section).

These two locations should be either raised to reduce peak water depths or emergency evacuation should be directed along alternative routes during extreme Macintyre River floods.

Peak water velocities and flow patterns are shown on Figures 5.3 and 6.3 for Existing and Proposed Case 1% AEP events. Peak velocities at the site are generally between 0.25 and 0.5 m/s and locally up to 1 m/s. On the site no velocities over 1 m/s are reported.

Increases in velocities are in general within the 50% range.

No changes in peak flows up- and downstream of the site are reported and no significant changes occur in flow distribution.

8. CONCLUSIONS

This report has been prepared for SMK Irrigation Consultants Pty Ltd by CLT to provide hydraulic advice for a proposed rural residential subdivision on Moloney just south of Goondiwindi in New South Wales.

The aim of this investigation has been to assess existing flooding conditions associated with the Macintyre River on and adjacent to the site and to quantify the effect of the proposed development on regional flooding for the surrounding area.

The hydraulic model developed as part of the Goondiwindi Environs Flooding Investigation has been used to investigate the proposed subdivision on Moloney. This hydraulic model has been set up using accurate survey data and has been calibrated and validated against recorded and observed water levels for the 1996 and 1976 flooding events; in particular at the Boggabilla and Goondiwindi gauges.

The model has been used to assess existing and developed case peak water levels, peak water depths and velocities at Moloney.

The results show that the existing site is inundated during the 1% AEP flood, with peak water levels ranging approximately between 216.6mAHD to RL 217.9mAHD (Refer to Figure 3.1).

In the proposed developed case off-site impacts up to 50mm occur during the 1% AEP events, which is well below the statutory authority acceptable impacts.

Peak velocities and peak water depths are critical elements for determining flood hazard and for emergency evacuation.

Peak velocities generally range between 0.25 and 1.0 m/s. On the site no velocities over 1.5 m/s are reported.

Existing and Proposed Case water depths generally range between 0.5 and 1.0 metre. Two locations show water depths over 1.5metres:

- The eastern access road from Goondiwindi on the southern bank of the Macintyre River; and
- Water depths of up to 2.0 metres occur on the proposed road in the north western corner near lots 78, 77 and 76.

These two locations should be either raised to reduce peak water depths or emergency evacuation should be directed along alternative routes during extreme Macintyre River floods.

9. QUALIFICATIONS AND CERTIFICATION

Cardno Lawson Treloar (CLT) provides certification of this report as follows:

The report

This report has been prepared by CLT specifically for SMK Irrigation Consultants Pty Ltd to provide advice on the theoretical flooding characteristics of the Macintyre River on the proposed subdivision on Moloney.

In order to ensure that statutory requirements in relation to flooding are met by the proposed development, CLT was commissioned to carry out a hydraulic study to support a Material Change of Use Application.

The report was prepared using a detailed two-dimensional SOBEK model, that was originally build for the Goondiwindi Environs Flooding Investigation.

Limitations, Qualifications and Reservations

Our analysis and overall approach have been specifically catered for the particular requirements of SMK Irrigation Consultants Pty Ltd, and may not be applicable beyond this scope. For this reason any other third parties are not authorised to utilise this report without further input and advice from CLT.

CLT has relied on the following studies and information prepared by others:

- 3D ground survey data of the existing Moloney site (September 2006) provided by SMK Consultants Pty Ltd.
- 3D terrain information and survey provided by AAMHatch (March 2006).
- 3D ground survey data of the existing levee system (July 2006) provided by SMK Consultants Pty Ltd.
- Limited historic flood levels and flows at the Department of Infrastructure, Planning & Natural Resources (DIPNR) Boggabilla stream gauge and at the Department of Natural Resources and Mines (DNRM) Goondiwindi stream gauge.
- Photogrammetry carried out for the Border Rivers Floodplain Hydraulic Analysis (BRFHA) Study.

The accuracy of the report is dependent on the accuracy of this information.

Future observed flood levels may vary from the predicted levels in this report depending on the characteristics of the catchments, rainfall, channels and floodplain.

In particular caution is required in the use of events larger than the 1976 flood.

Performance Criteria

Relevant performance criteria are generally complied with, subject to accuracy limitations of the flood modelling. Modelling accuracy or computational noise is recognised as being of the order of +/- 5mm for two dimensional flood modelling.

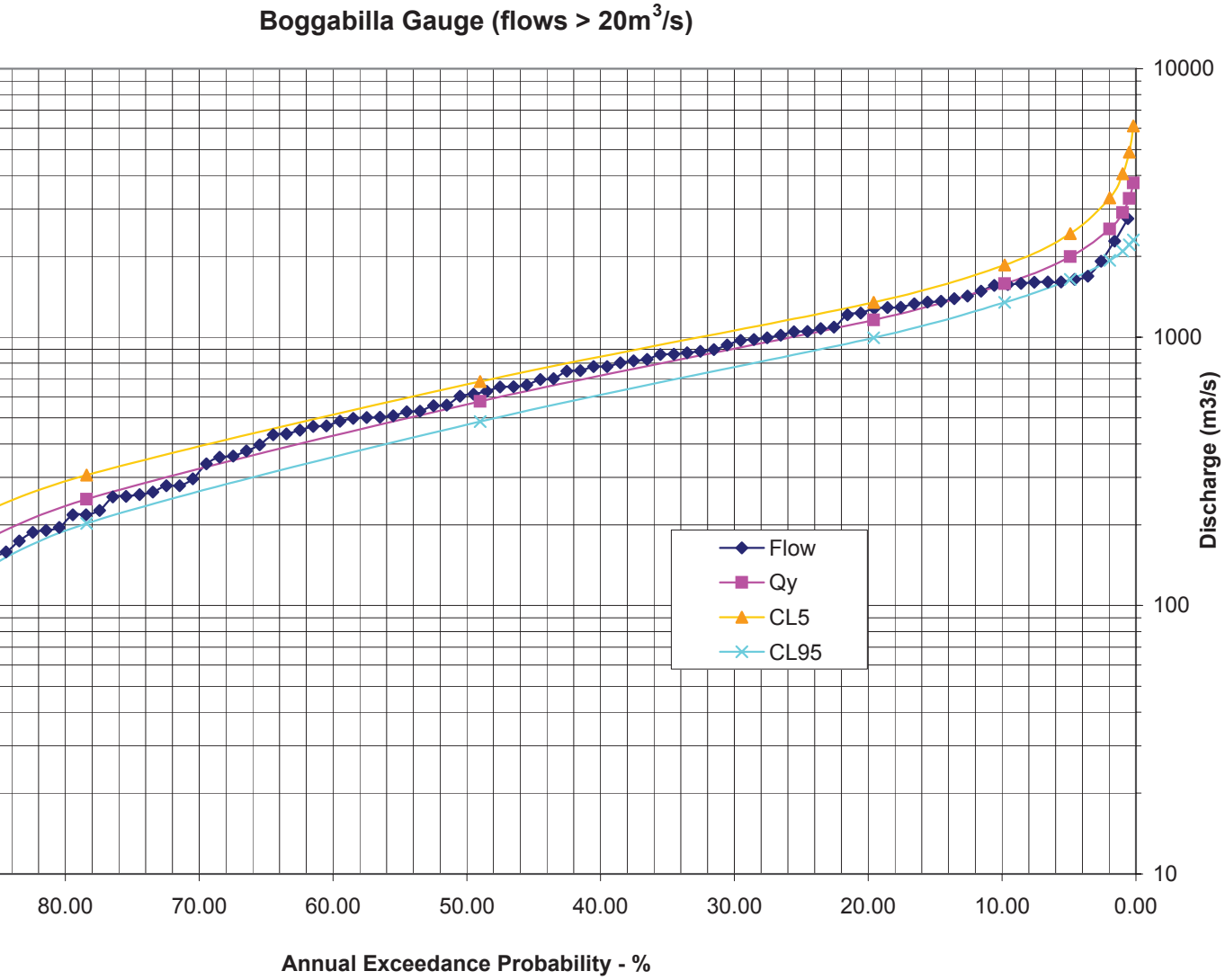
Our assessments are based on standard engineering practices.

CLT acknowledge that Statutory Authorities may rely on this certification and associated documentation in its assessment of the proposal.

FIGURES

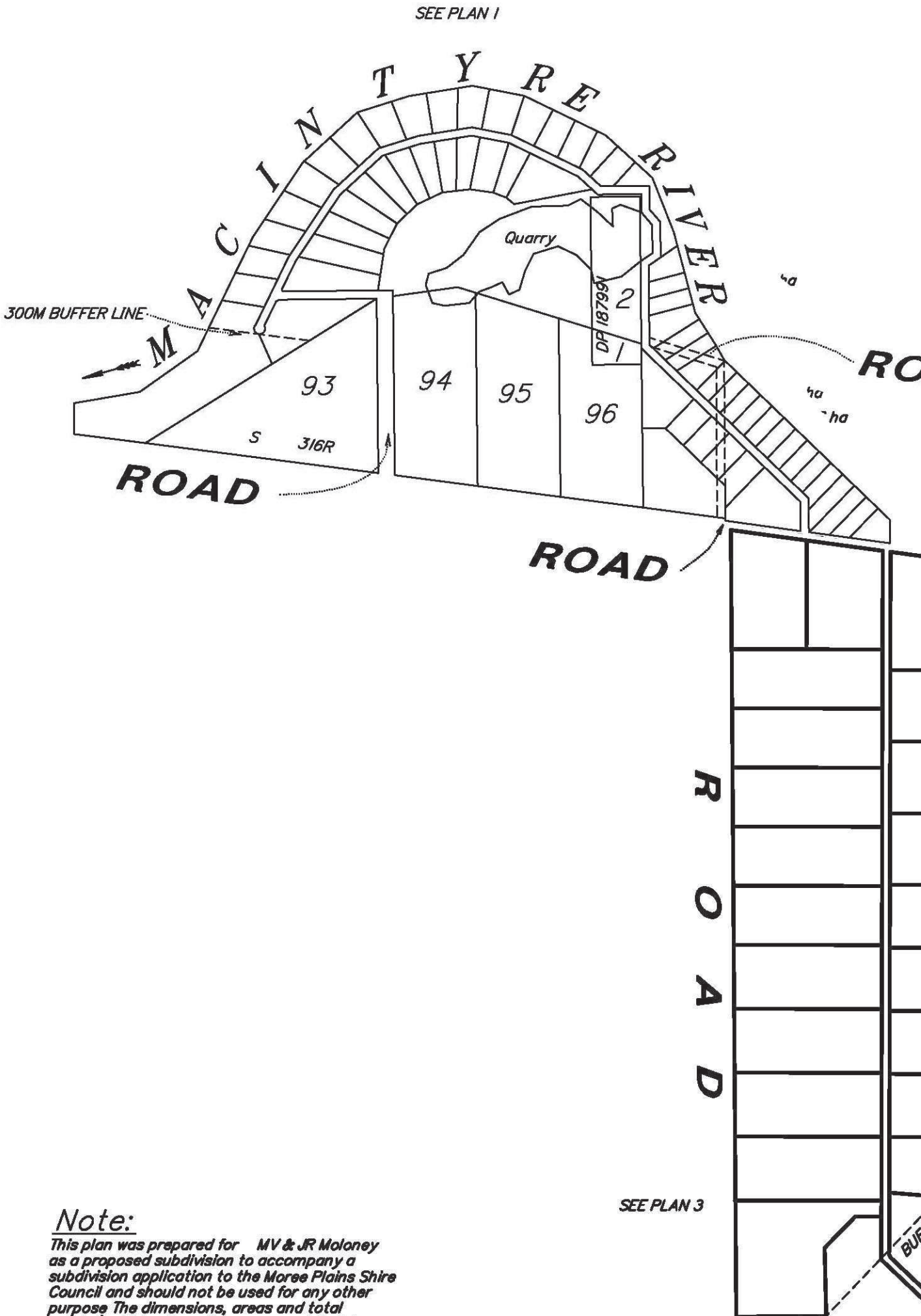
APPENDIX A

Boggabilla Flood Frequency Analysis


Boggabilla Gauge (flows > 20m3/s)
10000
1000
100
10
Discharge (m3/s)
Flow
Qy
CL5
CL95
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
Annual Exceedance Probability - %

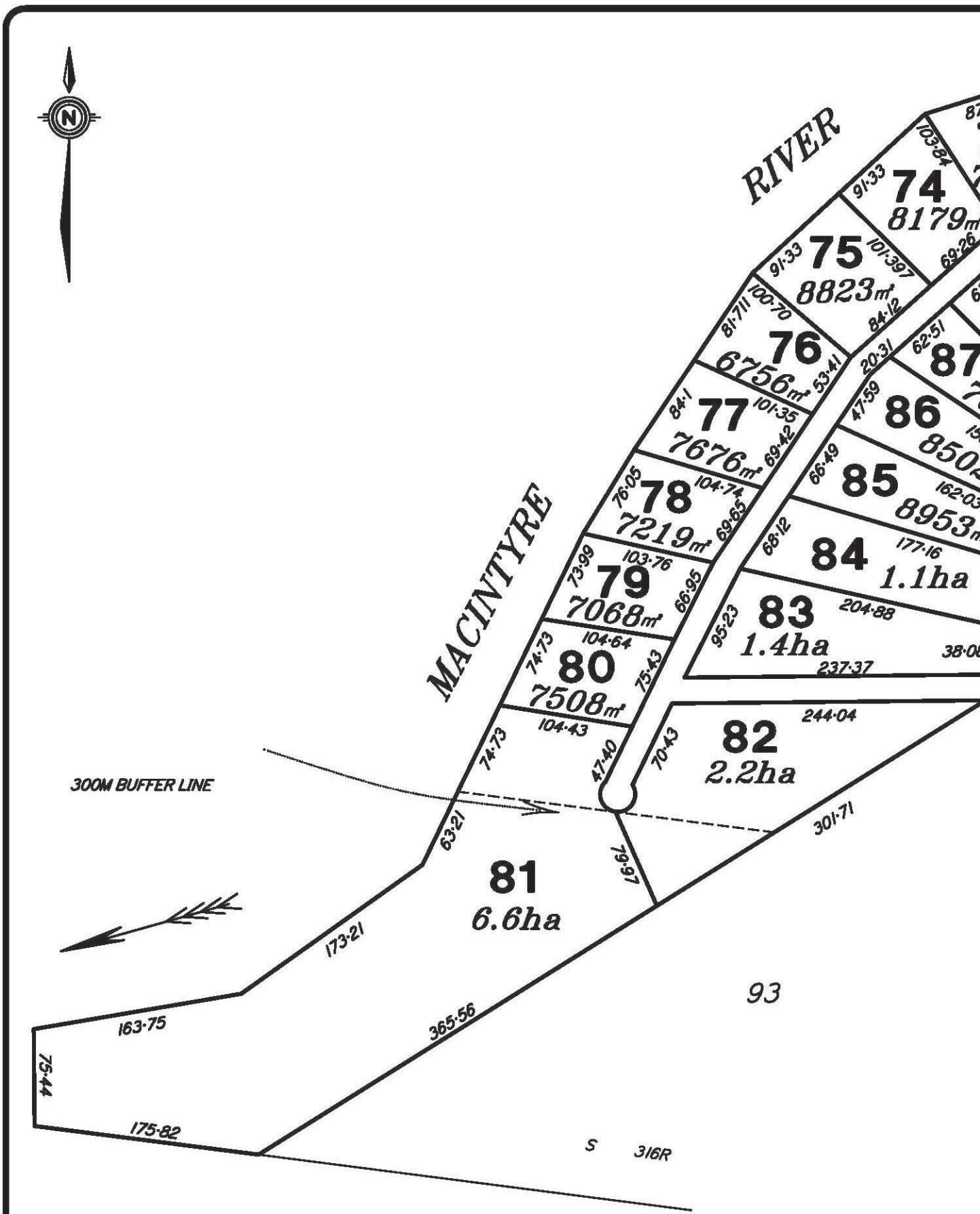
APPENDIX B

Reference Figures Lot Layout Plan



Note:

This plan was prepared for MV & JR Moloney as a proposed subdivision to accompany a subdivision application to the Moree Plains Shire Council and should not be used for any other purpose The dimensions, areas and total



MV & JR MOLONEY

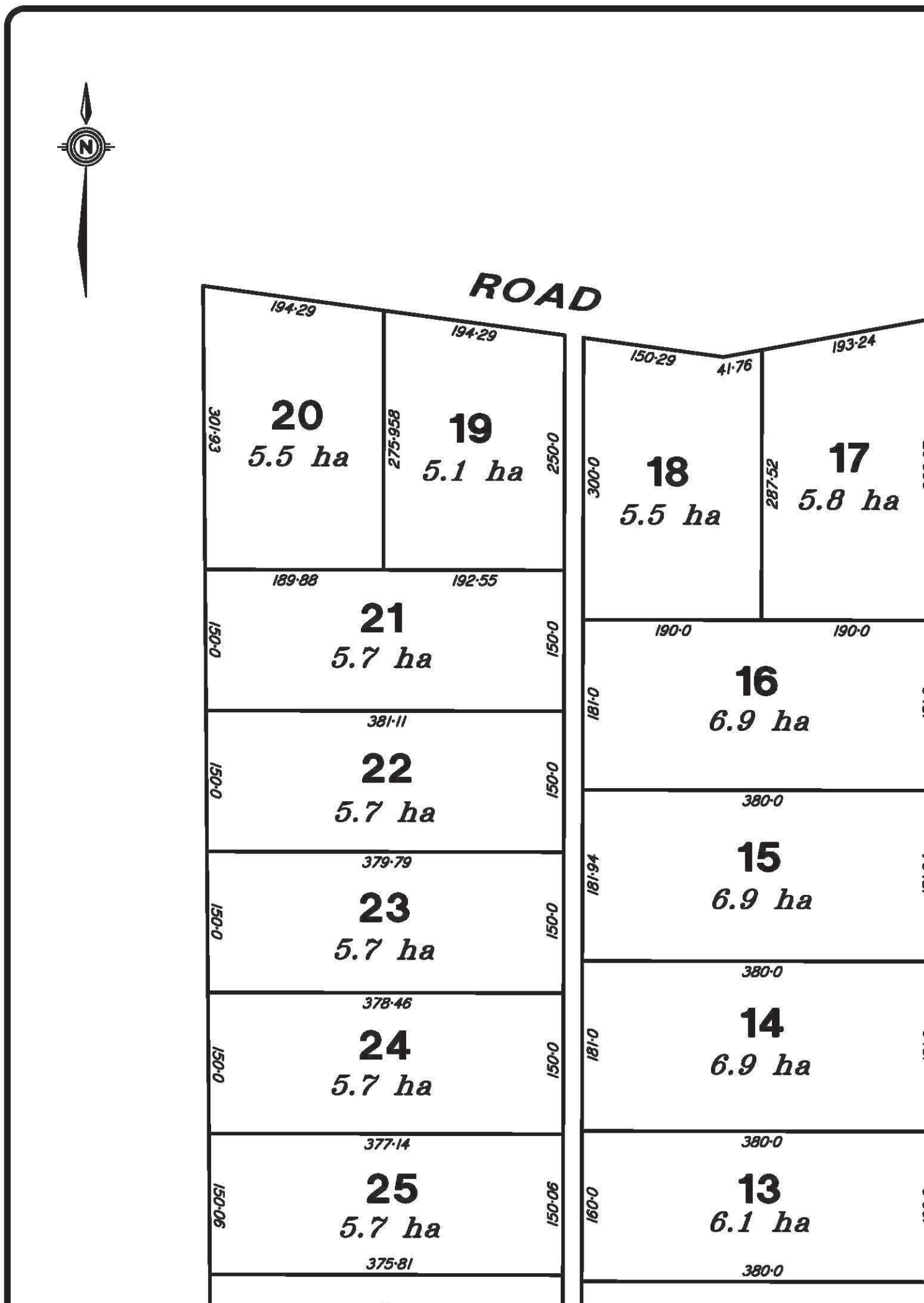
PLAN OF PROPOSED S

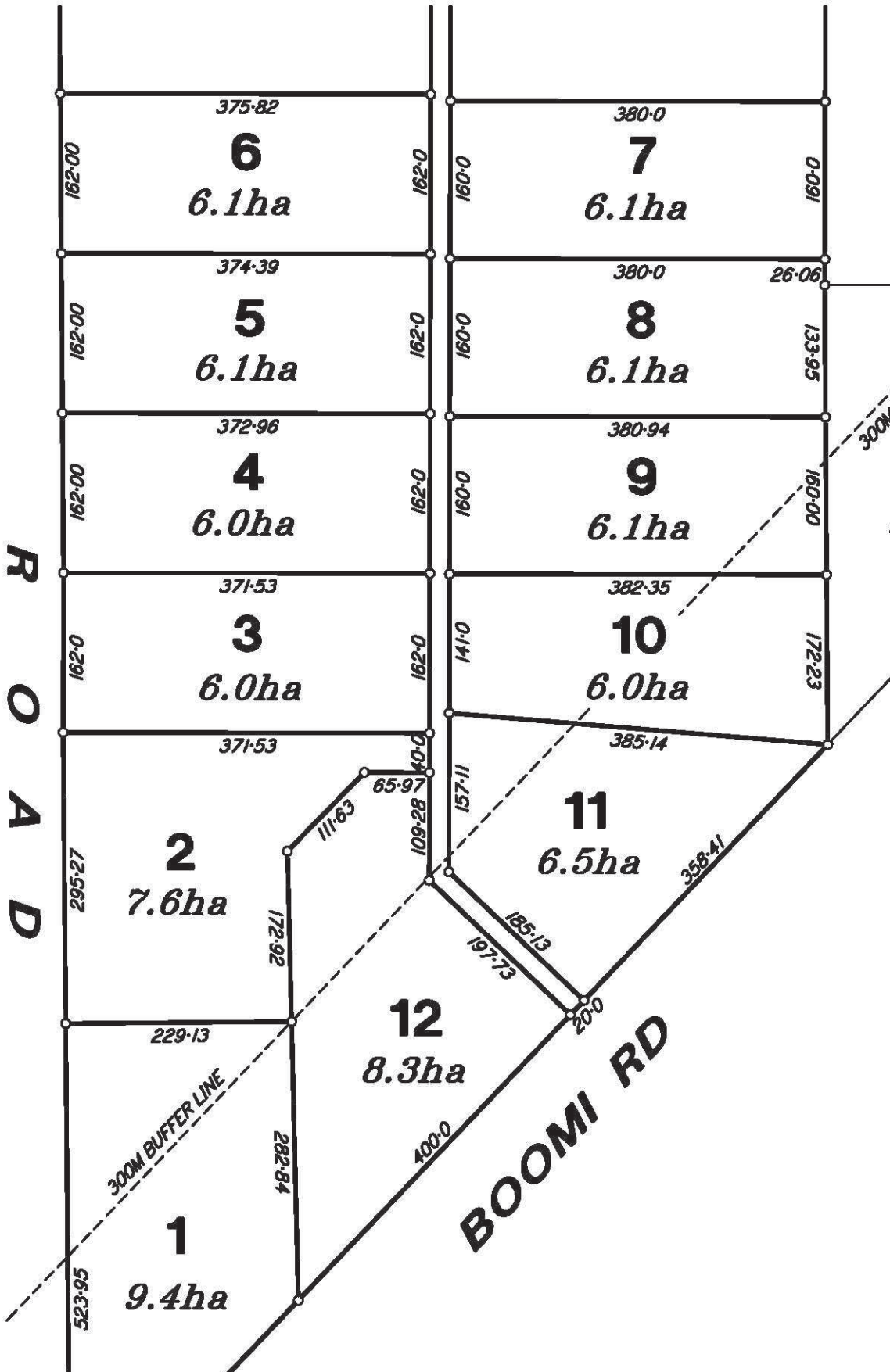
SMK CONSULTANTS PTY LTD.

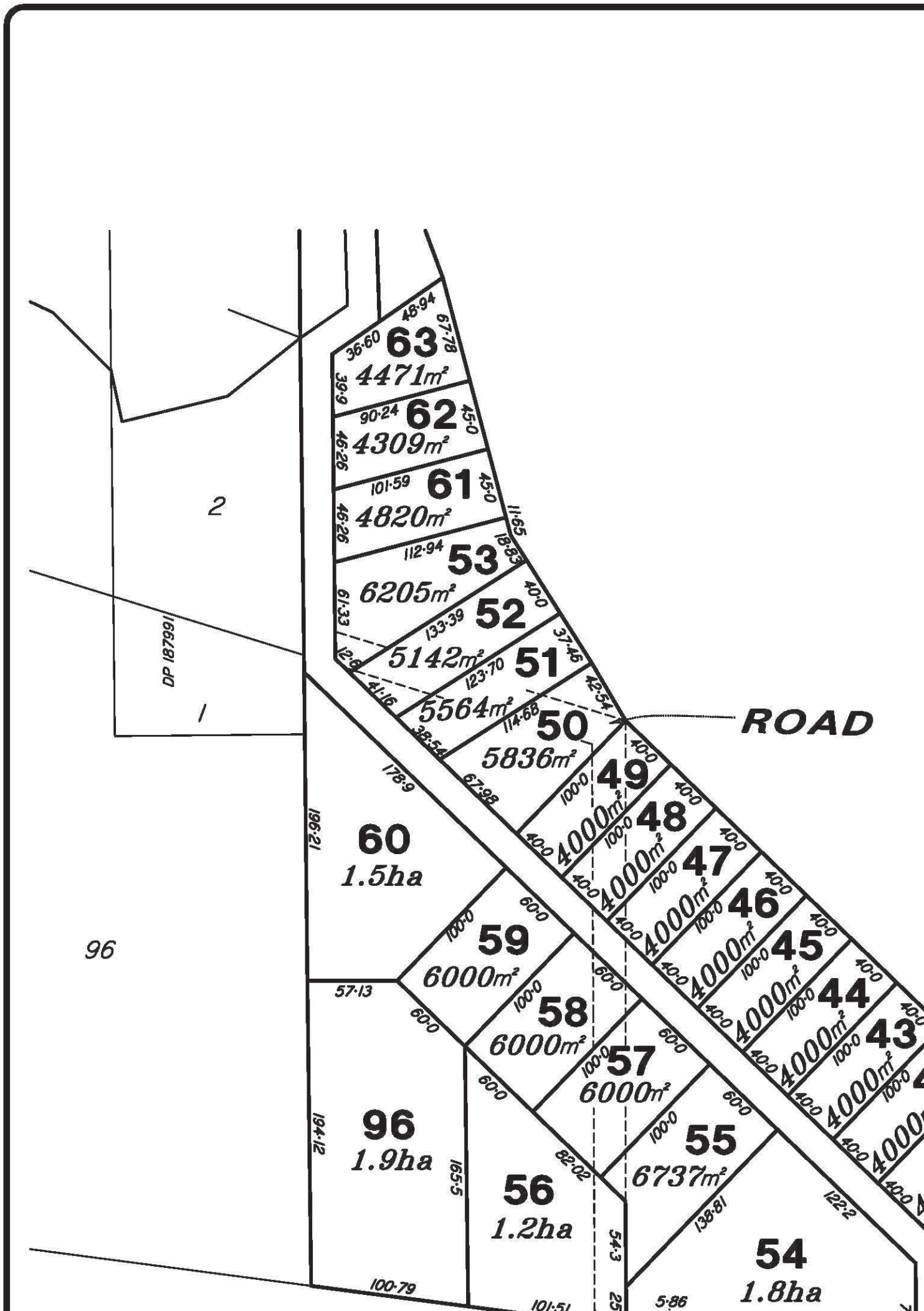
Goondiwindi 130 Marshall St Goondiwindi 4390
Ph (07)4671 2445 Fax (07)4671 2561
E'Mail qld@smk.com.au

Moree 13 Frome St Moree 2400
Ph (02)6752 1640 Fax (02)6752 5070

PARISH: *BOGGABILLA* COUNTY


ROAD
194·29
194·29
301·93
20
5.5 ha
275·958
19
5.1 ha
250·0
150·29
41·76
193·24
300·0
18
5.5 ha
287·52
17
5.8 ha
189·88
192·55
150·0
21
5.7 ha
150·0
190·0
190·0
181·0
16
6.9 ha
381·11
150·0
22
5.7 ha
150·0
380·0
181·94
15
6.9 ha
379·79
150·0
23
5.7 ha
150·0
380·0
181·0
14
6.9 ha
378·46
150·0
24
5.7 ha
150·0
377·14
150·06
25
5.7 ha
150·06
380·0
160·0
13
6.1 ha
375·81
380·0

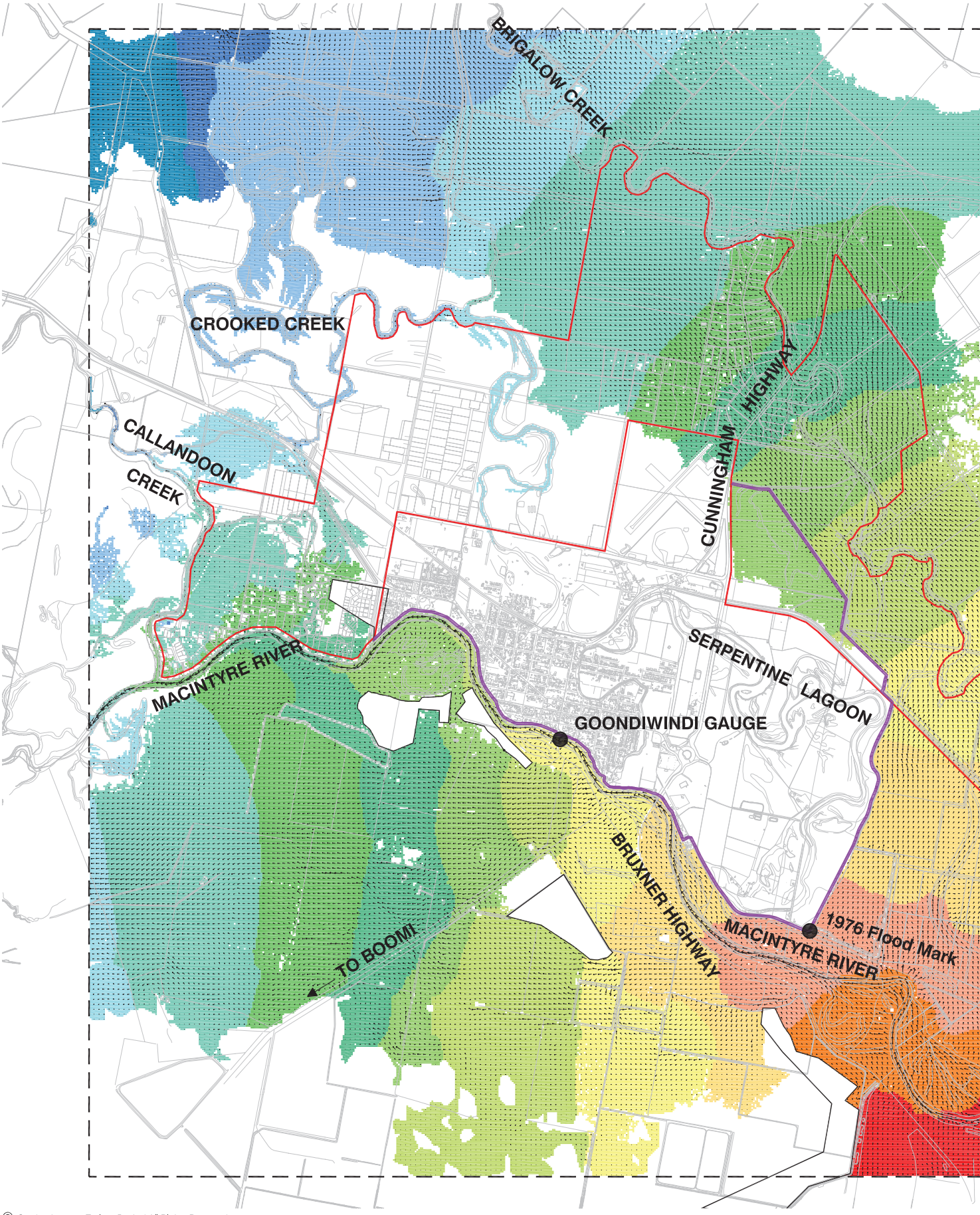

ROAD
BOOMI RD
300M BUFFER LINE
1
9.4ha
2
7.6ha
3
6.0ha
4
6.0ha
5
6.1ha
6
6.1ha
7
6.1ha
8
6.1ha
9
6.1ha
10
6.0ha
11
6.5ha
12
8.3ha
375·82
374·39
372·96
371·53
371·53
380·0
380·0
380·94
382·35
385·14
229·13
162·00
162·0
160·0
141·0
65·97
111·63
109·28
157·11
172·92
197·73
185·13
358·41
400·0
282·84
523·95
295·27
172·23
133·95
160·00
26·06
20·0


63
4471m²
62
4309m²
61
4820m²
53
6205m²
52
5142m²
51
5564m²
50
5836m²
49
4000m²
48
4000m²
47
4000m²
46
4000m²
45
4000m²
44
4000m²
43
60
1.5ha
59
6000m²
58
6000m²
57
6000m²
55
6737m²
96
1.9ha
56
1.2ha
54
1.8ha
2
1
96
DP 187991
ROAD
48·94
67·78
36·60
39·9
90·24
45·0
46·26
101·59
45·0
46·26
11·65
18·83
112·94
40·0
61·33
133·39
37.46
12·8
123·70
41·16
42·54
114·68
38·54
67·98
178·9
196·21
57·13
194·12
165·5
82·02
122·2
138·81
54·3
100·79
5·86
100·0
40·0
60·0

APPENDIX C

Reference Figures 1976 and 1996 Floods

1976 Flooding Event - Peak Water Levels and Flow Patterns
1996 Flooding Event - Peak Water Levels and Flow Patterns

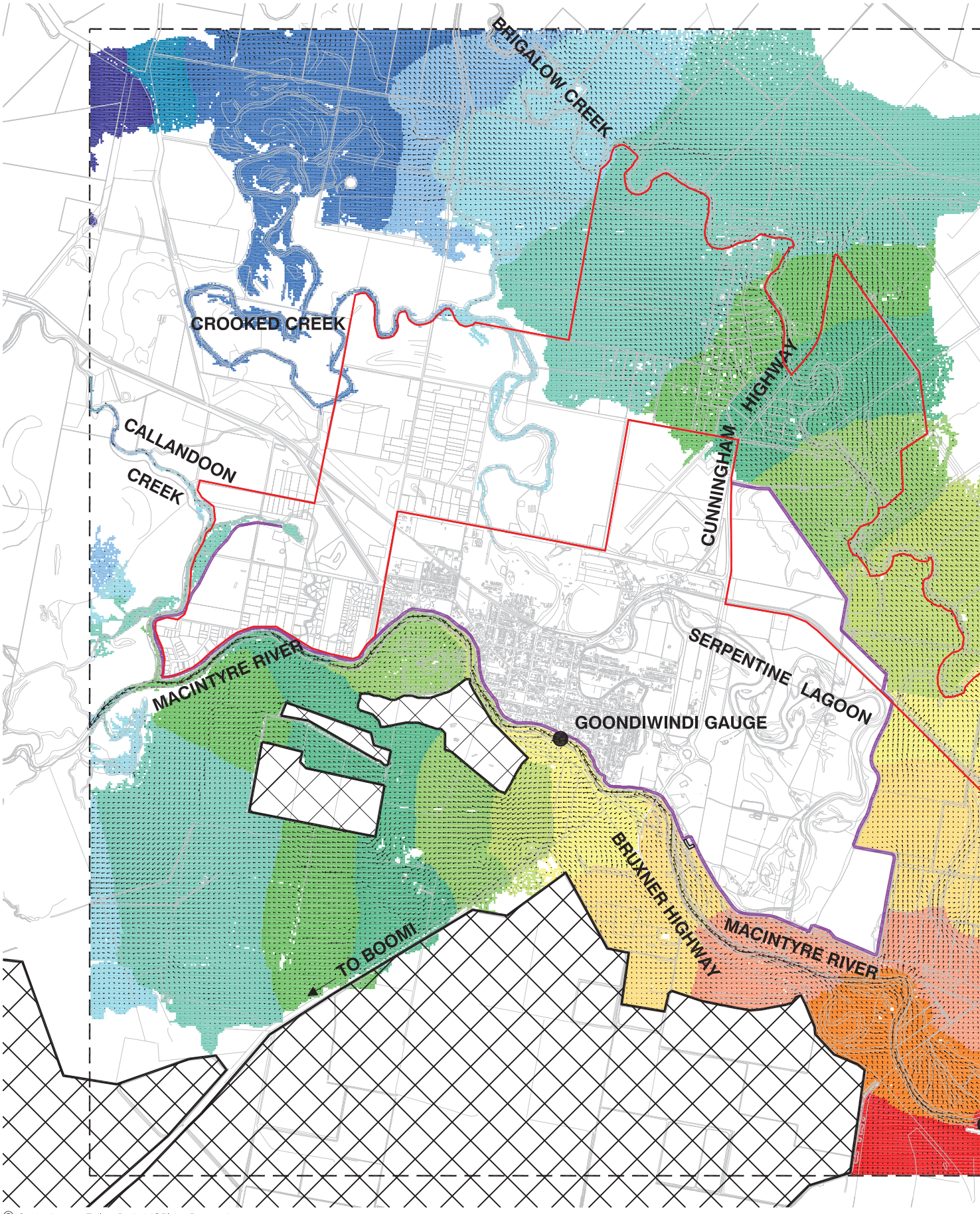


600 0 600

Rev: Orig. Date: March 2007

Waggamba Shire Council

CAD FILE: O:\WorkLAT\J8709\wp\R1v1\Reference Figures\Figure 1976.dwg
XREF's: J7803FigureBase; Levees 1996; Results; Waggamba_Shire_2005; HAZARD; R1_text; R1_text50

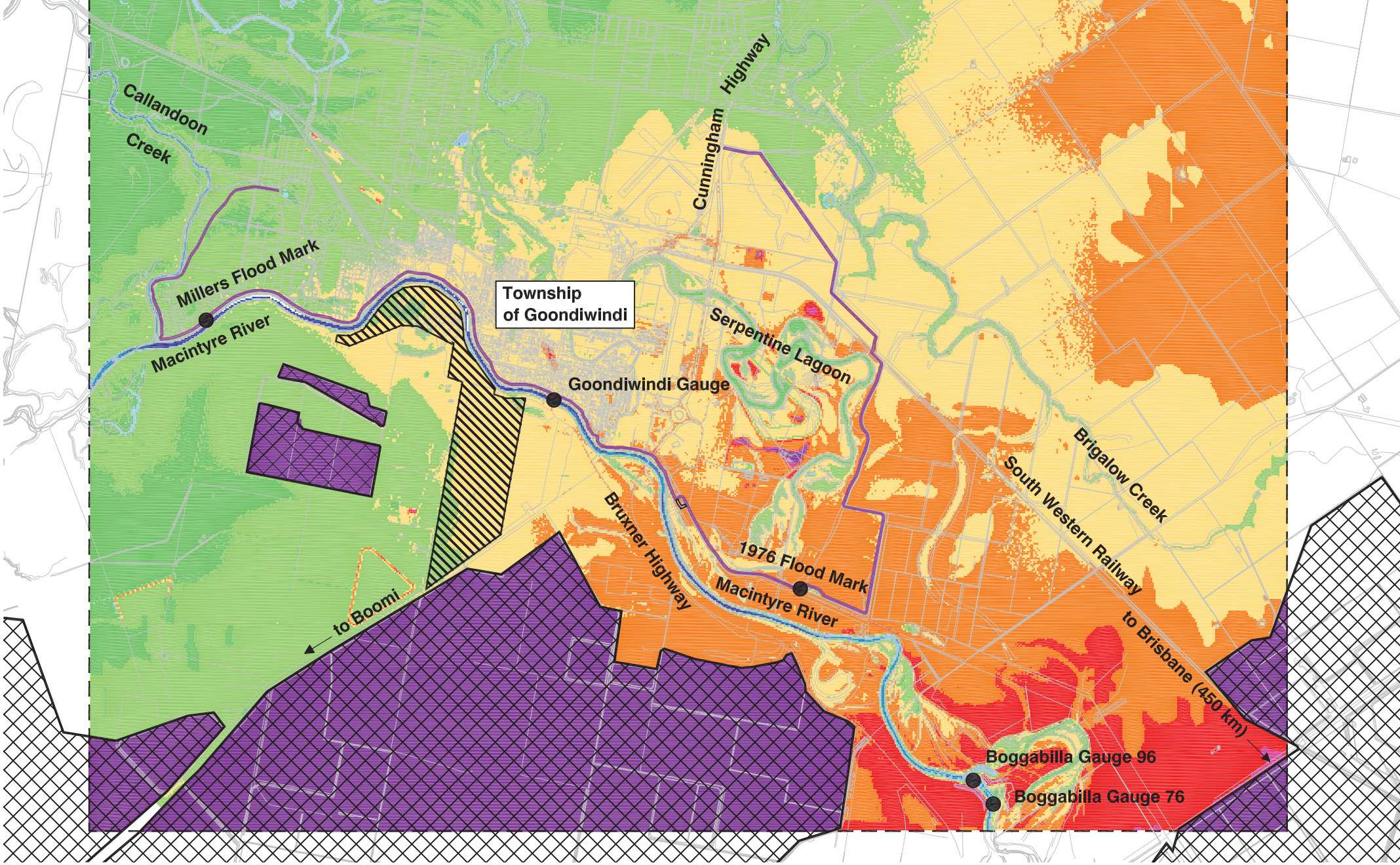


600 0 600

Rev: Orig. Date: March 2007

Waggamba Shire Council

CAD FILE: O:\WorkLAT\J8709\wp\R1v1\Reference Figures\Figure 1996.dwg
XREF's: J7803FigureBase; Levees 1996; Results; Waggamba_Shire_2005; HAZARD; R1_text



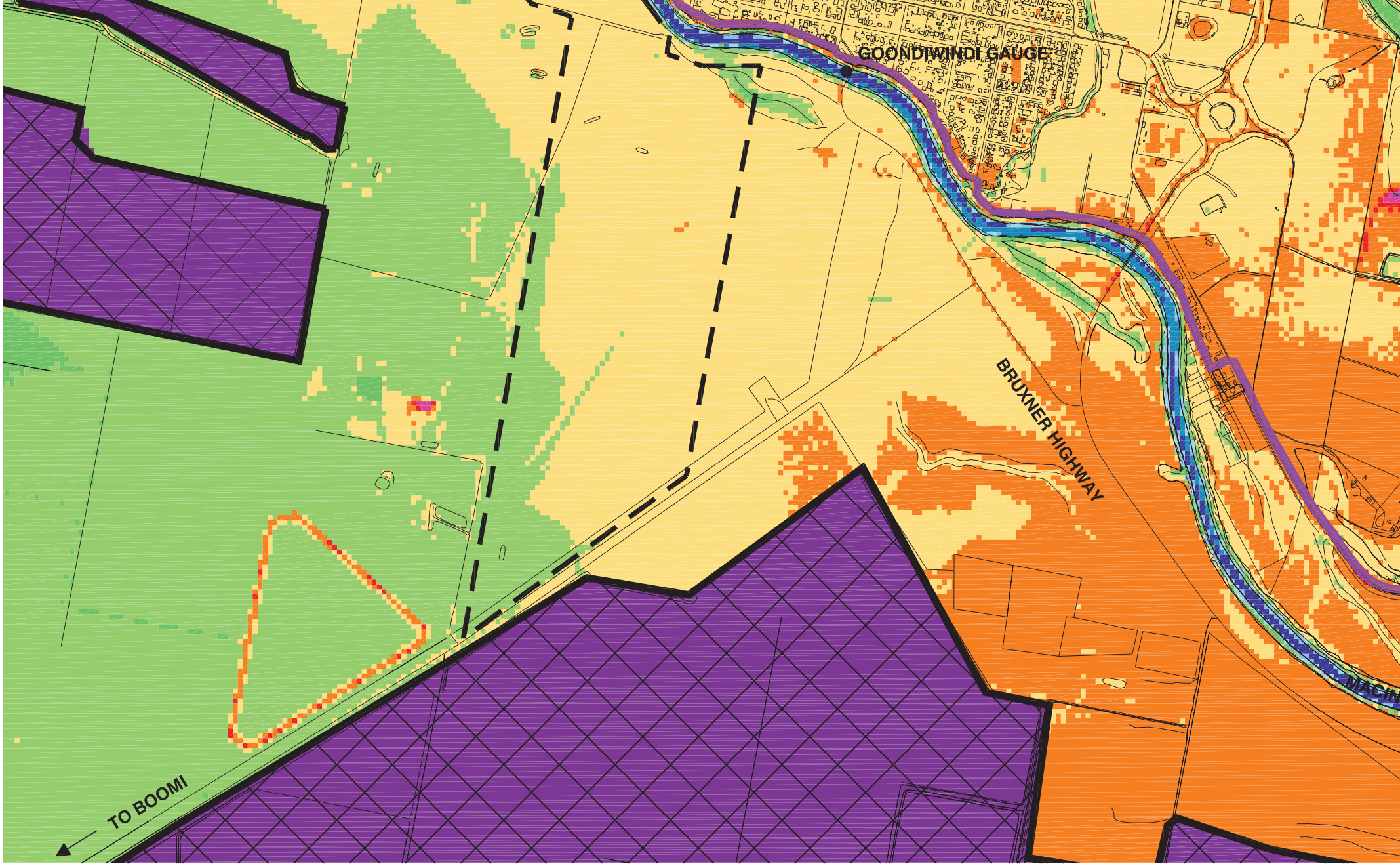
600 0 600 1200 1800 2400 3000m
1:60,000

SOBEK MODEL EXTENT, TOPOGRAPHY,

Rev: Orig. Date: April 2007

SMK Irrigation Consultants Pty Ltd

CAD FILE: O:\WorkLAT\J8709\Figures\D1\Figure 1.1 Study Area.dwg
XREF's: J7803FigureBase; Levees 1996; Results; Waggamba_Shire_2005; R1_text



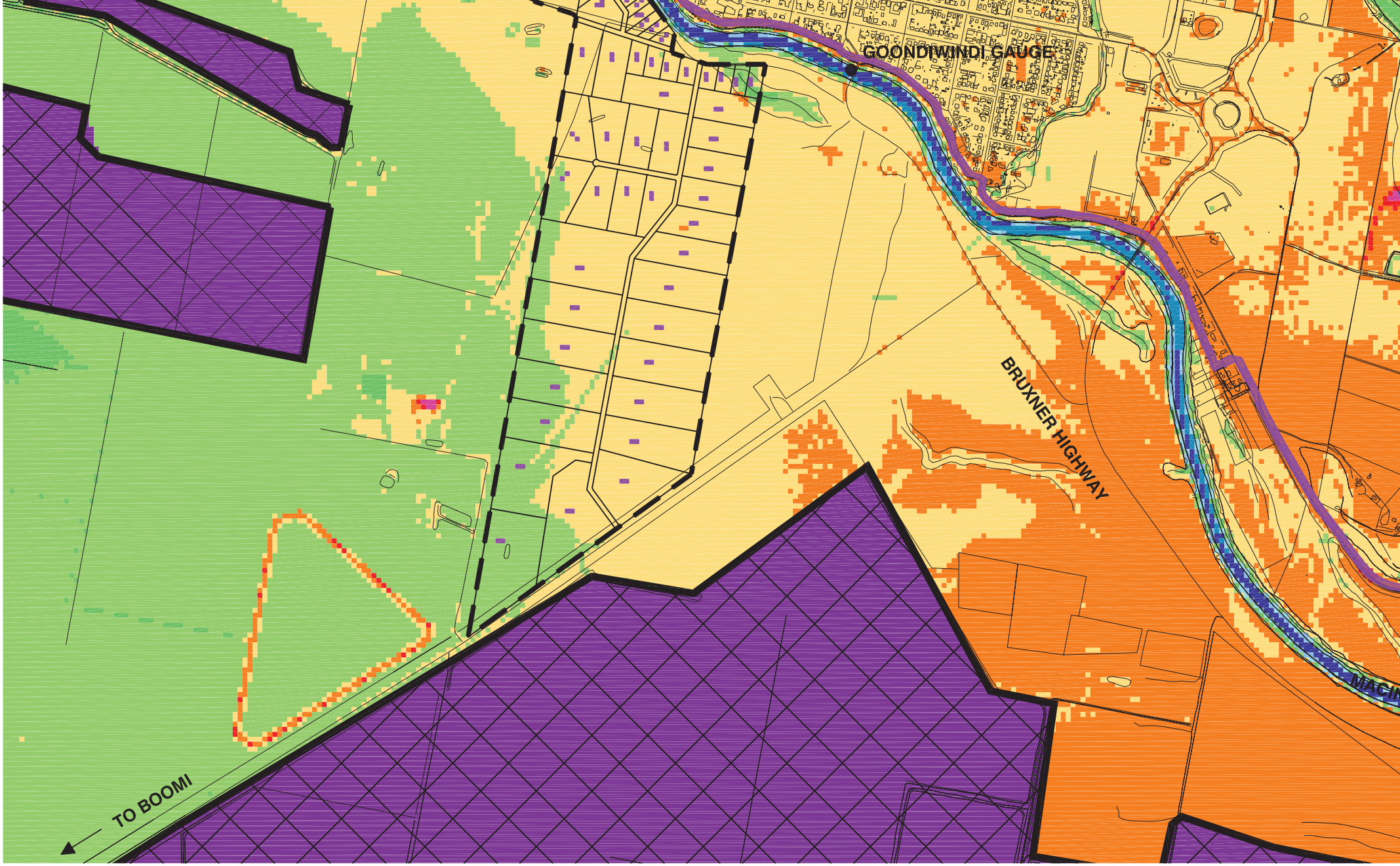
200 0 200 400 600 800 1000m
1:20,000

EXISTI

Rev: Orig. Date: April 2007

SMK Irrigation Consultants Pty Ltd

CAD FILE: O:\WorkLAT\J8709\Figures\D1\Figure 3 Existing Case EX02c Q100.dwg
XREF's: J7803FigureBase; Levees 1996; Results; Waggamba_Shire_2005; velocity; J8609 Moloney Layout



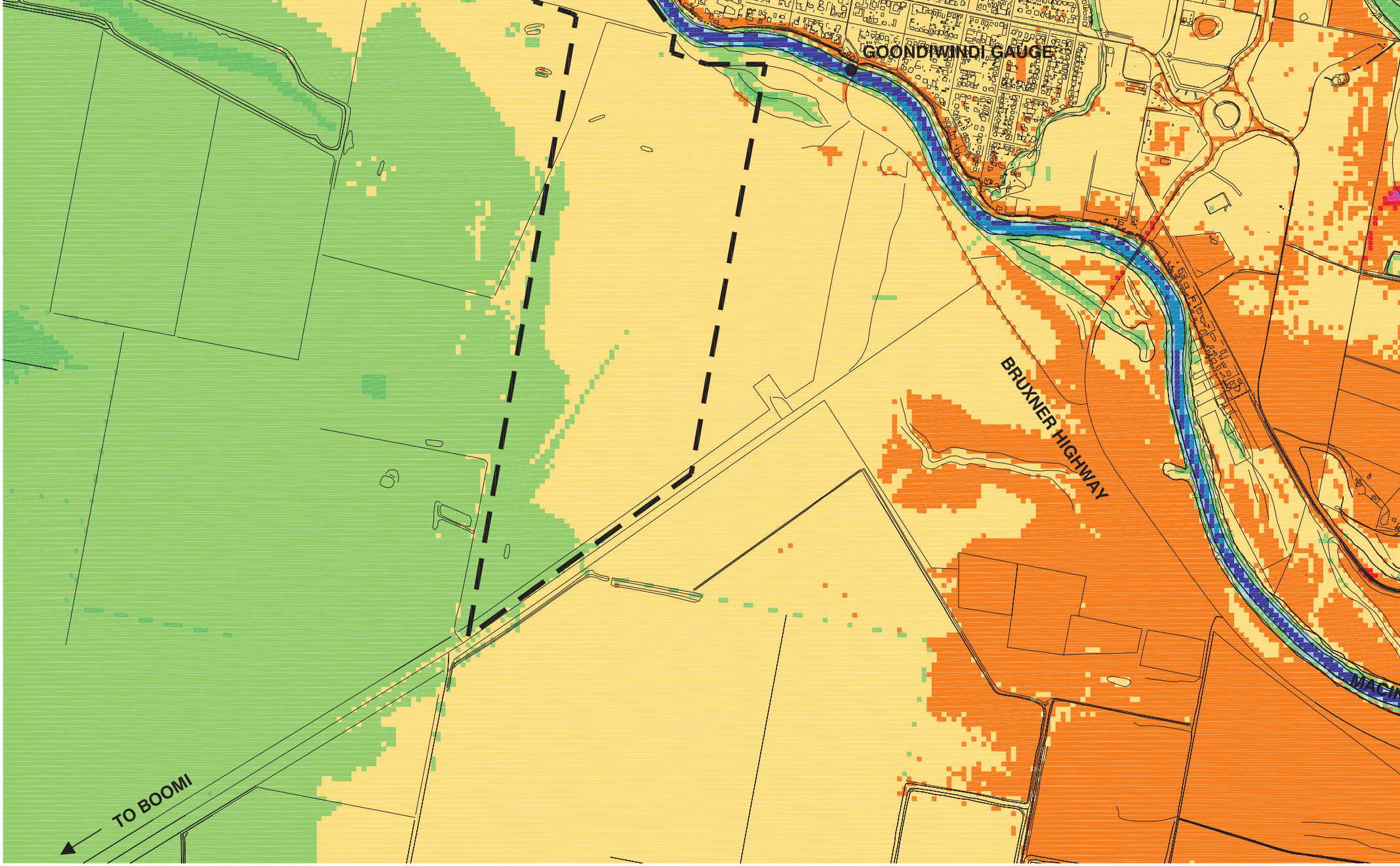
200 0 200 400 600 800 1000m
1:20,000

PROPOSED DEVELOP

Rev: Orig. Date: April 2007

SMK Irrigation Consultants Pty Ltd

CAD FILE: O:\WorkLAT\J8709\Figures\D1\Figure 4 Proposed Case DE04b Q100.dwg
XREF's: J7803FigureBase; Levees 1996; Results; Waggamba_Shire_2005; velocity; XR J8609 Moloney Layout March 2007



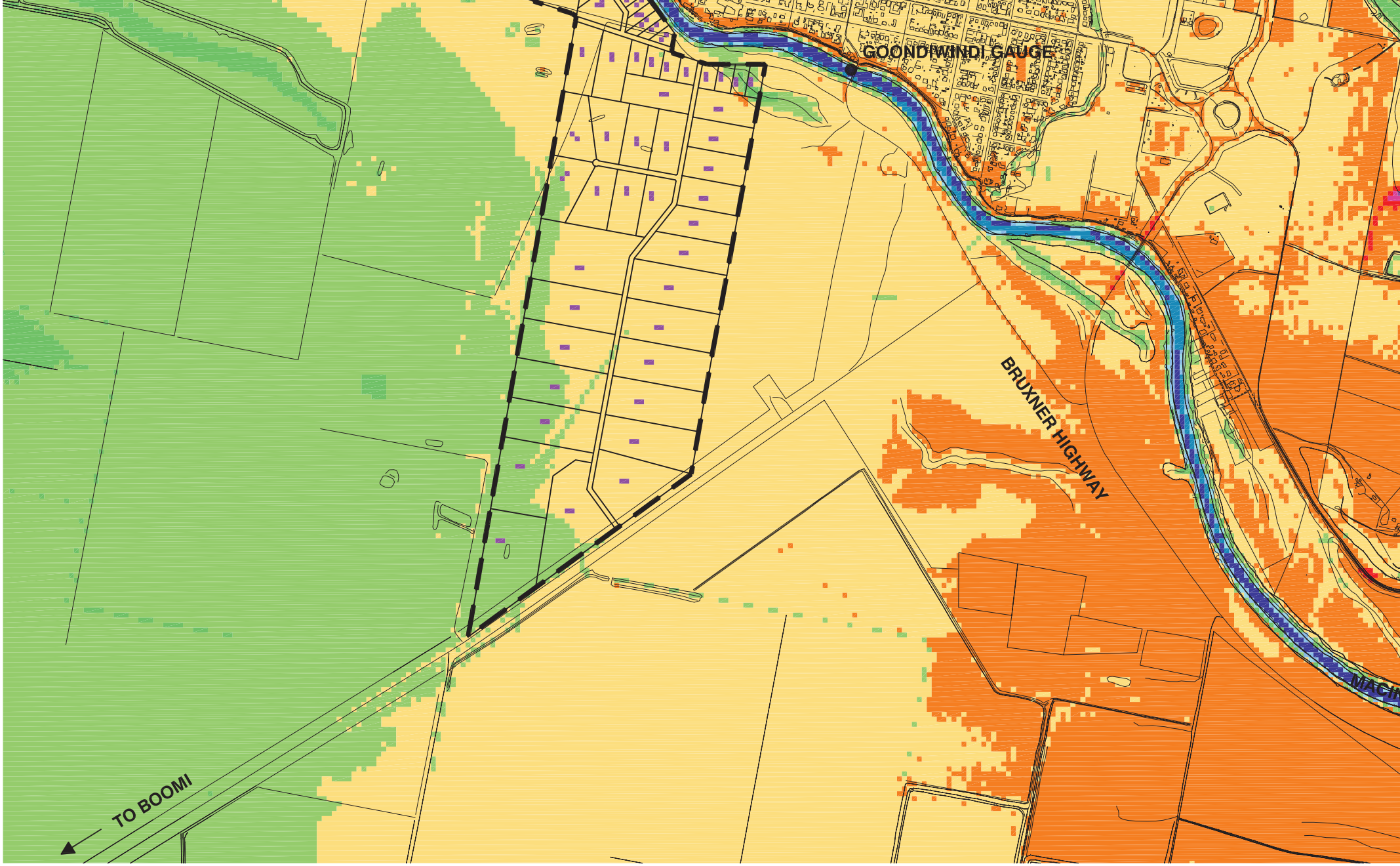
200 0 200 400 600 800 1000m
1:20,000

EXISTING GR

Rev: Orig. Date: April 2007

SMK Irrigation Consultants Pty Ltd

CAD FILE: O:\WorkLAT\J8709\Figures\D1\Figure 5 Greenfield Existing Case EX2f Q100.dwg
XREF's: J7803FigureBase; Levees 1996; Results; Waggamba_Shire_2005; velocity; XR J8609 Moloney Layout March 2007



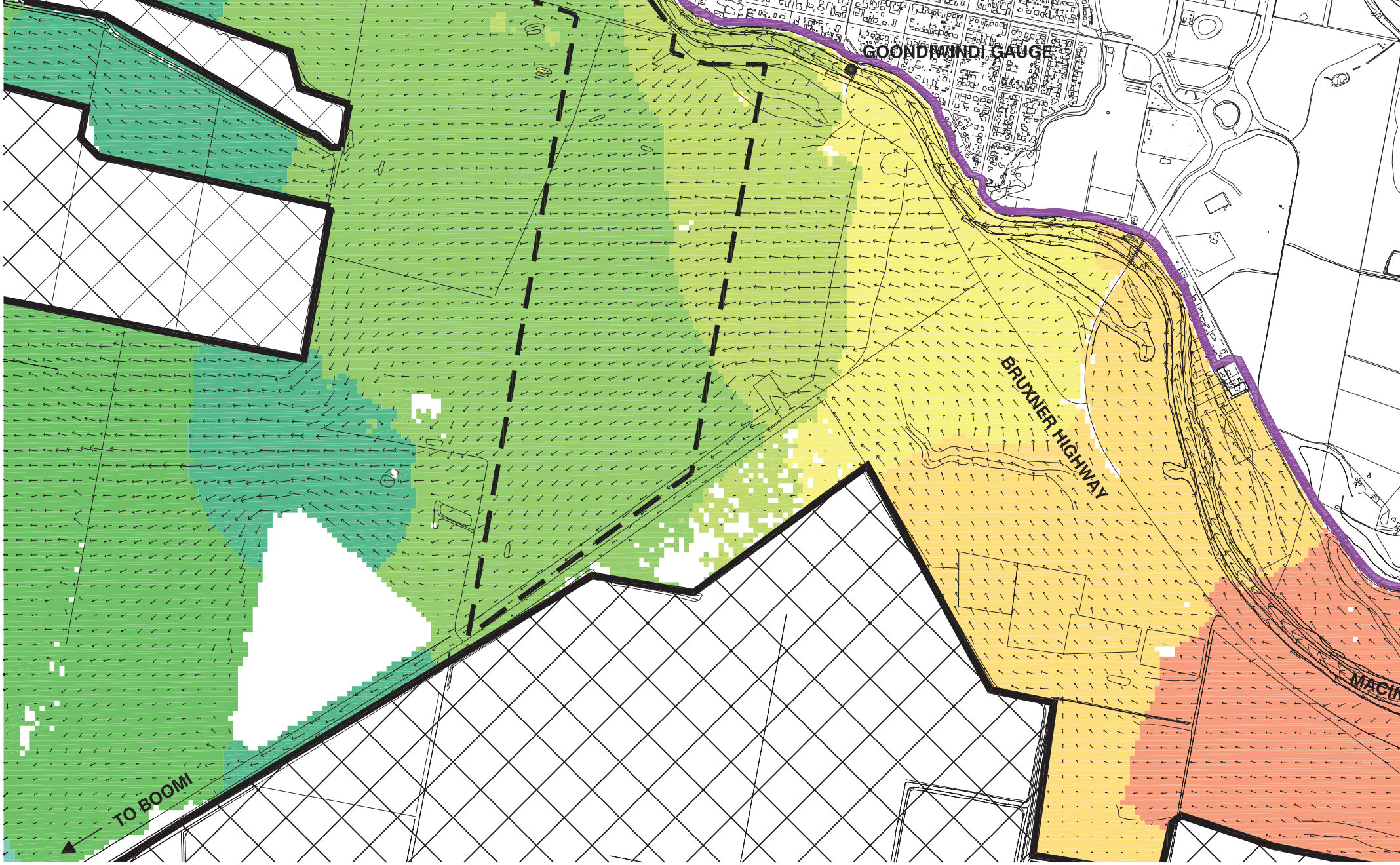
200 0 200 400 600 800 1000m
1:20,000

DEVELOPED GR

Rev: Orig. Date: April 2007

SMK Irrigation Consultants Pty Ltd

CAD FILE: O:\WorkLAT\J8709\Figures\D1\Figure 6 Greenfield Developed DE4b vs EX2f.dwg
XREF's: J7803FigureBase; Levees 1996; Results; Waggamba_Shire_2005; velocity; XR J8609 Moloney Layout March 2007

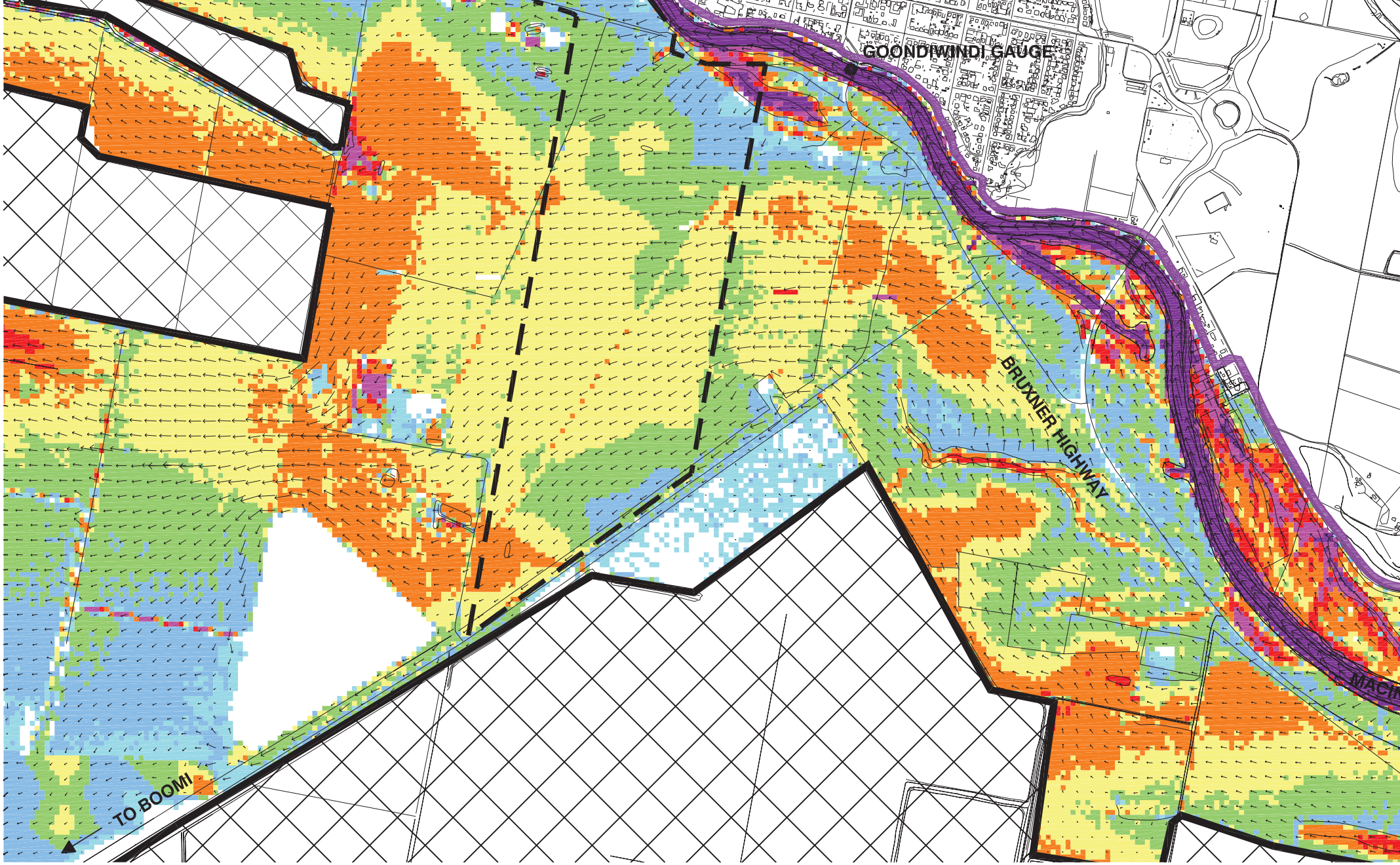


EXISTING CASE EX02C - 1% AEP FLOODING EVENT - PEAK V

Rev: Orig. Date: April 2007

SMK Irrigation Consultants Pty Ltd

CAD FILE: O:\WorkLAT\J8709\Figures\D1\Figure 3 Existing Case EX02c Q100.dwg
XREF's: J7803FigureBase; Levees 1996; Results; Waggamba_Shire_2005; velocity; J8609 Moloney Layout



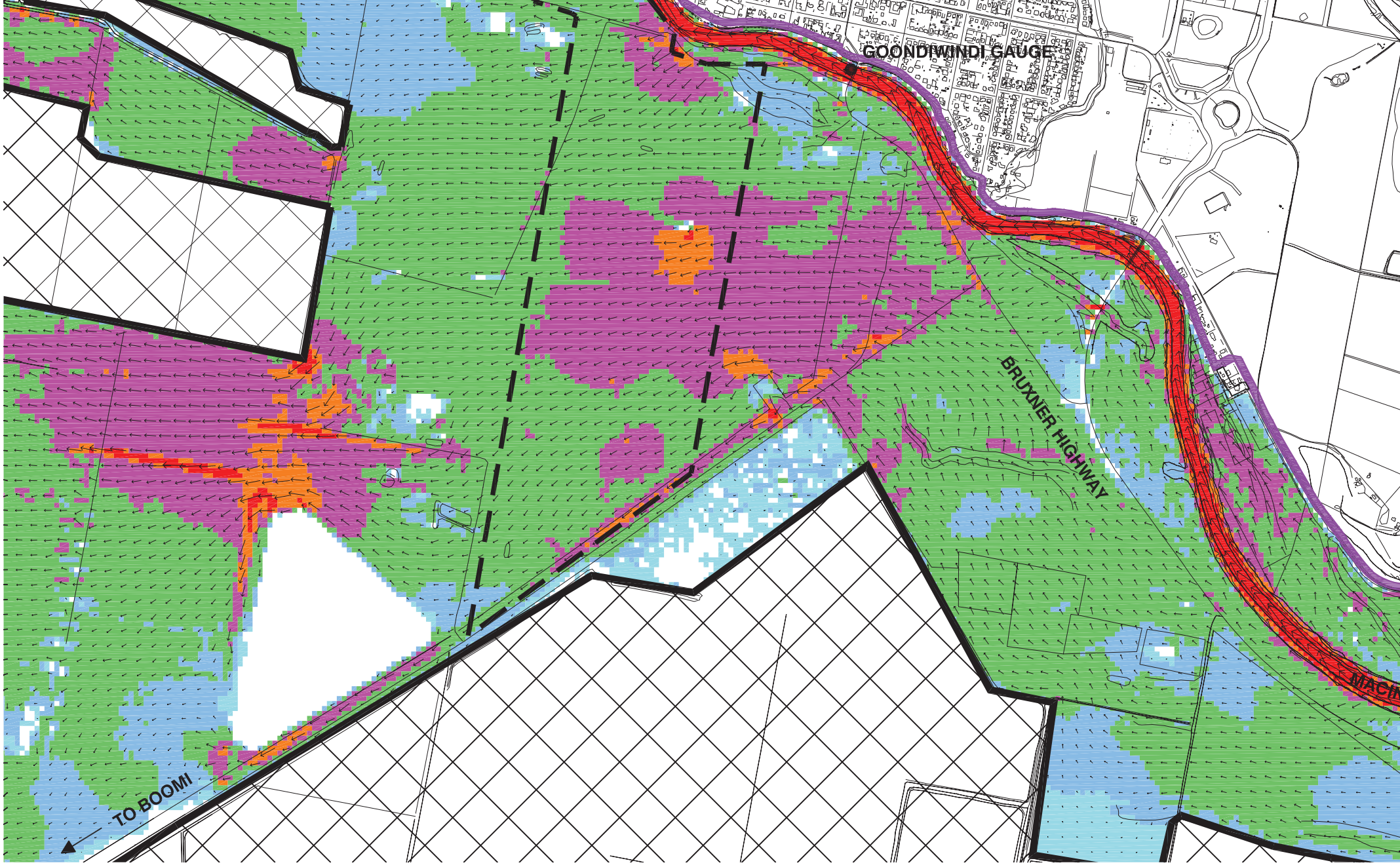
200 0 200 400 600 800 1000m
1:20,000

EXISTING CASE EX02C -1% AEP FLOODING EVENT - PEAK V

Rev: Orig. Date: April 2007

SMK Irrigation Consultants Pty Ltd

CAD FILE: O:\WorkLAT\J8709\Figures\D1\Figure 3 Existing Case EX02c Q100.dwg
XREF's: J7803FigureBase; Levees 1996; Results; Waggamba_Shire_2005; velocity; J8609 Moloney Layout



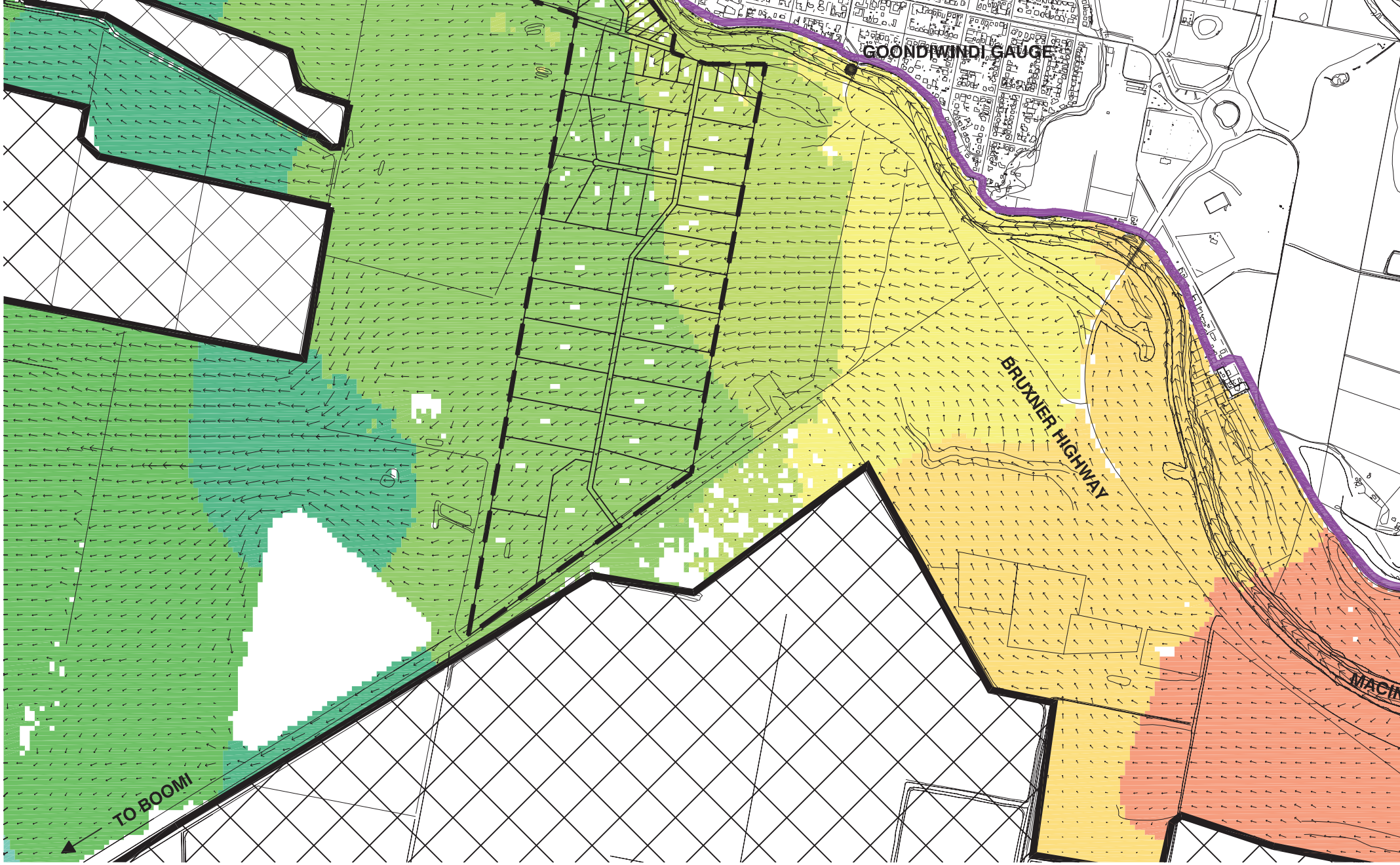
200 0 200 400 600 800 1000m
1:20,000

EXISTING CASE EX02C - 1% AEP FLOODING EVENT - PE

Rev: Orig. Date: April 2007

SMK Irrigation Consultants Pty Ltd

CAD FILE: O:\WorkLAT\J8709\Figures\D1\Figure 3 Existing Case EX02c Q100.dwg
XREF's: J7803FigureBase; Levees 1996; Results; Waggamba_Shire_2005; velocity; J8609 Moloney Layout

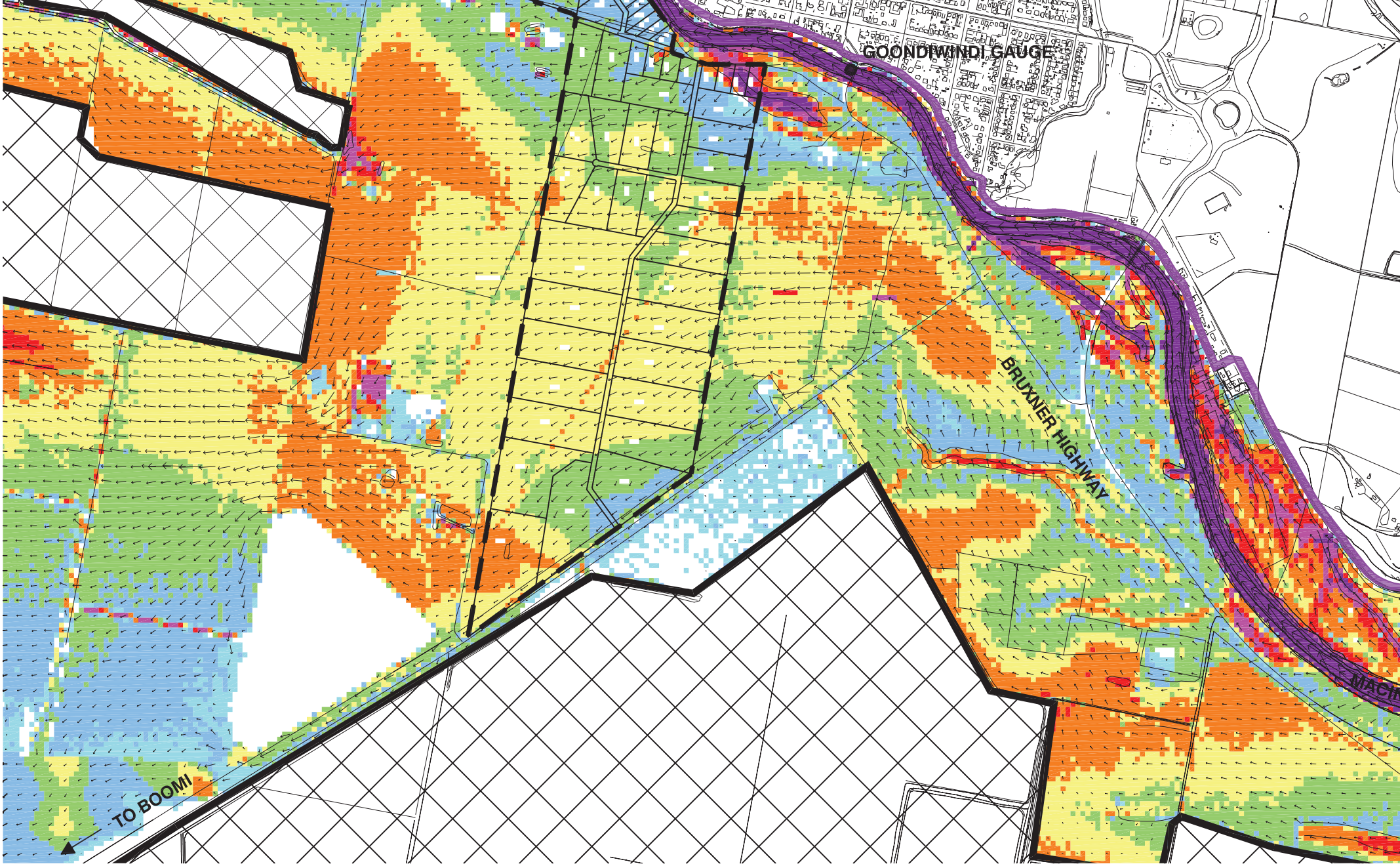


PROPOSED DEVELOPED CASE DE04B - 1% AEP FLOODING EVENT - PEAK V

Rev: Orig. Date: April 2007

SMK Irrigation Consultants Pty Ltd

CAD FILE: O:\WorkLAT\J8709\Figures\D1\Figure 4 Proposed Case DE04b Q100.dwg
XREF's: J7803FigureBase; Levees 1996; Results; Waggamba_Shire_2005; velocity; XR J8609 Moloney Layout March 2007



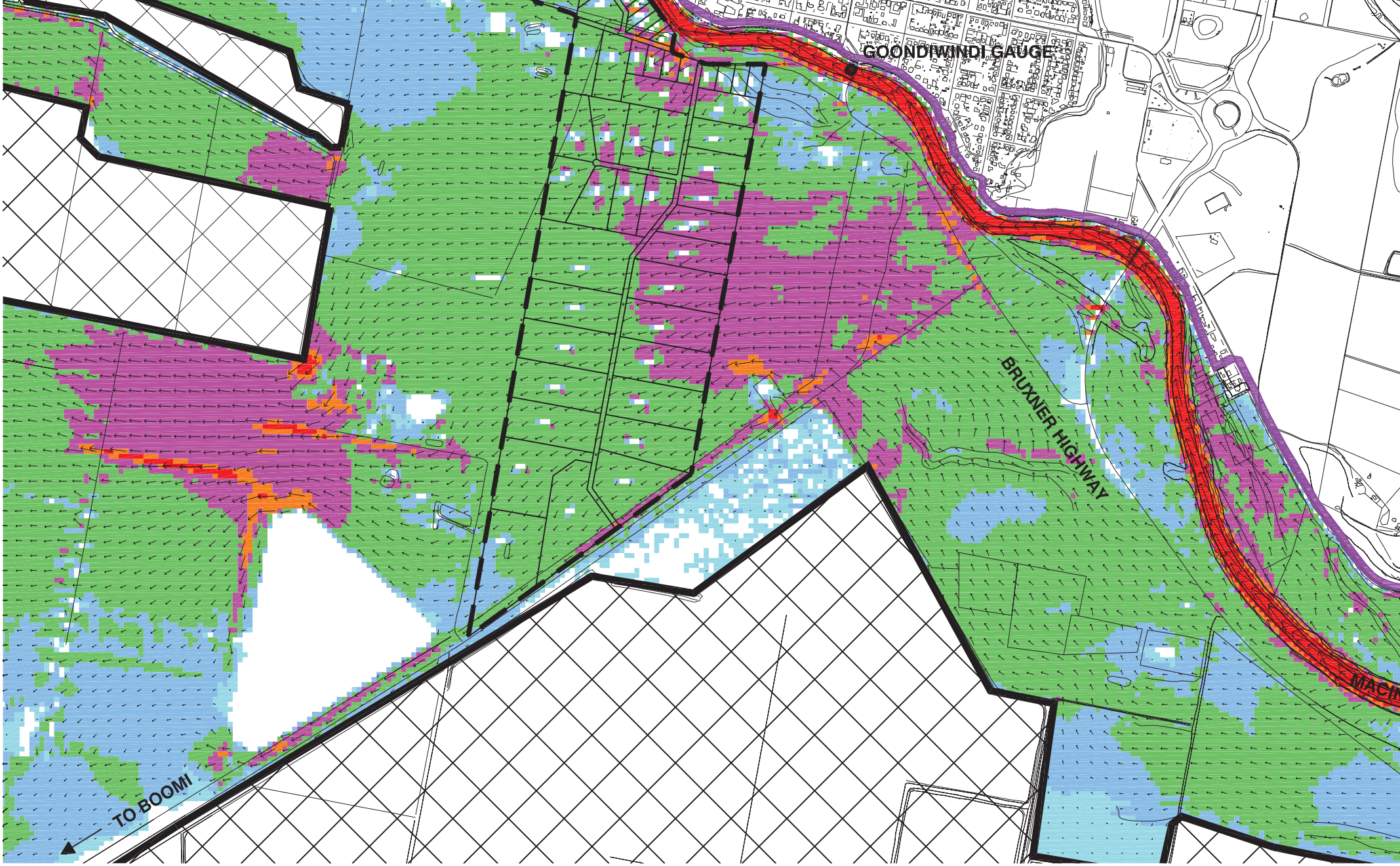
200 0 200 400 600 800 1000m
1:20,000

PROPOSED DEVELOPED CASE DE04B - 1% AEP FLOODING EVENT - PEAK V

Rev: Orig. Date: April 2007

SMK Irrigation Consultants Pty Ltd

CAD FILE: O:\WorkLAT\J8709\Figures\D1\Figure 4 Proposed Case DE04b Q100.dwg
XREF's: J7803FigureBase; Levees 1996; Results; Waggamba_Shire_2005; velocity; XR J8609 Moloney Layout March 2007



200 0 200 400 600 800 1000m
1:20,000

PROPOSED DEVELOPED CASE DE04B - 1% AEP FLOODING EVENT - PE

Rev: Orig. Date: April 2007

SMK Irrigation Consultants Pty Ltd

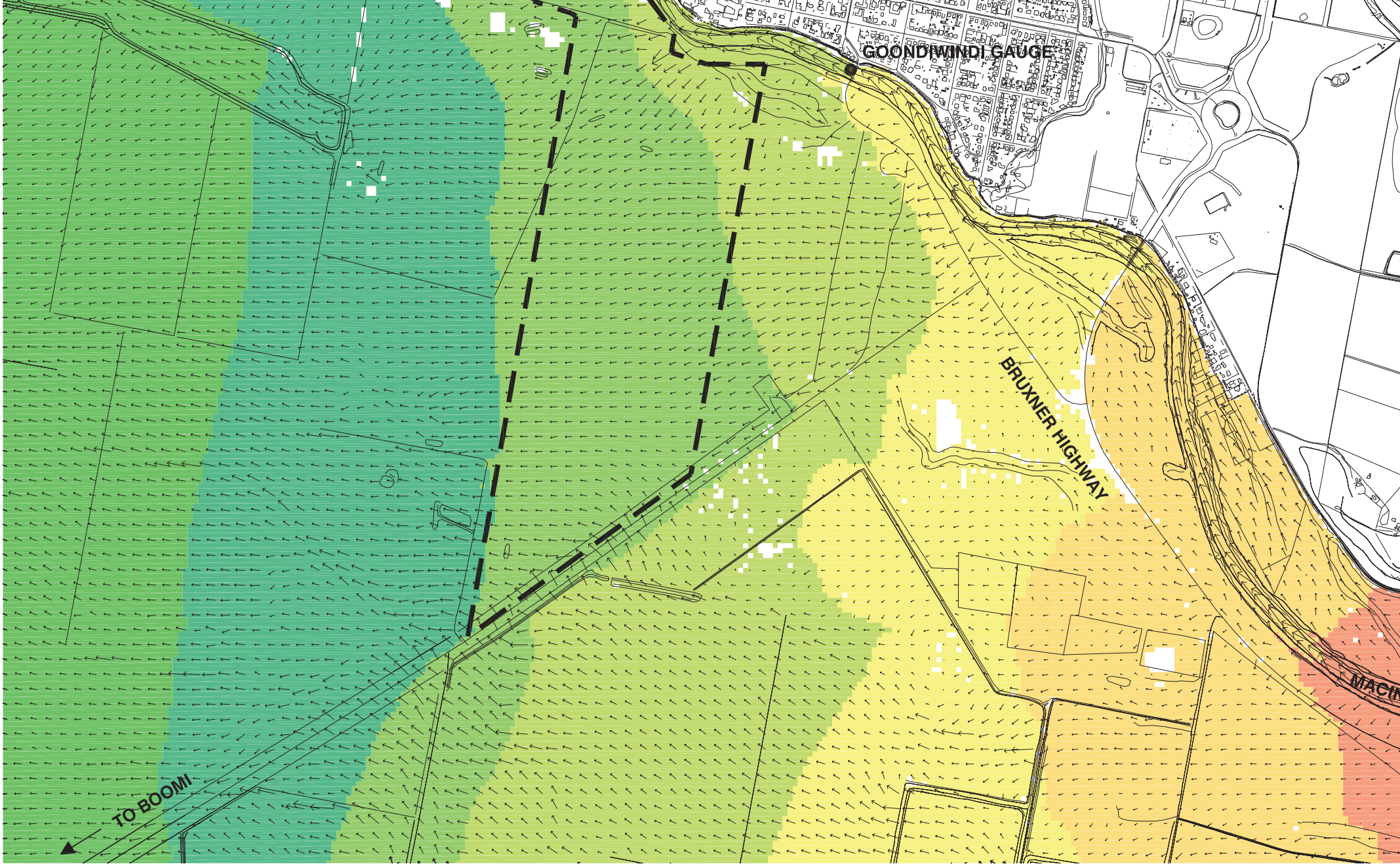
CAD FILE: O:\WorkLAT\J8709\Figures\D1\Figure 4 Proposed Case DE04b Q100.dwg
XREF's: J7803FigureBase; Levees 1996; Results; Waggamba_Shire_2005; velocity; XR J8609 Moloney Layout March 2007

1% AEP FLOODING EVENT - PEAK WA

Rev: Orig. Date: April 2007

SMK Irrigation Consultants Pty Ltd

CAD FILE: O:\WorkLAT\J8709\Figures\D1\Figure 4 Proposed Case DE04b Q100.dwg
XREF's: J7803FigureBase; Levees 1996; Results; Waggamba_Shire_2005; velocity; XR J8609 Moloney Layout March 2007



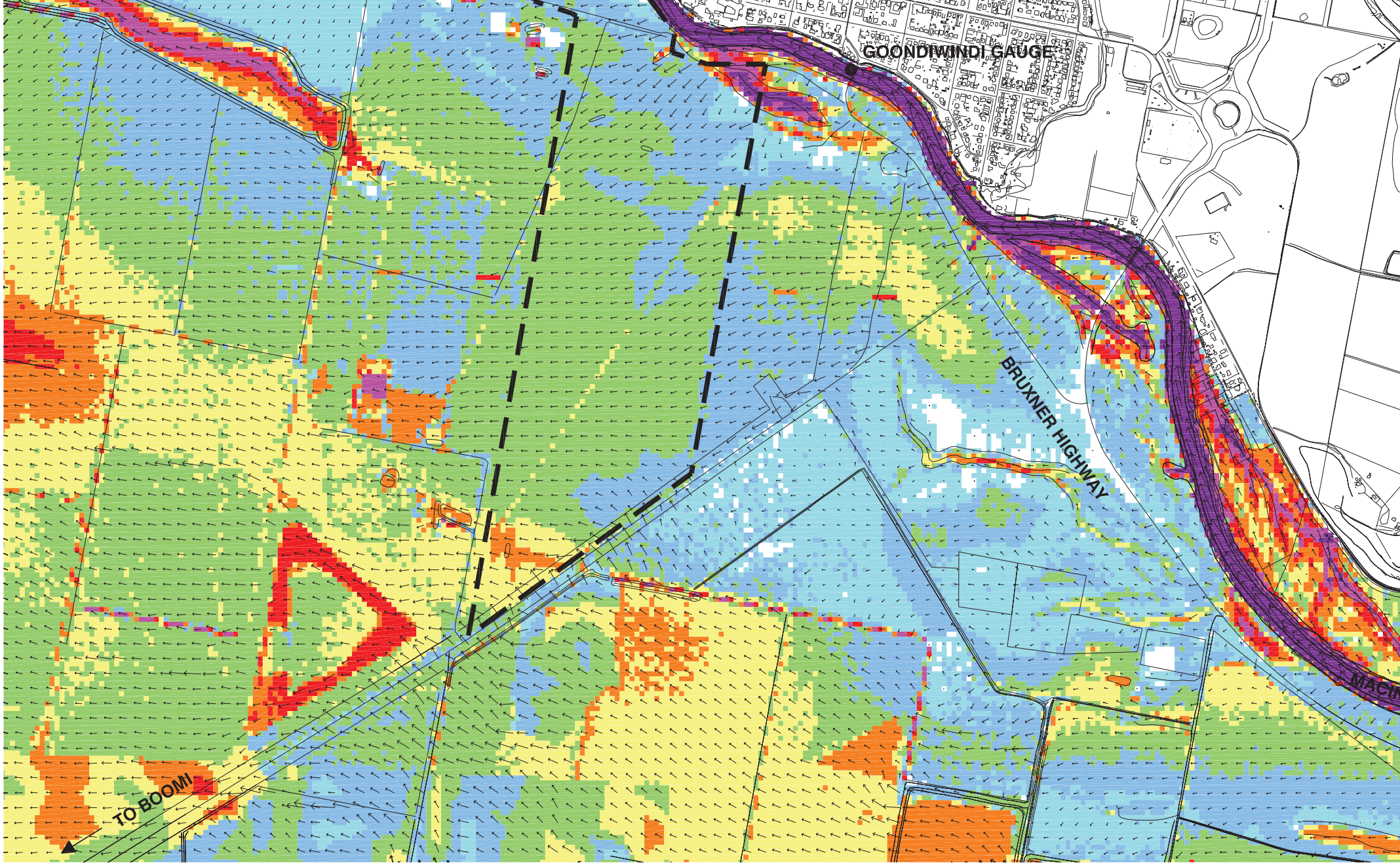
200 0 200 400 600 800 1000m
1:20,000

EXISITNG GREENFIELD CASE - 1% AEP FLOODING EVENT - PEAK V

Rev: Orig. Date: April 2007

SMK Irrigation Consultants Pty Ltd

CAD FILE: O:\WorkLAT\J8709\Figures\D1\Figure 5 Greenfield Existing Case EX2f Q100.dwg
XREF's: J7803FigureBase; Levees 1996; Results; Waggamba_Shire_2005; velocity; XR J8609 Moloney Layout March 2007



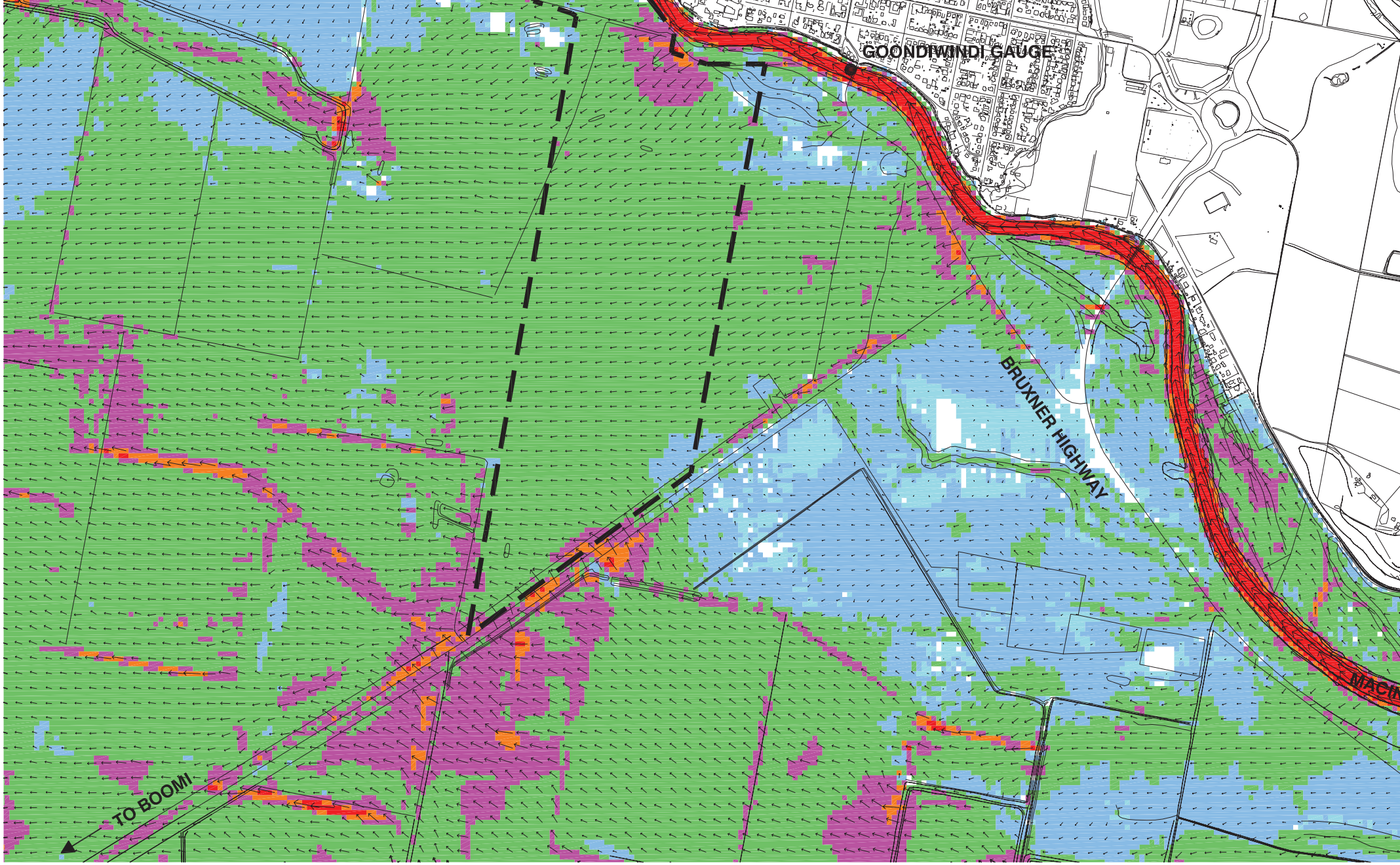
200 0 200 400 600 800 1000m
1:20,000

EXISTING GREENFIELD CASE - 1% AEP FLOODING EVENT - PEAK V

Rev: Orig. Date: April 2007

SMK Irrigation Consultants Pty Ltd

CAD FILE: O:\WorkLAT\J8709\Figures\D1\Figure 5 Greenfield Existing Case EX2f Q100.dwg
XREF's: J7803FigureBase; Levees 1996; Results; Waggamba_Shire_2005; velocity; XR J8609 Moloney Layout March 2007



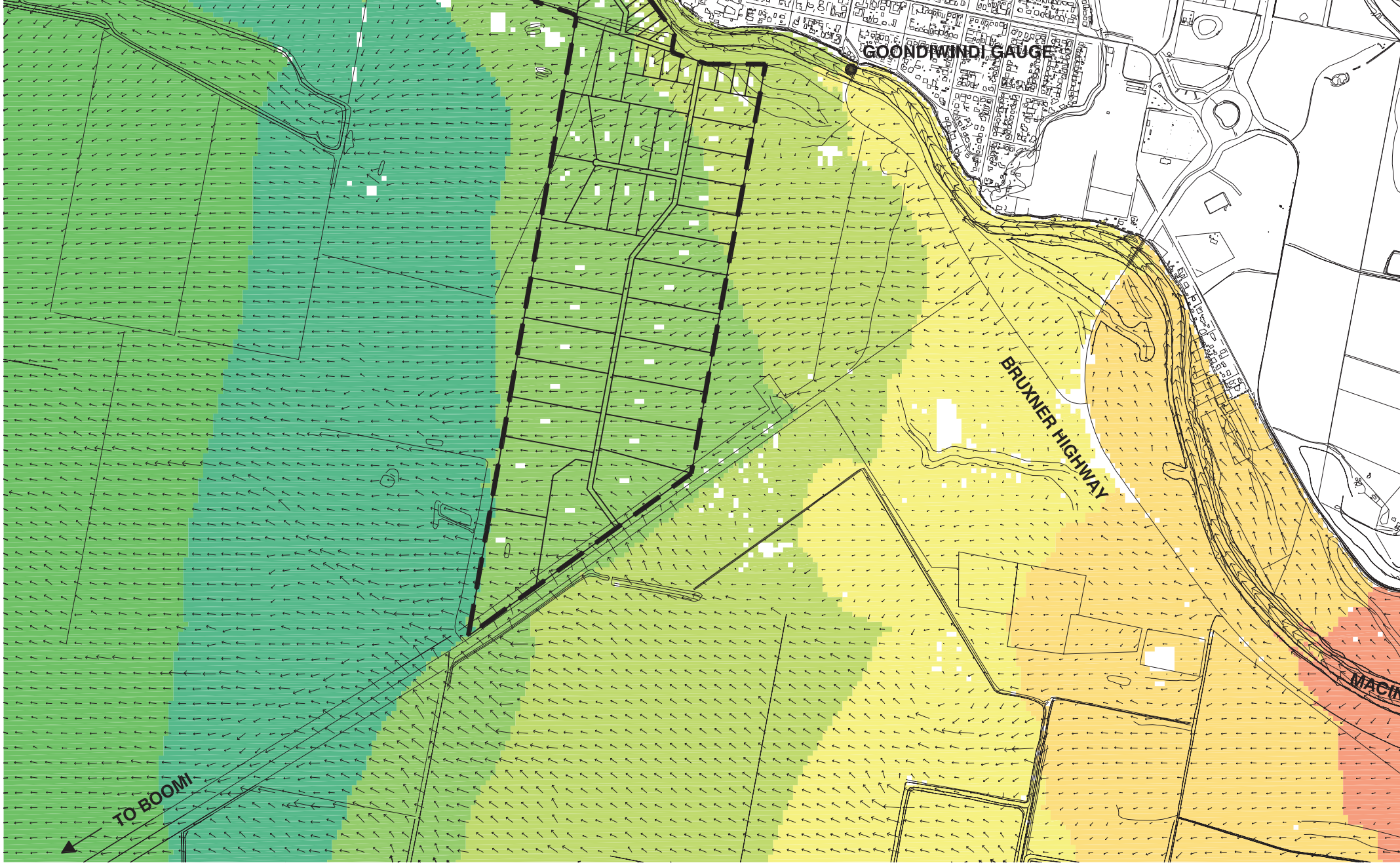
200 0 200 400 600 800 1000m
1:20,000

EXISTING GREENFIELD CASE - 1% AEP FLOODING EVENT - PE

Rev: Orig. Date: April 2007

SMK Irrigation Consultants Pty Ltd

CAD FILE: O:\WorkLAT\J8709\Figures\D1\Figure 5 Greenfield Existing Case EX2f Q100.dwg
XREF's: J7803FigureBase; Levees 1996; Results; Waggamba_Shire_2005; velocity; XR J8609 Moloney Layout March 2007



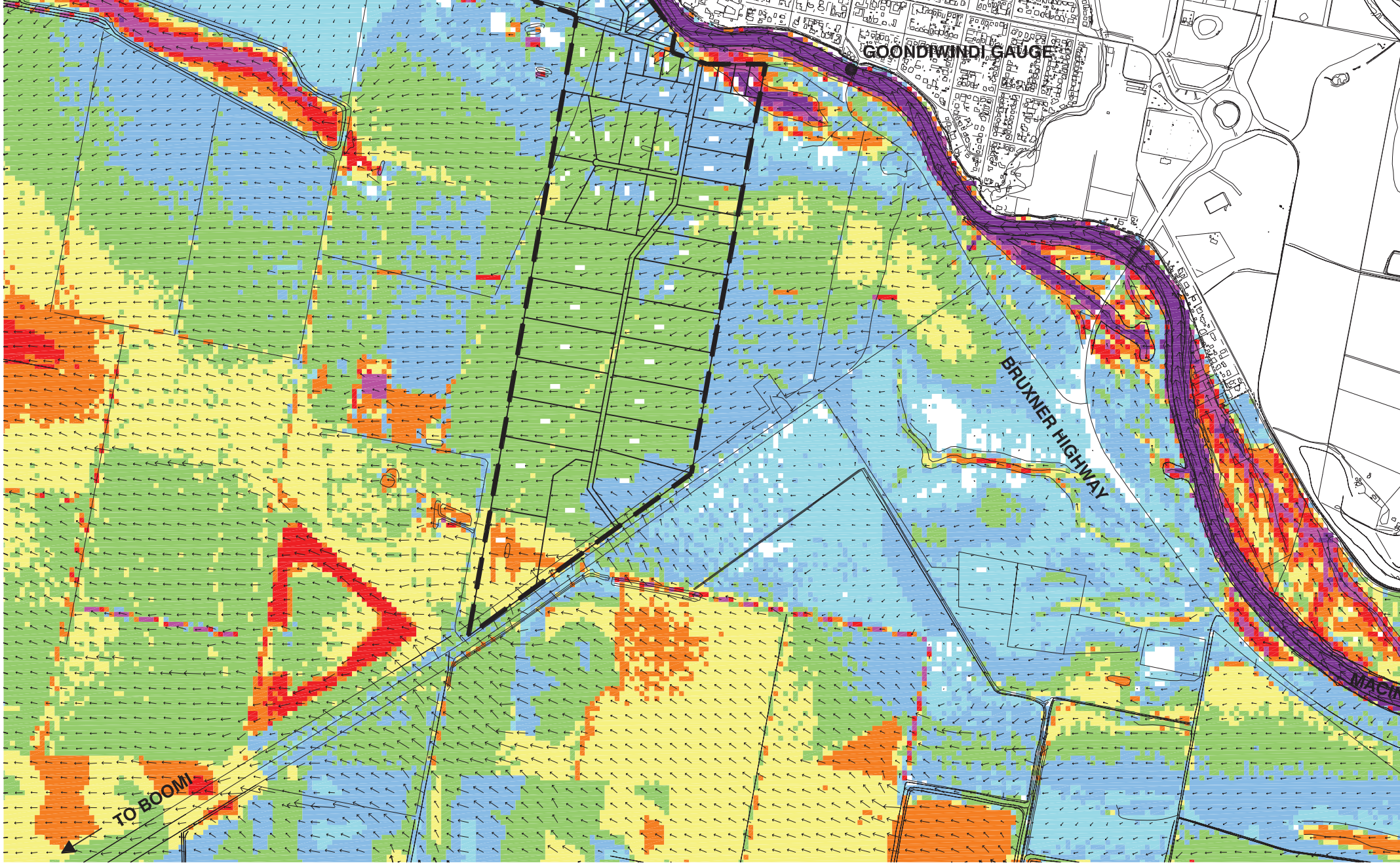
200 0 200 400 600 800 1000m
1:20,000

DEVELOPED GREENFIELD CASE - 1% AEP FLOODING EVENT - PEAK V

Rev: Orig. Date: April 2007

SMK Irrigation Consultants Pty Ltd

CAD FILE: O:\WorkLAT\J8709\Figures\D1\Figure 6 Greenfield Developed DE4b vs EX2f.dwg
XREF's: J7803FigureBase; Levees 1996; Results; Waggamba_Shire_2005; velocity; XR J8609 Moloney Layout March 2007



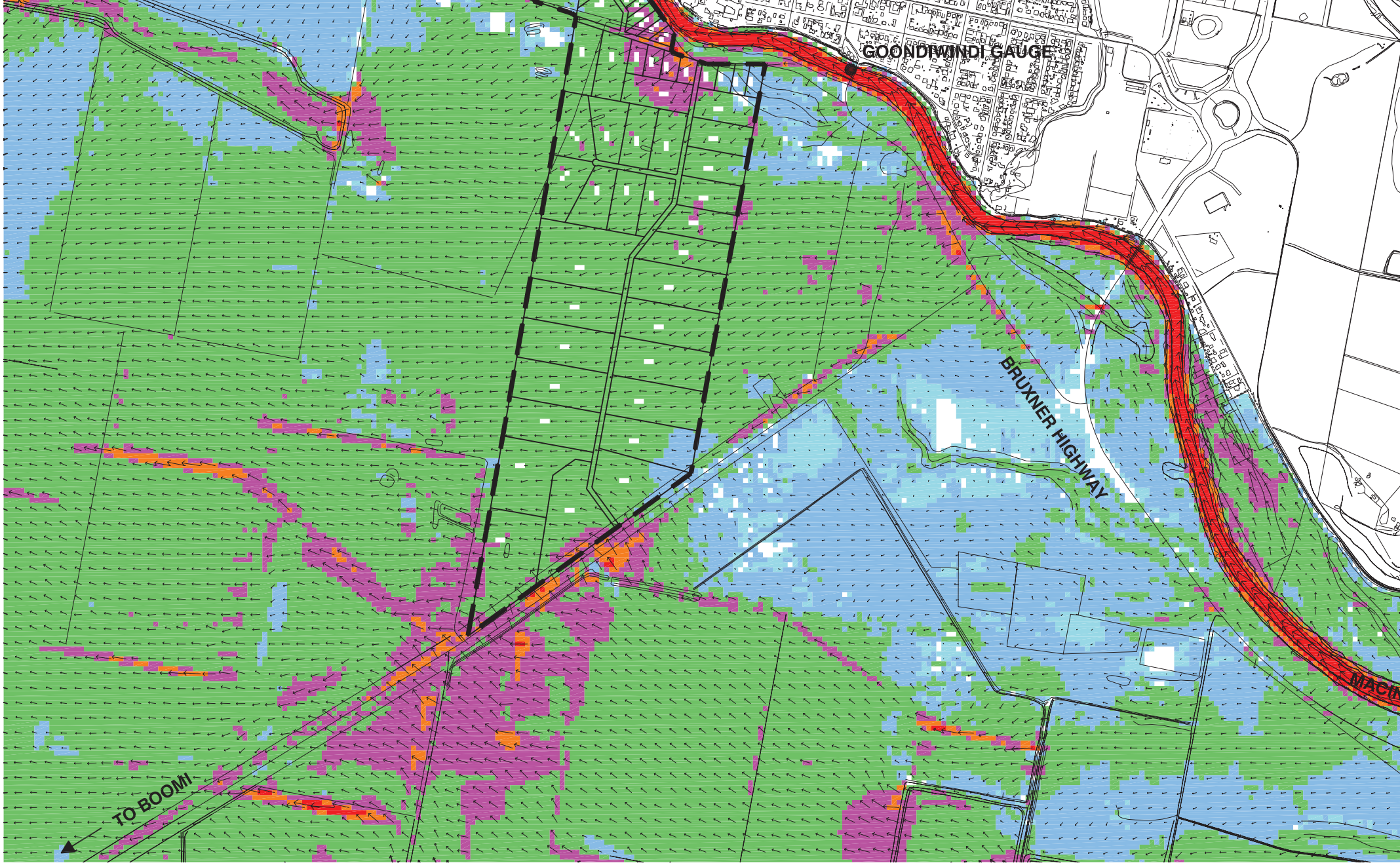
200 0 200 400 600 800 1000m
1:20,000

DEVELOPED GREENFIELD CASE - 1% AEP FLOODING EVENT - PEAK V

Rev: Orig. Date: April 2007

SMK Irrigation Consultants Pty Ltd

CAD FILE: O:\WorkLAT\J8709\Figures\D1\Figure 6 Greenfield Developed DE4b vs EX2f.dwg
XREF's: J7803FigureBase; Levees 1996; Results; Waggamba_Shire_2005; velocity; XR J8609 Moloney Layout March 2007



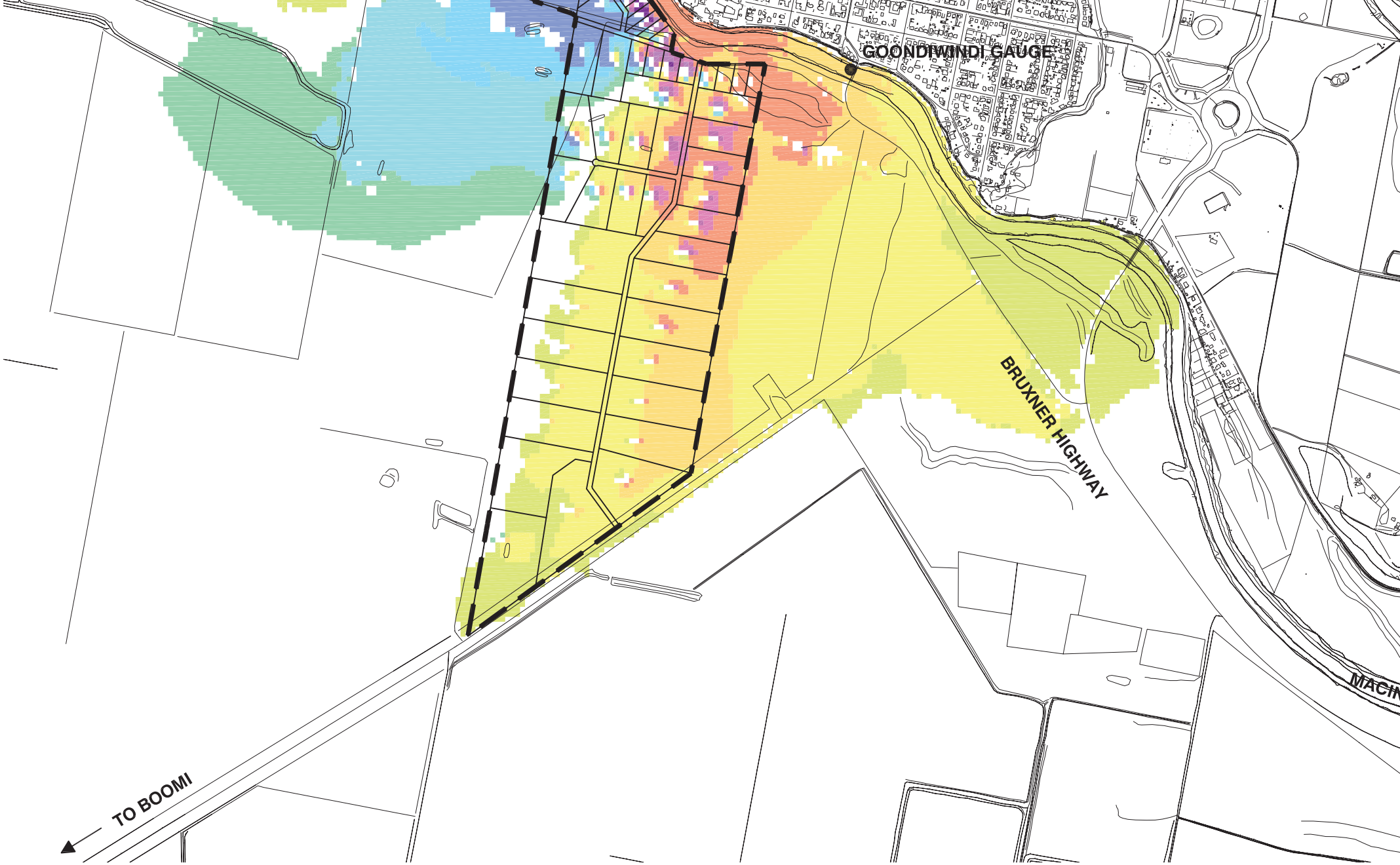
200 0 200 400 600 800 1000m
1:20,000

DEVELOPED GREENFIELD CASE - 1% AEP FLOODING EVENT - PE

Rev: Orig. Date: April 2007

SMK Irrigation Consultants Pty Ltd

CAD FILE: O:\WorkLAT\J8709\Figures\D1\Figure 6 Greenfield Developed DE4b vs EX2f.dwg
XREF's: J7803FigureBase; Levees 1996; Results; Waggamba_Shire_2005; velocity; XR J8609 Moloney Layout March 2007



DEVELOPED GREENFIELD CASE - 1% AEP FLOODING

Rev: Orig. Date: April 2007

SMK Irrigation Consultants Pty Ltd

CAD FILE: O:\WorkLAT\J8709\Figures\D1\Figure 6 Greenfield Developed DE4b vs EX2f.dwg
XREF's: J7803FigureBase; Levees 1996; Results; Waggamba_Shire_2005; velocity; XR J8609 Moloney Layout March 2007