4.4 Sensitivity Analysis

The hydraulic model for the Lower Bohle/Stony Creek was not calibrated due to the lack of stream gauge data within the model extent. A sensitivity analysis was undertaken to evaluate how sensitive the hydraulic model was to changes of roughness. The sensitivity analysis was completed for the 100 year, 12 hour event and involved testing a range of high and low values for roughness as summarised below:

Table 4-3 Summary of Sensitivity Analysis

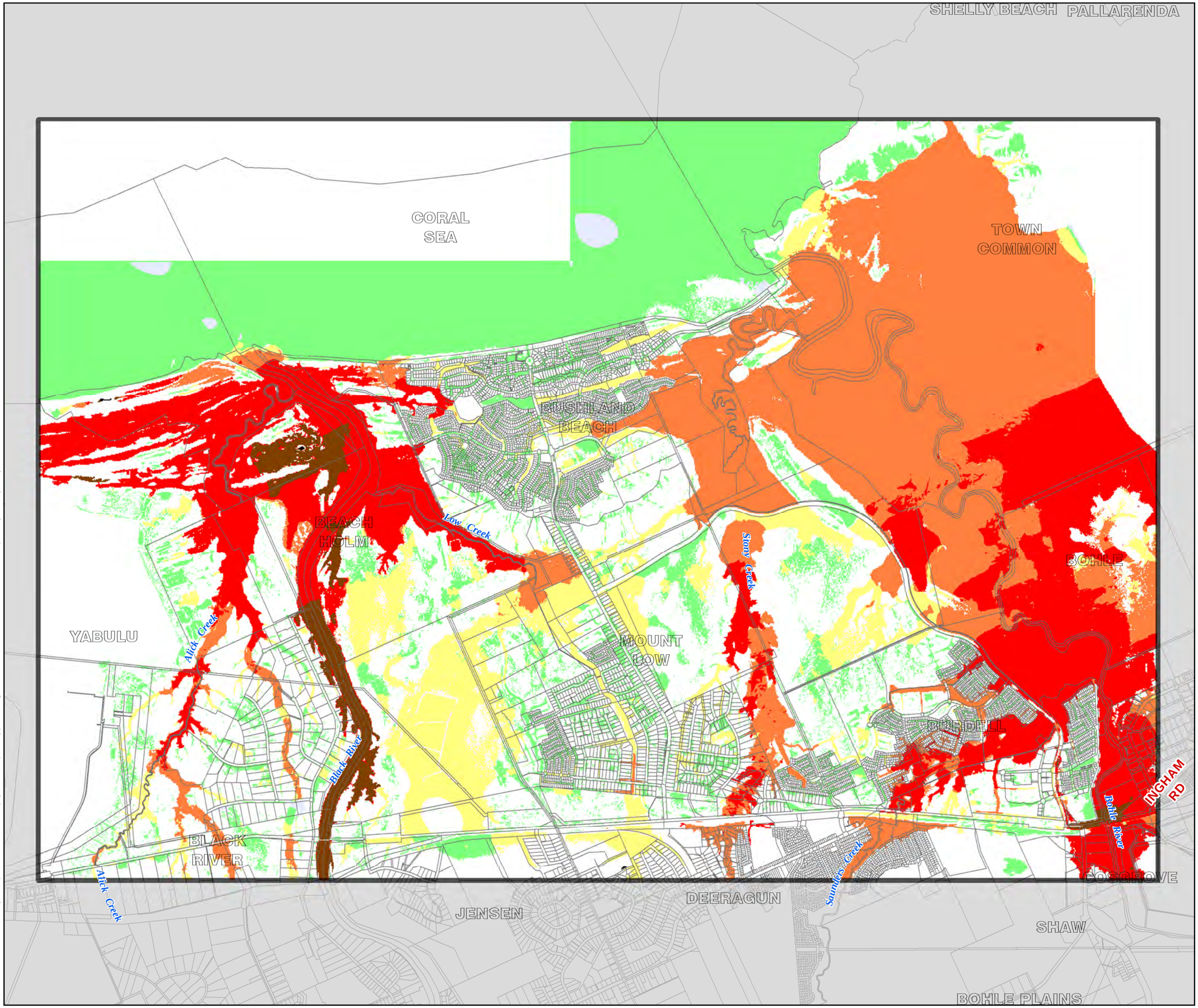
Parameter Assessed	Low	Normal (Used)	High
Roughness	Decrease by 20%	As per Figure 3-4	Increase by 20%

The results of the sensitivity analysis are shown in Figure 4-2 and Figure 4-3.

The following conclusions were reached from the sensitivity analysis:

- Increases in roughness resulted in higher flood depths. Water levels increased by up to 0.5 m along the main channel of the Black River, up to 0.25 m for Stony Creek, Saunders Creek and Bohle River, and up to 0.1 m in more urbanised areas.
- Decreases in roughness resulted in lower flood depths. Water levels reduced by up to 0.25 m along the main channel of the Black River, Stony Creek and Bohle River and up to 0.1 m in more urbanised areas.
- The roughness factors adopted for the MIKE FLOOD model were determined to be appropriate for the study. The roughness factors adopted are consistent with those used for other previous modelling studies completed in the Bohle Flood Plains area.

TOWNSVILLE CITY COUNCIL
LOWER BOHLE/STONY CREEK
FLOOD STUDY
Sensitivity Analysis
Roughness Increased by 20%
Figure 4-2



Difference (m)

- Below -1
- -1 - -0.5
- -0.5 - -0.25
- -0.25 - -0.1
- -0.1 - -0.05
- -0.05 - -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.05 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- Above 0.5

0 500 1,000 2,000
Metres

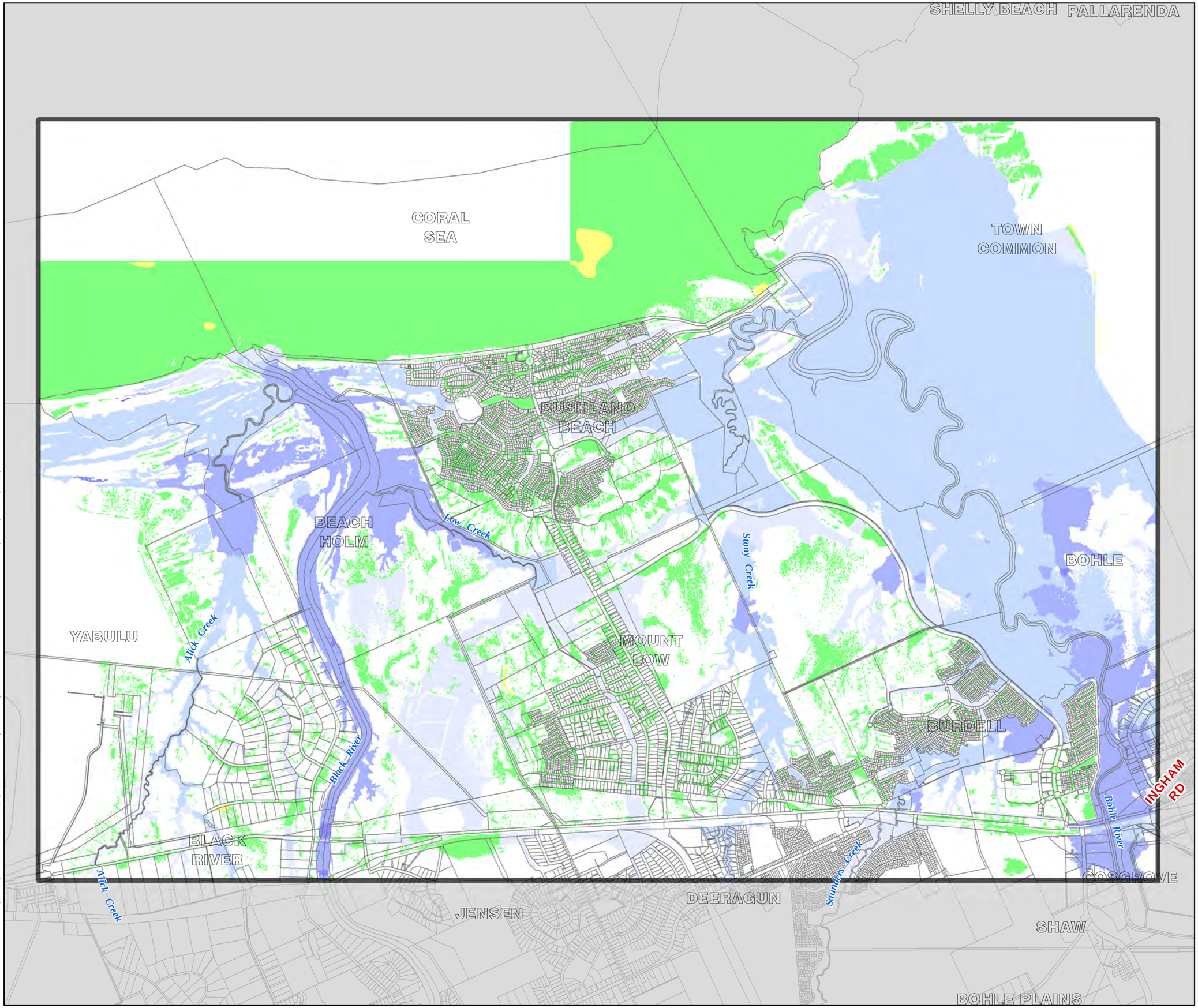
1:40,000 (when printed at A3)

Coordinate System: GDA 1994 MGA Zone 55

Data sources:
Roads © 2012 (StreetPro)
Localities © 2012 (Queensland Govt)

AECOM
www.aecom.com

TOWNSVILLE CITY COUNCIL
LOWER BOHLE/STONY CREEK FLOOD STUDY
Sensitivity Analysis
Roughness Decreased by 20%
Figure 4-3



Difference (m)

- Below -1
- -1 - -0.5
- -0.5 - -0.25
- -0.25 - -0.1
- -0.1 - -0.05
- -0.05 - -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.05 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- Above 0.5

0 500 1,000 2,000

Metres

1:40,000 (when printed at A3)

Coordinate System: GDA 1994 MGA Zone 55

Data sources:
Roads © 2012 (StreetPro)
Localities © 2012 (Queensland Govt)

AECOM
www.aecom.com

5.0 Conclusions and Recommendations

5.1 Conclusion

The following conclusions are drawn from this study:

- A hydraulic model that covers the Lower Bohle/Stony Creek area was developed TCC 2009 and 2012 LiDAR topography, TCC 2011 aerial photography, TCC refined XP-RAFTS hydrologic model and refined *Middle Bohle Flood Study (2014)* and *Black River Flood Study (2014)* inflows according to the *Preparation of Flood Studies and Reports - Guidelines* (2010) developed by TCC.
- Sensitivity testing was undertaken in the absence of calibration data. The hydraulic model was found to be sensitive (up to 0.5 m) to changes in the assumed Manning's roughness value.
- The model parameters adopted for roughness as well as initial and continuous losses are in line with those used in other studies undertaken as part of the City Wide Flood Constraints Project in the area. Furthermore, the predicted flooding in the Mount Low Parkway area appears to match residents' anecdotal accounts which provides further confidence in the parameters used.
- The critical durations adopted for all ARI events up to 500 year were 12 and 24 hours.
- 3 hours was used as critical duration for the 500 year ARI and PMP storms to ensure consistency with previous studies.
- A significant number of properties within the suburb of Mount Low, Bushland Beach and Burdell are likely to be affected by flooding to some extent under the range of ARI events assessed. Also likely to be affected, to a lesser extent, are properties within other suburbs across the study area.
- No extensive inundation is expected for the Mount Low and Bushland Beach areas during the 50 and 100 year ARI events.
- Mount Low Parkway is estimated to have a level of flood immunity in excess of 100 year ARI. North Shore Boulevard is estimated to have a level of flood immunity of greater than the 20 year ARI.

5.2 Recommendations

The following recommendations are made as part of this study:

- Calibration and verification of the MIKE FLOOD hydraulic model should be performed when new flood level survey or stream gauge data relating to actual flood events is available for the study area.
- Opportunities to reduce the number of lots affected by flooding across the study area should be sought. This could include the use of flood mitigation measures at strategic locations and should be explored as part of city wide strategic projects.
- Review of the model results by an RPEQ qualified engineer is recommended for site specific assessment of flood risk as some local refinement of the model may be required, in particular where development within the floodplain has taken place since model development.
- In order to ensure continued accurate representation of flooding conditions across the study area, it is recommended that the flood modelling is regularly reviewed in the light of any newly available survey data, changes to floodplain conditions and changes to accepted hydrologic and hydraulic engineering standards and practices.

6.0 References

The following publications were used as references during the production of this study:

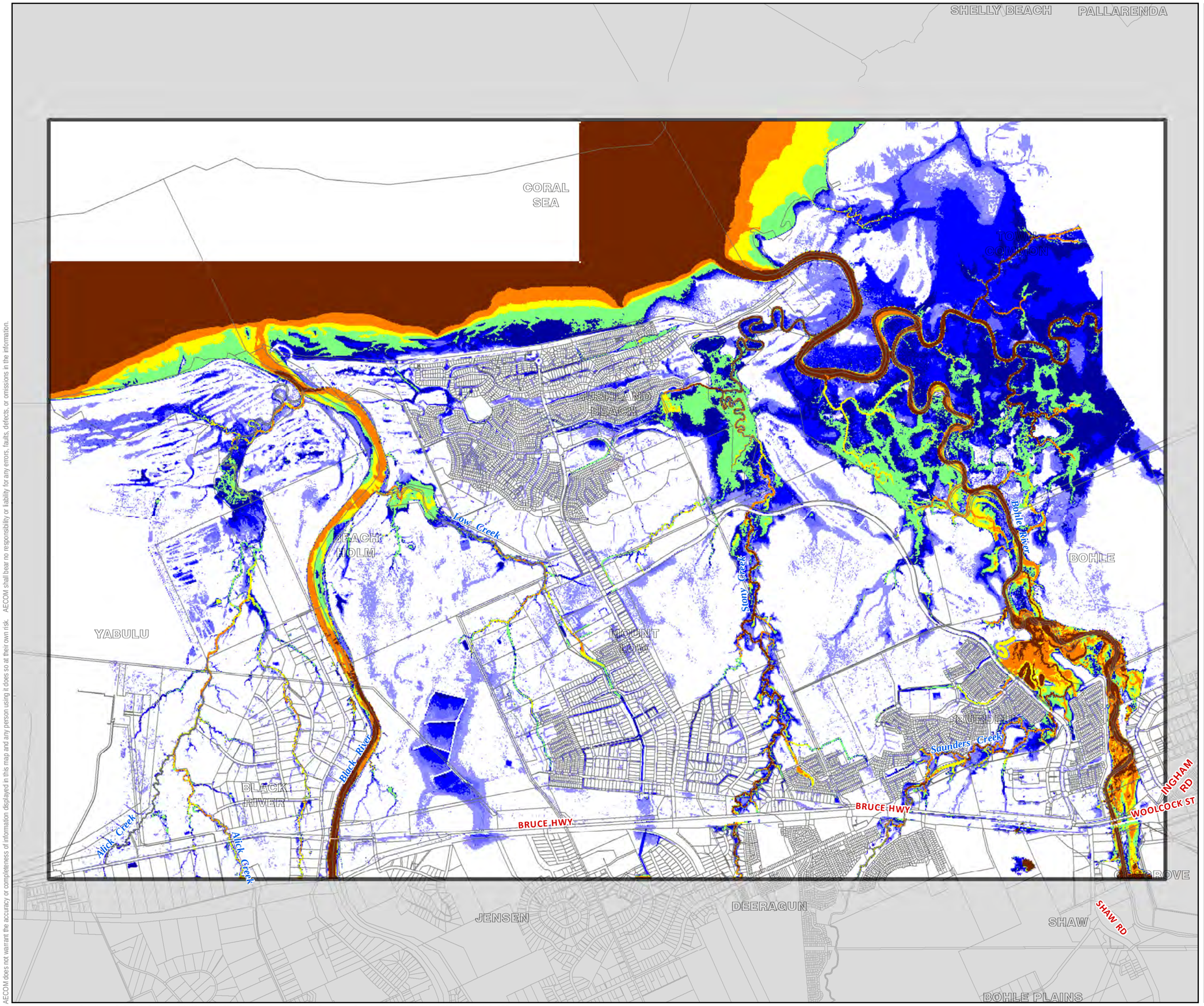
- AECOM Australia Pty Ltd (2014) "*Black River Flood Study*"
- AECOM Australia Pty Ltd (2014) "*Upper and Middle Bohle Flood Study*"
- AECOM Australia Pty Ltd (2014) "*Louisa Creek Flood Study*"
- AECOM Australia Pty Ltd (2012) "*Deeragun Flood Study*"
- AECOM Australia Pty Ltd (2011) "*Upper Bohle Plains Flood Study*"
- AECOM Australia Pty Ltd (2010) "*Bohle Plains Flood Planning Study*"
- Bureau of Meteorology - Hydrometeorological Advisory Service (2003) "*The Estimation of Probable Maximum Precipitation in Australia: Generalised Short-Duration Method*"
- Chow (1959) "*Open Channel Hydraulics*"
- DHI Software (2009) "*MIKE FLOOD 1D-2D Modelling User Manual*"
- Townsville City Council (2010) "*Preparation of Flood Studies and Reports – Guidelines*"
- Institution of Engineers Australia (1987) "*Australian Rainfall and Runoff, Volumes 1 and 2*"
- Institution of Engineers Australia *(2011)* "*Rainfall-on-Grid Modelling - a Decade of Practice*"
- Maunsell McIntyre Pty Ltd (2001) "*Bohle River Floodplain Management Study*"
- XP Software (1994) "*RAFTS-XP User's Manual*"

Appendix A

Flood Maps

LOWER BOHLE/STONY CREEK FLOOD STUDY

Maximum Water Depths
2-yr ARI
Appendix Figure A1



Water Depths (m)

- 0 - 0.3
- 0.3 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- > 3

0 250 500 1,000 1,500

Metres

1:40,000 (when printed at A3)

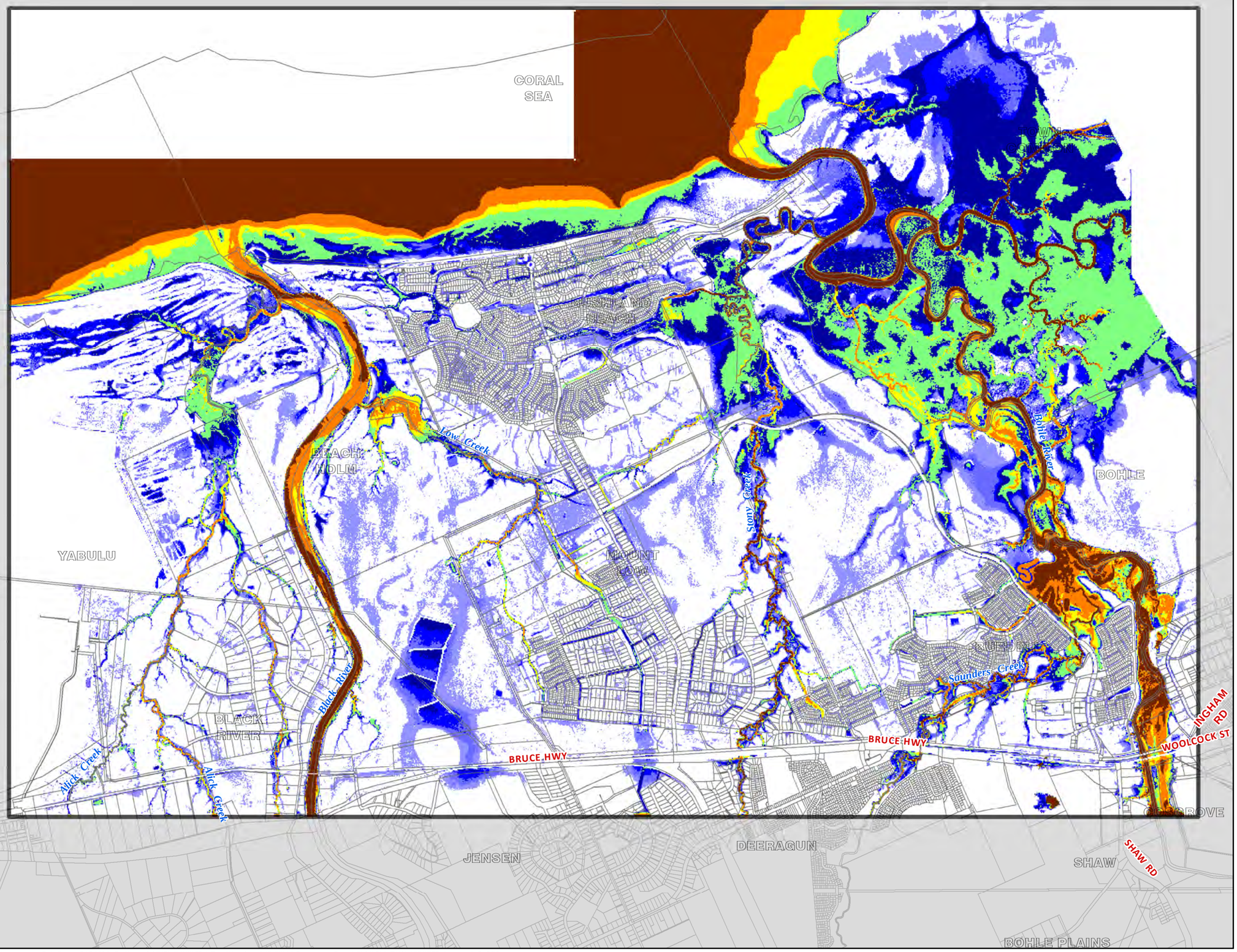
Coordinate System: GDA 1994 MGA Zone 55

Data sources:
Road, Rail, Localities - StreetPro© 2010
Contours - Derived from 30m DEM, QLD Gov 2010
Imagery - QLD Gov 2010
Elevation - TCC 2013

AECOM
www.aecom.com

LOWER BOHLE/STONY CREEK FLOOD STUDY

Maximum Water Depths
5-yr ARI
Appendix Figure A2



Water Depths (m)

- 0 - 0.3
- 0.3 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- > 3

0 250 500 1,000 1,500
Metres

1:40,000 (when printed at A3)

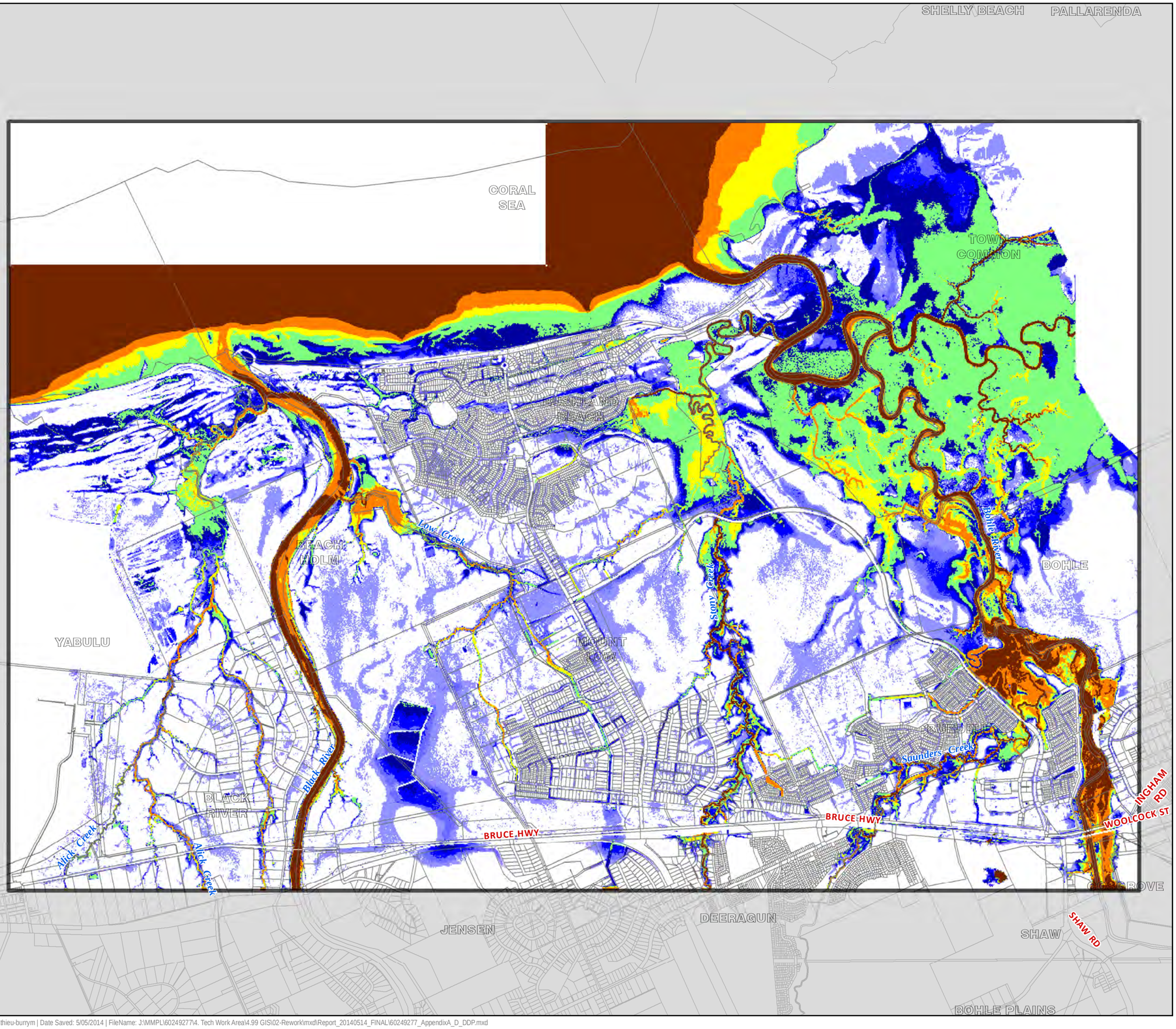
Coordinate System: GDA 1994 MGA Zone 55

Data sources:
Road, Rail, Localities - StreetPro© 2010
Contours - Derived from 30m DEM, QLD Gov 2010
Imagery - QLD Gov 2010
Elevation - TCC 2013

AECOM
www.aecom.com

LOWER BOHLE/STONY CREEK FLOOD STUDY

Maximum Water Depths
10-yr ARI
Appendix Figure A3



Water Depths (m)

- 0 - 0.3
- 0.3 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- > 3

0 250 500 1,000 1,500
Metres

1:40,000 (when printed at A3)

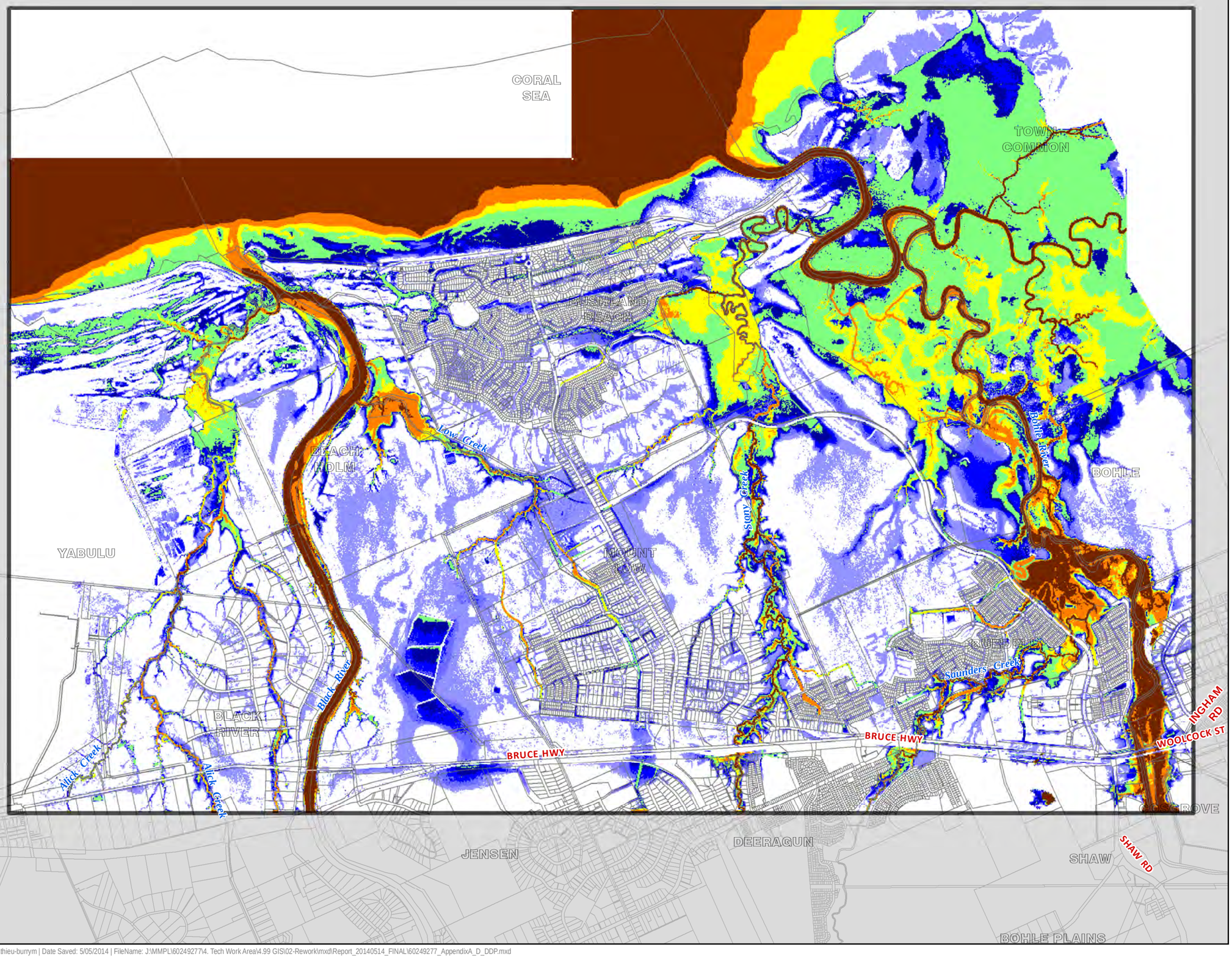
Coordinate System: GDA 1994 MGA Zone 55

Data sources:
Road, Rail, Localities - StreetPro© 2010
Contours - Derived from 30m DEM, QLD Gov 2010
Imagery - QLD Gov 2010
Elevation - TCC 2013

AECOM
www.aecom.com

LOWER BOHLE/STONY CREEK FLOOD STUDY

Maximum Water Depths
20-yr ARI
Appendix Figure A4



Water Depths (m)

- 0 - 0.3
- 0.3 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- > 3

0 250 500 1,000 1,500
Metres

1:40,000 (when printed at A3)

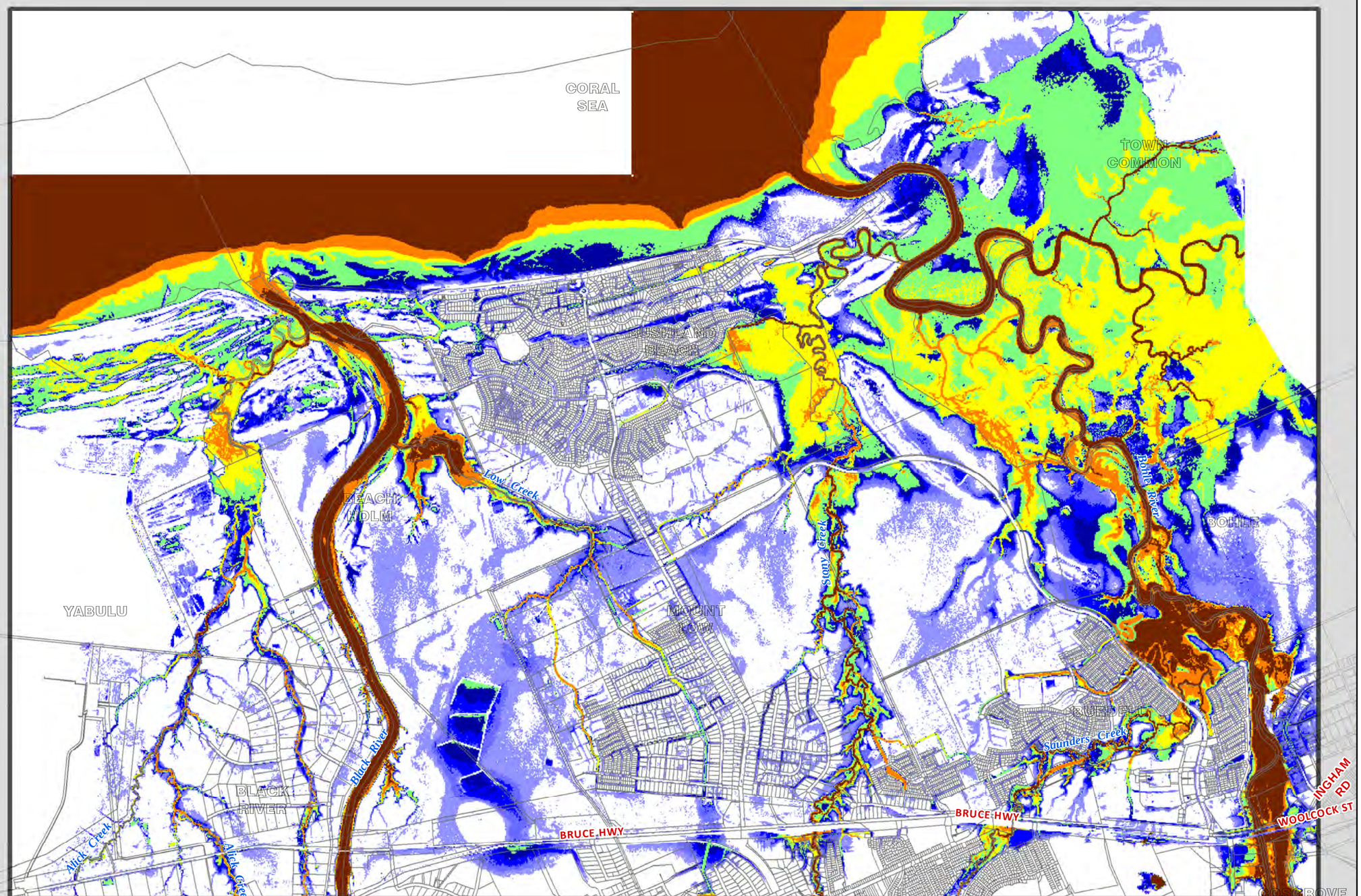
Coordinate System: GDA 1994 MGA Zone 55

Data sources:
Road, Rail, Localities - StreetPro© 2010
Contours - Derived from 30m DEM, QLD Gov 2010
Imagery - QLD Gov 2010
Elevation - TCC 2013

AECOM
www.aecom.com

LOWER BOHLE/STONY CREEK FLOOD STUDY

Maximum Water Depths
50-yr ARI
Appendix Figure A5



Water Depths (m)

- 0 - 0.3
- 0.3 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- > 3

0 250 500 1,000 1,500
Metres

1:40,000 (when printed at A3)

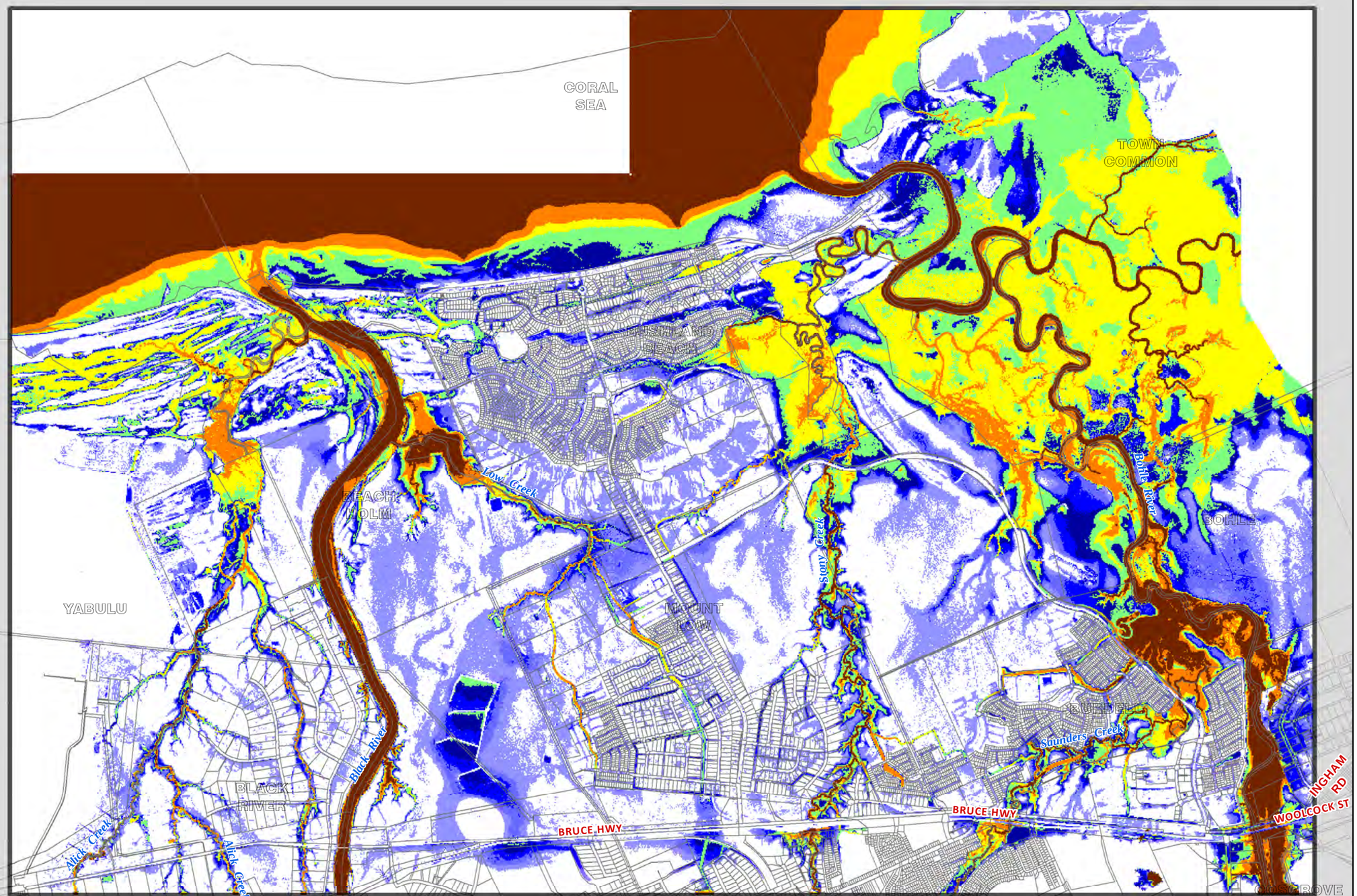
Coordinate System: GDA 1994 MGA Zone 55

Data sources:
Road, Rail, Localities - StreetPro© 2010
Contours - Derived from 30m DEM, QLD Gov 2010
Imagery - QLD Gov 2010
Elevation - TCC 2013

AECOM
www.aecom.com

LOWER BOHLE/STONY CREEK FLOOD STUDY

Maximum Water Depths
100-yr ARI
Appendix Figure A6



Water Depths (m)

- 0 - 0.3
- 0.3 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- > 3

0 250 500 1,000 1,500
Metres

1:40,000 (when printed at A3)

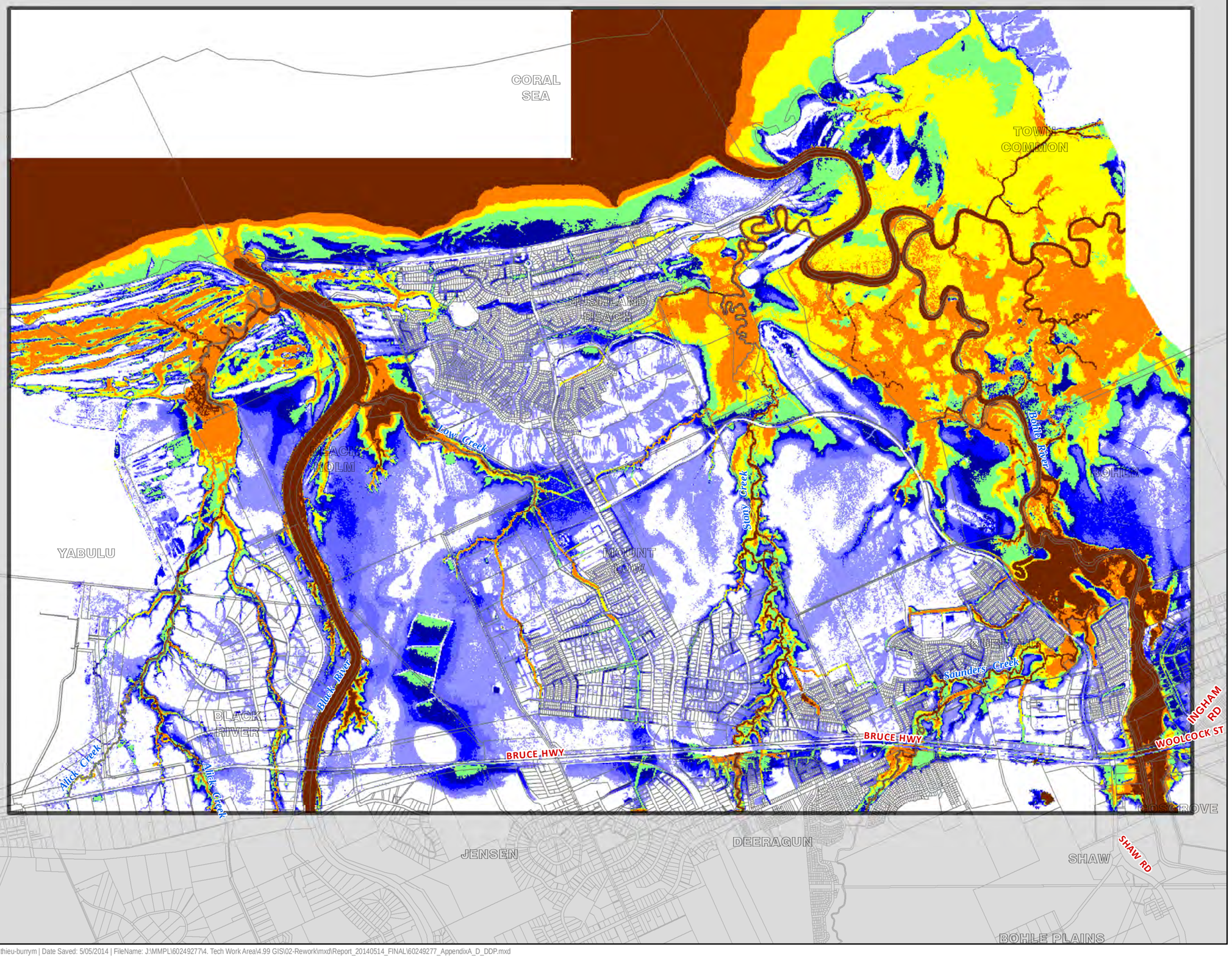
Coordinate System: GDA 1994 MGA Zone 55

Data sources:
Road, Rail, Localities - StreetPro© 2010
Contours - Derived from 30m DEM, QLD Gov 2010
Imagery - QLD Gov 2010
Elevation - TCC 2013

AECOM
www.aecom.com

LOWER BOHLE/STONY CREEK FLOOD STUDY

Maximum Water Depths
500-yr ARI
Appendix Figure A7



Water Depths (m)

- 0 - 0.3
- 0.3 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- > 3

0 250 500 1,000 1,500
Metres

1:40,000 (when printed at A3)

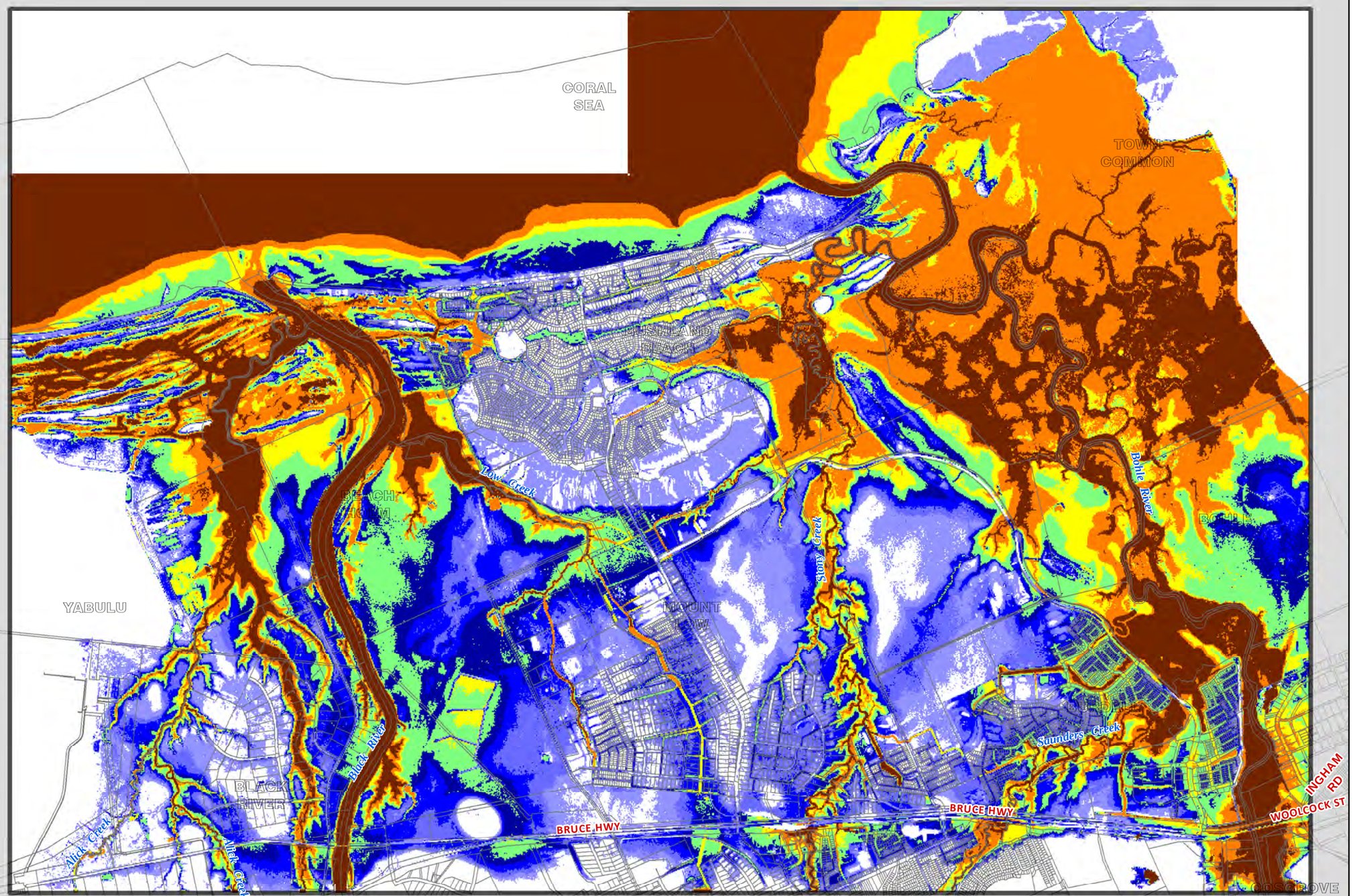
Coordinate System: GDA 1994 MGA Zone 55

Data sources:
Road, Rail, Localities - StreetPro© 2010
Contours - Derived from 30m DEM, QLD Gov 2010
Imagery - QLD Gov 2010
Elevation - TCC 2013

AECOM
www.aecom.com

LOWER BOHLE/STONY CREEK FLOOD STUDY

Maximum Water Depths
PMF
Appendix Figure A8



Water Depths (m)

- 0 - 0.3
- 0.3 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- > 3

0 250 500 1,000 1,500
Metres

1:40,000 (when printed at A3)

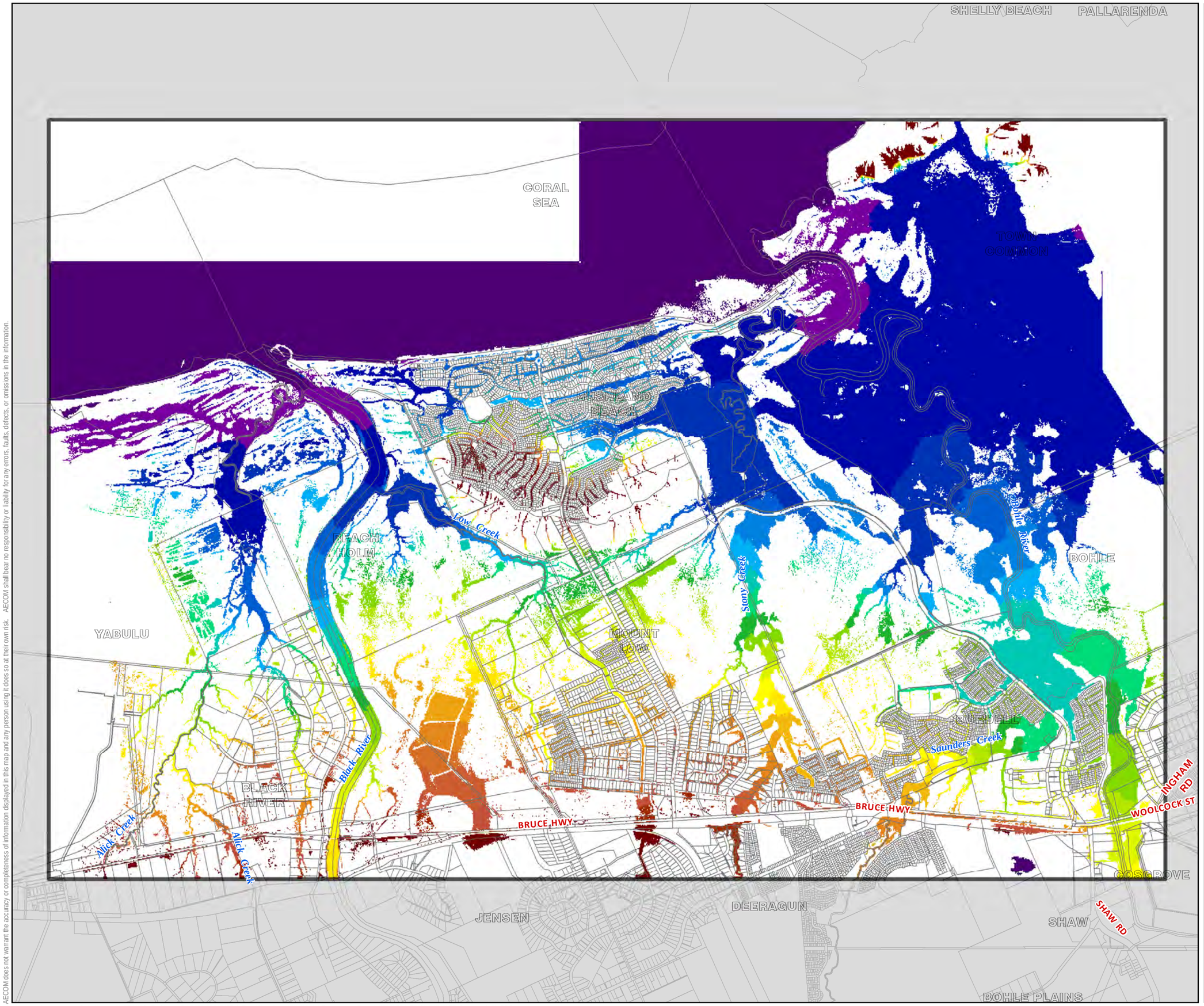
Coordinate System: GDA 1994 MGA Zone 55

Data sources:
Road, Rail, Localities - StreetPro© 2010
Contours - Derived from 30m DEM, QLD Gov 2010
Imagery - QLD Gov 2010
Elevation - TCC 2013

AECOM
www.aecom.com

LOWER BOHLE/STONY CREEK FLOOD STUDY

Maximum Water Surface Elevations
2-yr ARI
Appendix Figure A9



Water Levels (m AHD)

- Below 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- 3.5 - 4.0
- 4.0 - 4.5
- 4.5 - 5.0
- 5.0 - 5.5
- 5.5 - 6.0
- 6.0 - 6.5
- 6.5 - 7.0
- 7.0 - 7.5
- 7.5 - 8.0
- 8.0 - 8.5
- 8.5 - 9.0
- 9.0 - 9.5
- 9.5 - 10.0
- 10.0 - 10.5
- 10.5 - 11.0
- 11.0 - 11.5
- 11.5 - 12.0
- Above 12

0 250 500 1,000 1,500
Metres

1:40,000 (when printed at A3)

Coordinate System: GDA 1994 MGA Zone 55

Data sources:
Road, Rail, Localities - StreetPro© 2010
Contours - Derived from 30m DEM, QLD Gov 2010
Imagery - QLD Gov 2010
Elevation - TCC 2013

AECOM
www.aecom.com