UPPER MANGAONE STREAM

Final Report

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1 INTRODUCTION

1.1 Background

The Manawatu Region is a flood prone region. The severe flooding in 2004 has encouraged the HRC to assess the flood hazard in the region. HRC have contracted DHI to investigate one of the affected areas. This study focuses on the area around the Upper Mangaone Stream between Palmerston North and Bunnythorpe. The model includes the Mangaone Stream as well as significant tributary channels. It is a variation of the original Mangaone-Taonui study, which also encompasses the area down to Opiki in the south. The larger Mangaone-Taonui model lacked some significant detail in this region. This more detailed model will be developed so that flow capacities and the effects of undersized channels on flood behaviour can be accurately assessed.

1.2 Approach

The majority of the data used in this study were originally supplied for the Mangaone-Taonui study conducted in 2006. As with the Mangaone-Taonui model, this model combines a one-dimensional channel model with a two-dimensional overland model. The one-dimensional model describes the flow in the rivers and canals, while the two-dimensional model describes the flow over the floodplains. These two models are then dynamically linked to form a complete detailed model of the study area.

1.3 Projections and datum

All models have been built to NZMG map projection and levels refer to the Wellington datum.

1.4 Setting

The Upper Mangaone catchment is located north of Palmerston North and covers an area of approximately 165 km^2. The elevation ranges from just over 300 m down to 30 m. The catchment drains into the Mangaone Stream via many smaller tributary streams. The river is stopbanked from approximately 5km upstream of Palmerston North down to the Manawatu confluence. High flows are diverted at a spillway located at the bottom of the Upper Mangaone Catchment, at Flygers Line.

2 HYDROLOGICAL MODEL

2.1 Methodology and Data availability

For an in depth description of the hydrological model, refer to section 3 of the Mangaone-Taonui report.

2.2 Catchment delineation

Sub-catchments were delineated for the areas draining into the Mangaone Stream. The largest of these sub-catchments extends to the source of the Mangaone Stream, in the mountainous area above Pohangina, Drawing 1. Smaller sub-catchments were used for the model area as more detail was required here. The catchment areas range from 0.6km^2 to 96km^2. Hydraulic slope and length were calculated for each catchment by analysing the land level data. Initial and continuing losses for the catchments were taken as 20mm and 2mm/hr respectively as used in the original calibrated model.

2.3 Catchment Rainfall and Runoff

For the design storms, the catchment rainfall was derived by weighting the two gauges at Valley Road and Palmerston North as described in the Mangaone-Taonui report. Only the Palmerston North rainfall was used for the 1976 and 1988 events due to data unavailability at other gauges, while an additional rain gauge, near fielding, was used for the 2004 storm event.

3 HYDRODYNAMIC MODEL BUILD

3.1 Model Description

The hydrodynamic model comprises a separate 1D and 2D model, dynamically linked to enable full exchange of flows between the two modelling domains. The modelling software used was MIKE 11 for the 1D component and MIKE 21 for the 2D component. The coupling between the two is provided via MIKE FLOOD (MF). The model uses a fine grid (10 m) of the area north of the Mangaone spillway. The model extent is shown in Drawing 2.

3.2 Physical Description

The model area is a subset of the original model grid (25m). The study area covers 40km^2. The North Island Main Trunk Railway runs along the east and north east boundaries of the model area, while the Taouni River sits on the North West boundary. The south boundary is below the Milson Line Flow Gauge, on the Mangaone Spillway.

The major stream in the model is the Mangaone Stream. Numerous smaller streams feed into this stream from other catchments. Whiskey Creek is also included in the model; this runs parallel to the Mangaone Stream.

3.3 Data Availability

The grid data used in this model was the 1m raster grid supplied by HRC, which was used in the Oroua Flood Hazard assessment. This grid formed the basis of both the 1D and 2D models. The previously provided GIS datasets, from HRC, were also utilised in this study. HRC also supplied additional cross section data for the Mangaone Stream and Jacks Creek.

3.4 MIKE 11 Model Build

3.4.1 MIKE 11 Model Domain

The significant channels and streams chosen to be modelled with MIKE 11, were selected by careful consideration of the digital terrain model, knowledge from site visits and discussions from HRC. 15 streams in total were included in the MIKE11 model. Channels wider then 30m were not included in the MIKE 11 network, as these were able to be modelled satisfactorily in the MIKE 21 model. All of the Mangaone Stream, despite its width, was modelled in MIKE11. The river stopbanks were also included in the MIKE11 model. The top of each river starts at chainage zero and increases positively downstream. The final chainage of the Upper Mangaone stream is 8158 m.

3.4.2 Cross Sections

Cross sections were extracted from the 1m LiDAR grid, using MIKE 11 GIS. The cross sections were extracted at 25m intervals for the smaller streams and at 100m intervals for the Mangaone Stream. Additional Cross sections were provided by HRC for some chainages along the Mangaone Stream and Jack's Creek. At some points the cross sections, extracted from the LiDAR data, were not realistic, due to trees and or road crossings being included in the LiDAR data. These inconsistent cross sections were removed from the model to ensure numerical stability. It was also necessary to modify some of the cross sections where the ground level had not been represented properly due to LiDAR reflection off the water surface. In cases such as this it was necessary to lower the level to conform to the nearby surveyed cross section bed levels.

3.4.3 Structures

As with the previous models in this area, there are a number of structures present in the model where the road crosses the main drainage channels. Structure locations and data were taken from the previous site visit (6th July 2006) detailed in the Mangaone Taonui Report /1/. Additional cross section data was also provided by HRC at a number of bridges on the Mangaone Stream, and Jacks Creek. A total of 27 structures (modelled as 16 Culverts and 11 Bridges) have been included in the MIKE 11 model. Drawing 3 shows the locations of the modelled structures and Appendix A presents details of those structures.

3.4.4 Boundaries and Catchment Connections

Catchment connections are detailed in Drawing 4. In general the internal catchment runoff is applied along the dominant stream in the catchment, while the external catchments are applied as a point source at the top of the streams. Where there was no M11 stream in the catchment it was necessary to use a M21 source point to supply water to the model.

3.5 MIKE 21 Model Build

3.5.1 MIKE 21 Model Domain

The MIKE 21 10m grid extent is 819x619 grid cells in size. This makes a total of 507,000 grid points, approximately 160,000 of which are non land points. At the northern end of the model domain the interpolation of the LiDAR data is incorrect. This is most likely due to missing data in this area. In the MIKE 21 model it was necessary to set this area to dry land so that the model was not contaminated by an inaccurate surface. This will cause some local erroneous predictions in this area of the model, as the water moving up towards this land boundary will reflect back into the model domain.

3.5.2 Topography and Features

Four 1m grids covering the wider model area were provided by HRC. (LiDAR was processed by Phil Wallace for HRC). These grids were joined together and clipped to our model extent. This 1m grid was converted to a 10m grid and the stopbank and road levels were then burned into the 10m grid.

3.5.3 Source inflows

There are four source inflows in the MIKE 21 model. These input the runoff from the four catchments not handled in the MIKE 11 model, these are catchments 2, 16a, 16b and 16c, Drawing 4. These source points spill water directly onto the MIKE 21 domain. All other inflows into the MIKE 21 domain are from the lateral spilling from the MIKE11 rivers. These are controlled by the lateral linkages described in the MIKE Flood model, section 4.6.1.

3.5.4 Boundaries

There are no open boundaries in the MIKE 21 model. The downstream water in the MIKE 21 model is collected by a MIKE 11 collector channel at the boundary of the MIKE 21 domain. This ensures that the water will not rebound by removing it from the model.

3.5.5 Hydraulic Resistance

The hydraulic resistance distribution is the same as that used in the Mangaone-Taonui model /1/.

3.6 MIKE Flood Model Build

3.6.1 Linkages

There are 196 Lateral links in this model joining the MIKE 11 rivers to the MIKE 21 domain. Where the river is stopbanked or especially wide the lateral links link to both sides of the river. For all of the other smaller rivers there is a single link that links to the centre of the river.

3.6.2 Model simulations

The coupled models run with a 1 second time-step. The MIKE 21 results are saved every 20 minutes and the MIKE 11 results are saved every 10 minutes. The model simulations take approximately three days to run on an HPxw4400 workstation, with Duel Core 2.4GHz processor and 2GB ram.

3.6.3 Model Verification

The Historic Flood extents were compared to the observed extents, provided by HRC (Drawings 5, 6 and 7) and with the previous 25m grid model, by DHI. The 2004 flood water levels were compared to the actual values measured during the flooding, see Table 3-1, Figure 3-1.

The 1976 and 2004 flood extents compare well with the observed extents. The models predict flooding across the airport and down into Palmerston North. In reality the flooding did not reach the township, although some flooding was observed at the airport in the 2004 event. Furthermore two separate breakouts were predicted but were not shown in the observed flood extents. The first of these breakouts occurs just north of the intersection between Kairanga Bunnythorpe Road and Milsons Line. The water levels of this breakout are low ranging, for the most part, between 0-0.3 m. The second breakout occurs directly south of the first on Milsons Line. This second breakout is much larger but the water depths still remain below 0.5m for the majority of the area. The prediction for the 1988 flood extent is less accurate, but the areas with high flood depth are accounted for.

When comparing the results of the Fine Grid model to the coarser Mangaone-Taonui results we can see some differences, but generally the model results are quite similar for all three events. The Mangaone-Taonui model does not predict the spilling at the Airport stream, due to modifications to the stopbanks in this model. In addition the coarse model does not predict the first breakout at the Kiranga Bunnythorpe/Milsons Line intersection. The fine grid model also gives detail at the top of the Mangaone Stream and Jacks Creek, near Bunnythorpe, which was not modelled previously.

Table 3-1: Water Level Comparison for the 2004 flood event

Point	Measured Water Level (m)	Modelled Water Level (m)
1	54.51	54.31
2	54.41	54.32
3	54.38	54.32
5	50.32	49.79
6	50.28	49.77
7	50.26	49.95
8	50.25	50.04
10	43.43	43.24
11	43.01	42.30
15	34.99	34.34

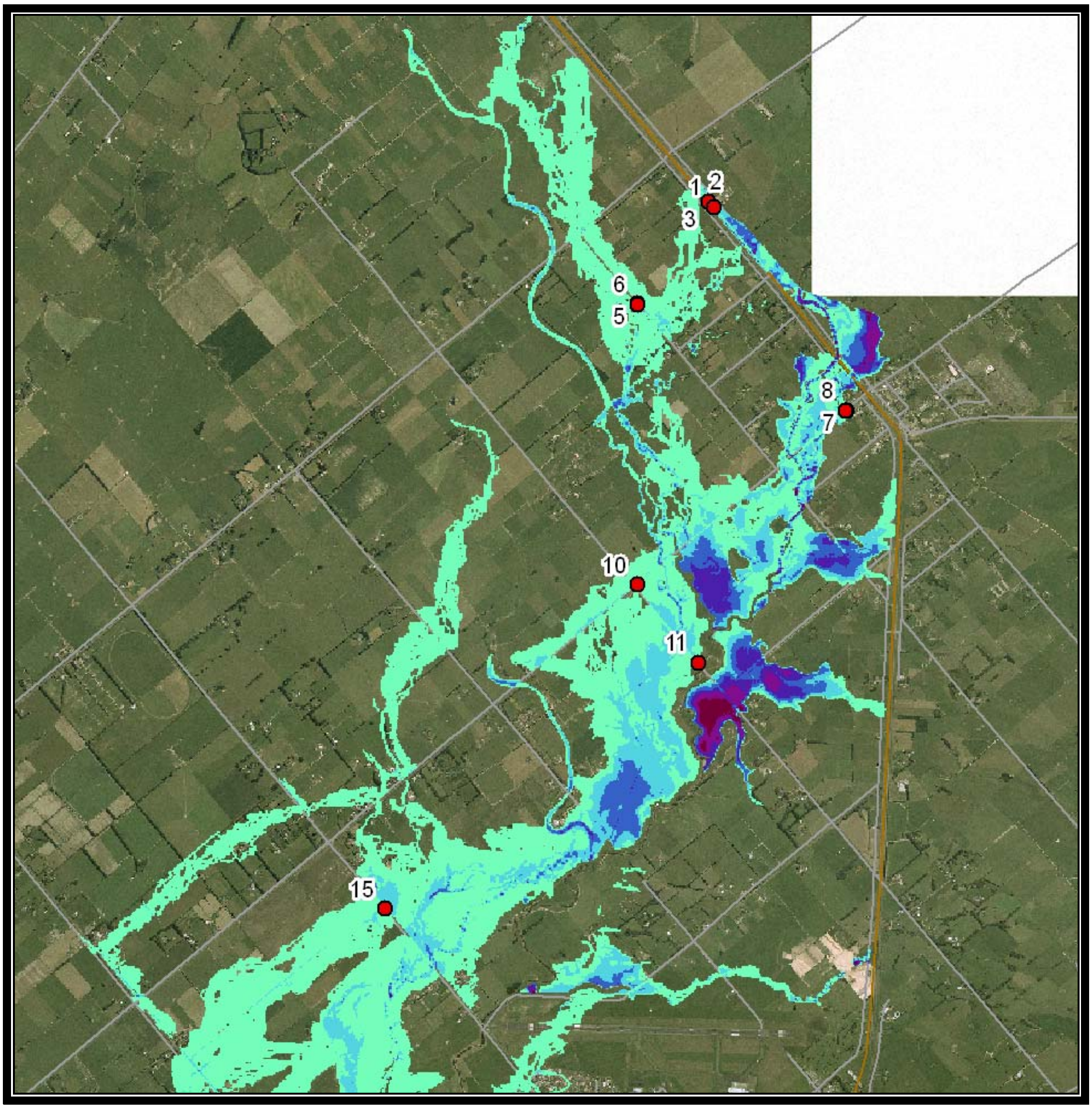


Figure 3-1: Location of Measured water levels

4 FLOOD RISK ASSESSMENT

4.1 Design Events

The Validated model has been used to produce flood maps for the three ARI events: 50 year, 100 year and 200 year. Each of the events predicts a similar flood extent, but the flood depths increase with rainfall volume. Areas of interest in the model are as follows:

- Airport stream spill upstream of Richardson's Line

Although there are stopbanks around the downstream end of the Airport Stream, spilling is predicted to still occur upstream of these stopbanks. This flow will then cross over Richardson's Line and will bypass the river to flow southwards over the Airport Strip and into Palmerston North City.

- Flooding north west of Bunnythorpe township

The flooding reaches the very edge of the township with only a couple of properties affected.

- High hazard zones around the Upper Mangaone stream

There are large areas near the Upper Mangaone stream that have been classified as High hazard. In the 200 year ARI event, in the area below Roberts Line, close to the Mangaone Stream, the flood depth reaches a level of up to 3m. Nevertheless this area appears to be unpopulated based on inspection of aerial photos supplied by HRC.

5 SUMMARY AND RECOMMENDATIONS

5.1 Summary

A 10m grid flood model has been made of the upper Mangaone region. The model uses dynamic coupling of a 1D and 2D model to represent both the channel flow, overland flow and the interaction between both. The area of interest follows the Upper Mangaone river between the Spillway at Flygers line, up towards Bunnythorpe township and Waughs Road in the North.

In a previous study by DHI a larger model has been created including the area down to the Taonui basin. This is called the Mangaone-Taonui model. Much of the data from this model has been reused in this more detailed Upper Mangaone model. In addition the calibrated hydrological model created for the Mangaone-Taonui study is used in the Upper Mangaone model.

The significant channels in the study area are included as Mike 11 channels, using both measured cross sections and those extracted from the LiDAR data. In addition significant culverts and bridges are included in the 1D model. The 2D model is built directly from the LiDAR data, ensuring that important flow thresholds such as roads and stopbanks are retained in the grid. These two models are dynamically linked to ensure free flow exchange can take place between the river channels and overland areas once water levels rise above bank levels.

The model has been verified against observed flood events in 1976, 1988 and 2004. The model has satisfactorily reproduced the main patterns of observed flooding in 1976 and 2004. Furthermore water levels were compared for the 2004 event, these have compared well in most areas of the model.

Maximum depth, water level and hazard maps have been produced for the three design storm events; 50 year, 100 year and 200 year ARI. At the Airport Stream spilling is predicted, that will cross the Airport Strip and continue into Palmerston North City. The area north west of Bunnythorpe Township predicts significant flooding, although only a couple of houses on the fringe of the City will be affected. Significant flood hazard has also been predicted in the areas either side of the Mangaone Stream. These areas are currently uninhabited.

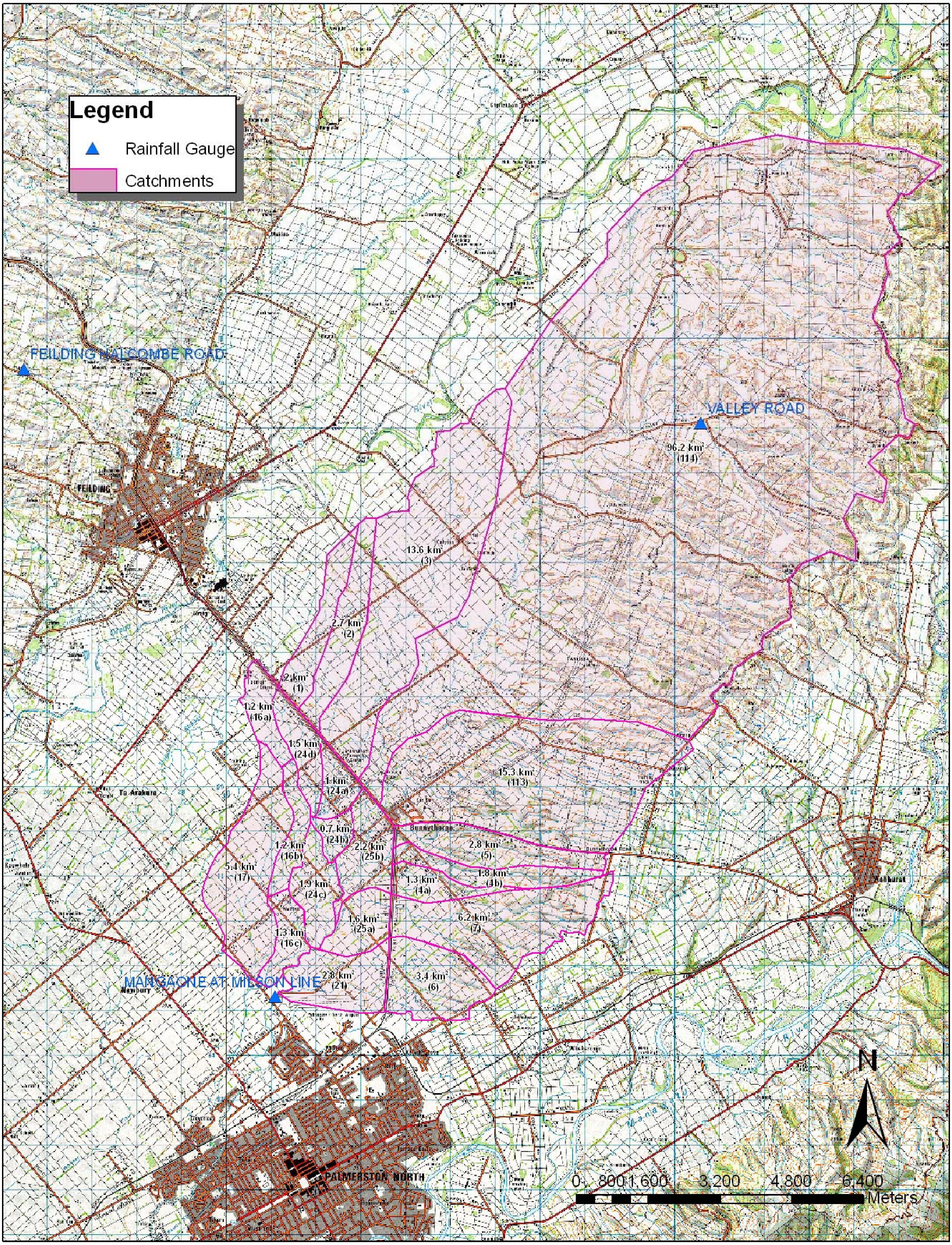
5.2 Recommendations

- In order to prevent any spilling from the Airport Stream, it would be necessary to build an additional embankment to prevent the flow from diverting away from the river. We understand this is on HRC's programme of works.
- Additional development on the north west side of Bunnythorp and close to the Mangaone Stream would not be recommended, due to the high risk of inundation.

6 REFERENCES

/1/. DHI Water & Environment: *Mangaone Stream and Taonui Basin, Floodplain Hazard Assessment, final report*, March 2007.

D R A W I N G S



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Upper Mangaone Flood Hazard Assessment	Catchment Delineation	Location	Upper Mangaone Area
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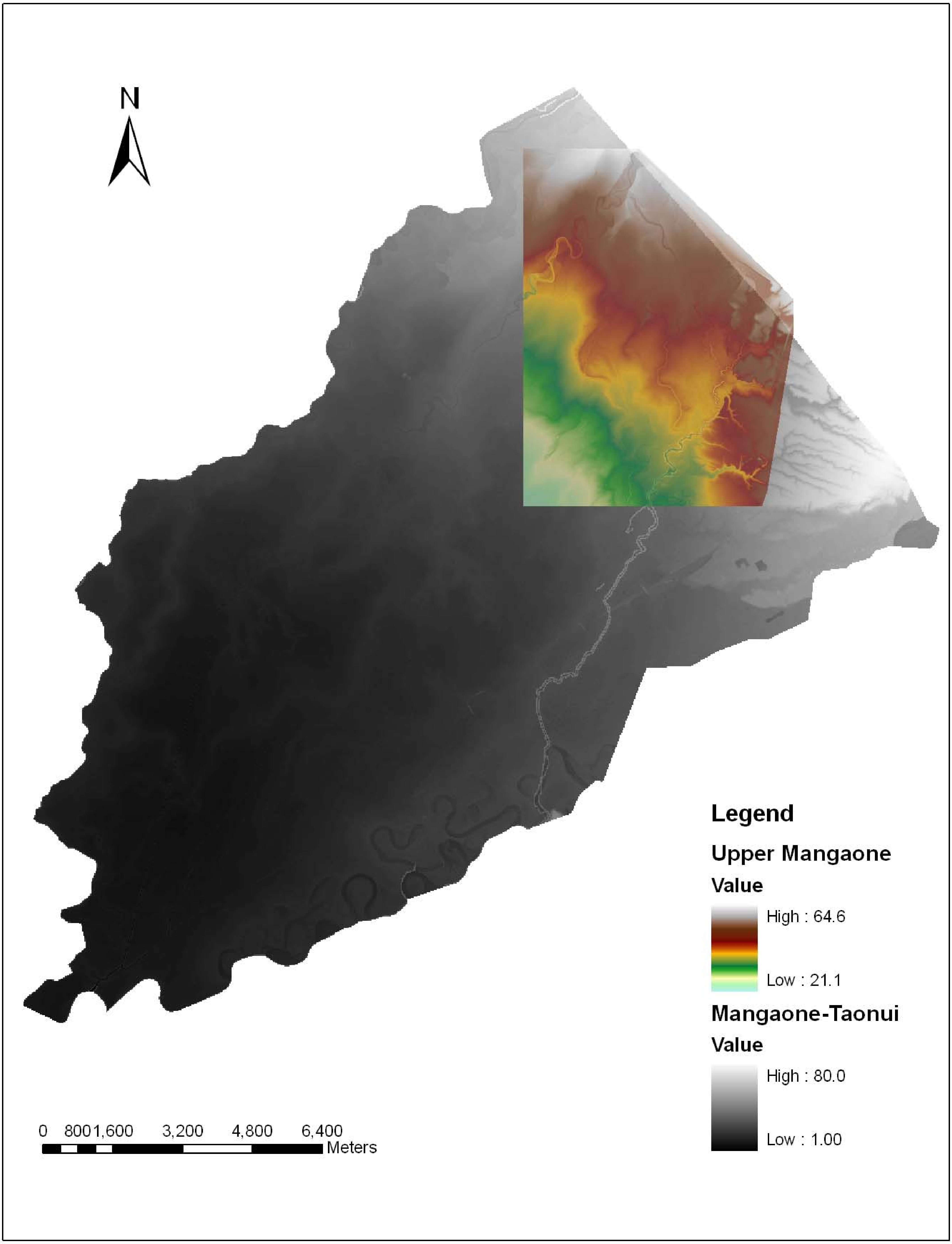
		Creation Date	18/12/2007
		Prepared By	DHI Water and Environment Ltd.
		Approved By	CJR



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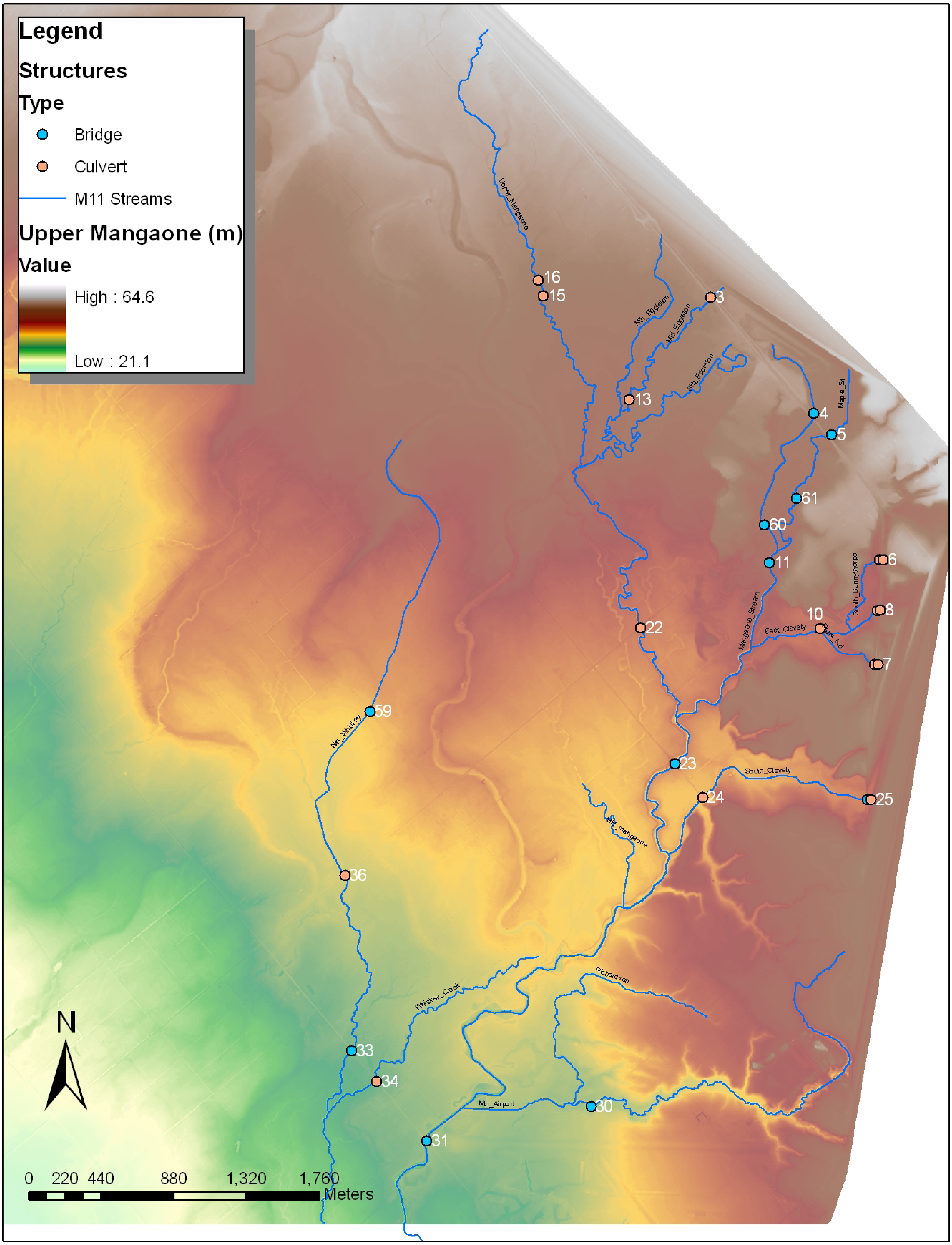
		Prepared By	DHI Water and Environment Ltd.
		Approved By	CJR



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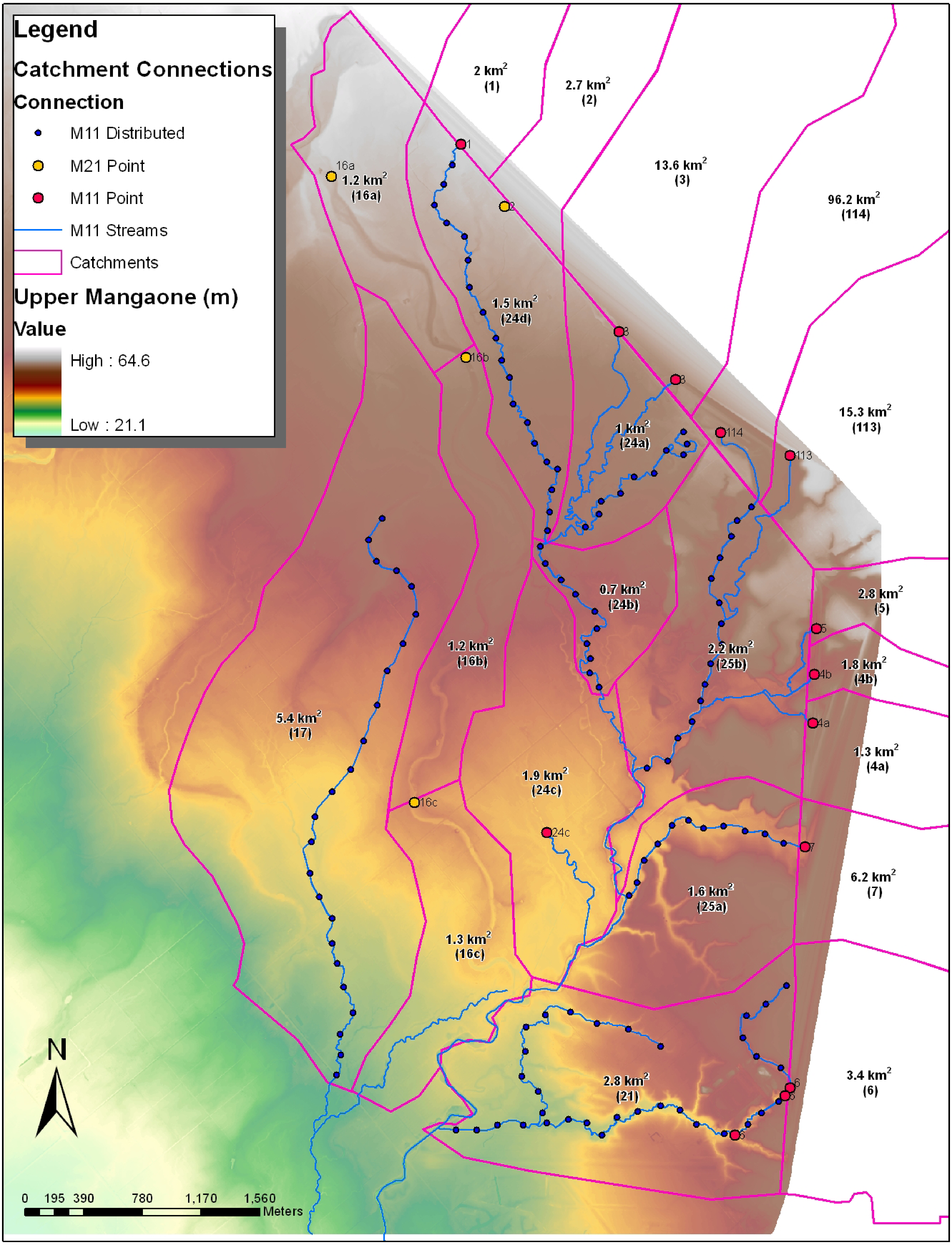
Upper Mangaone Flood Hazard Assessment

Structure Locations and MIKE 11 Branches

Location	Upper Mangaone Area
Drawing No.	3
Creation Date	18/12/2007
Prepared By	DHI Water and Environment Ltd.
Approved By	CJR



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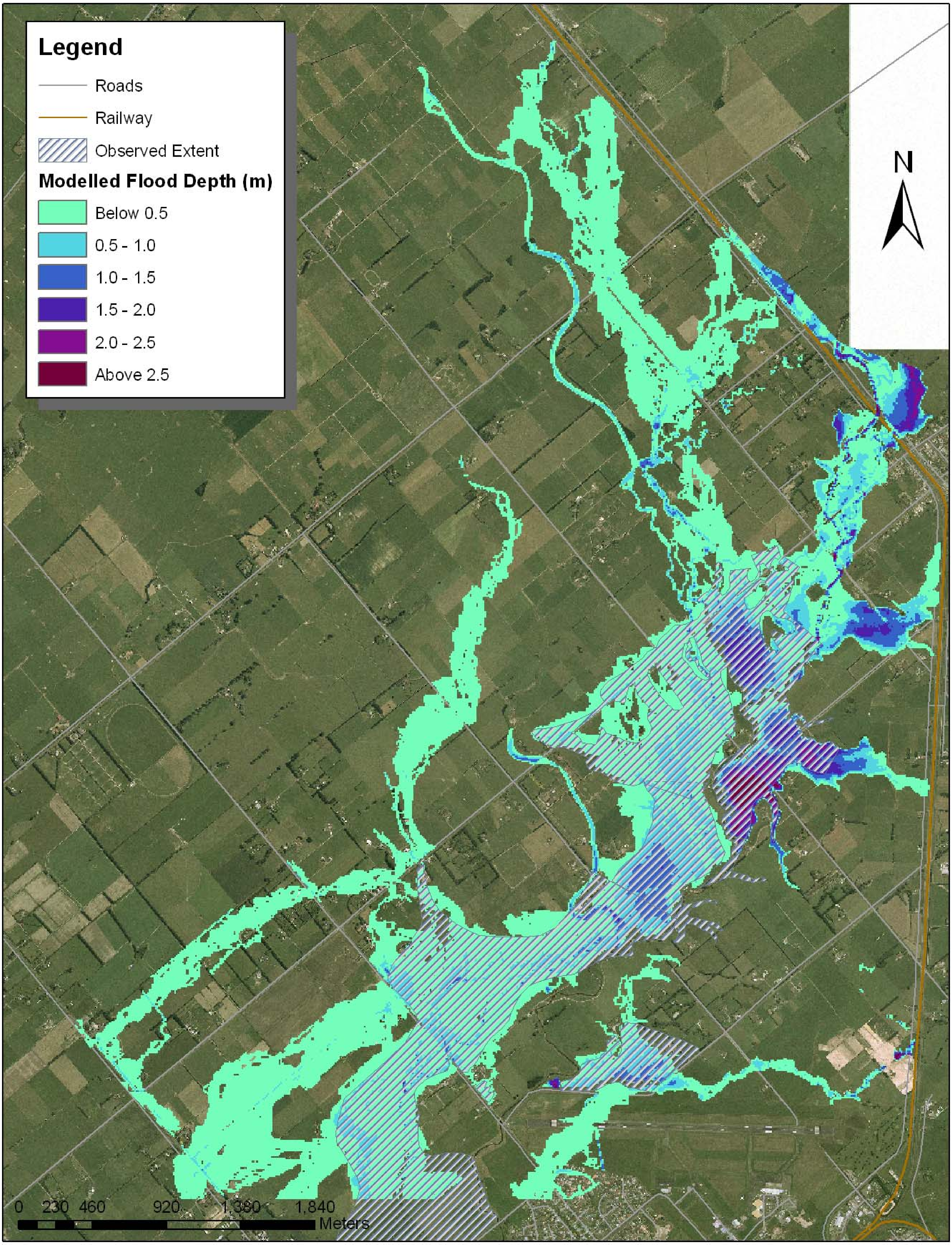
		Approved By	CJR



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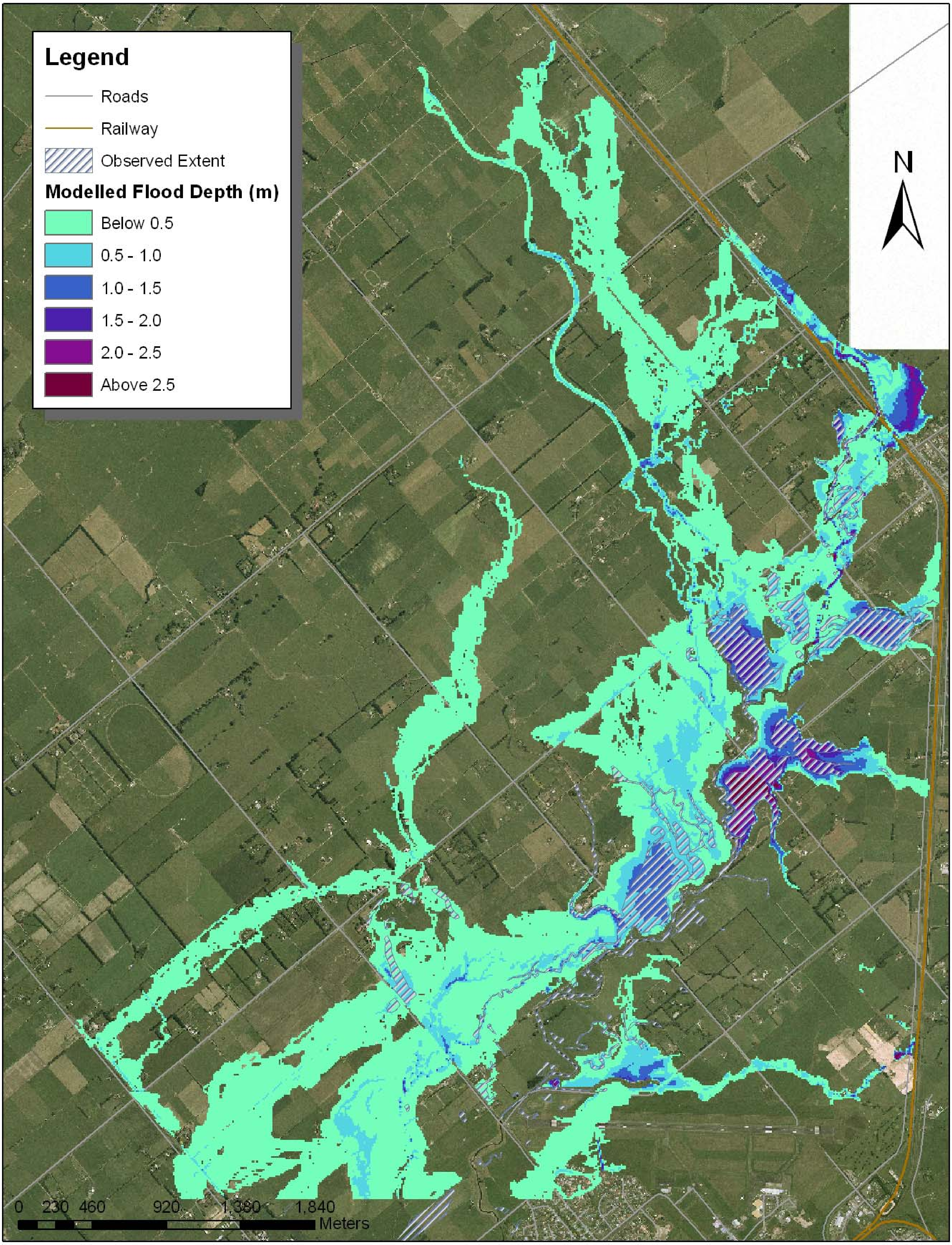
Upper Mangaone Flood Hazard Assessment

1976 Flooding Extent

Location	Upper Mangaone Area
Drawing No.	5
Creation Date	19/12/2007
Prepared By	DHI Water and Environment Ltd.
Approved By	



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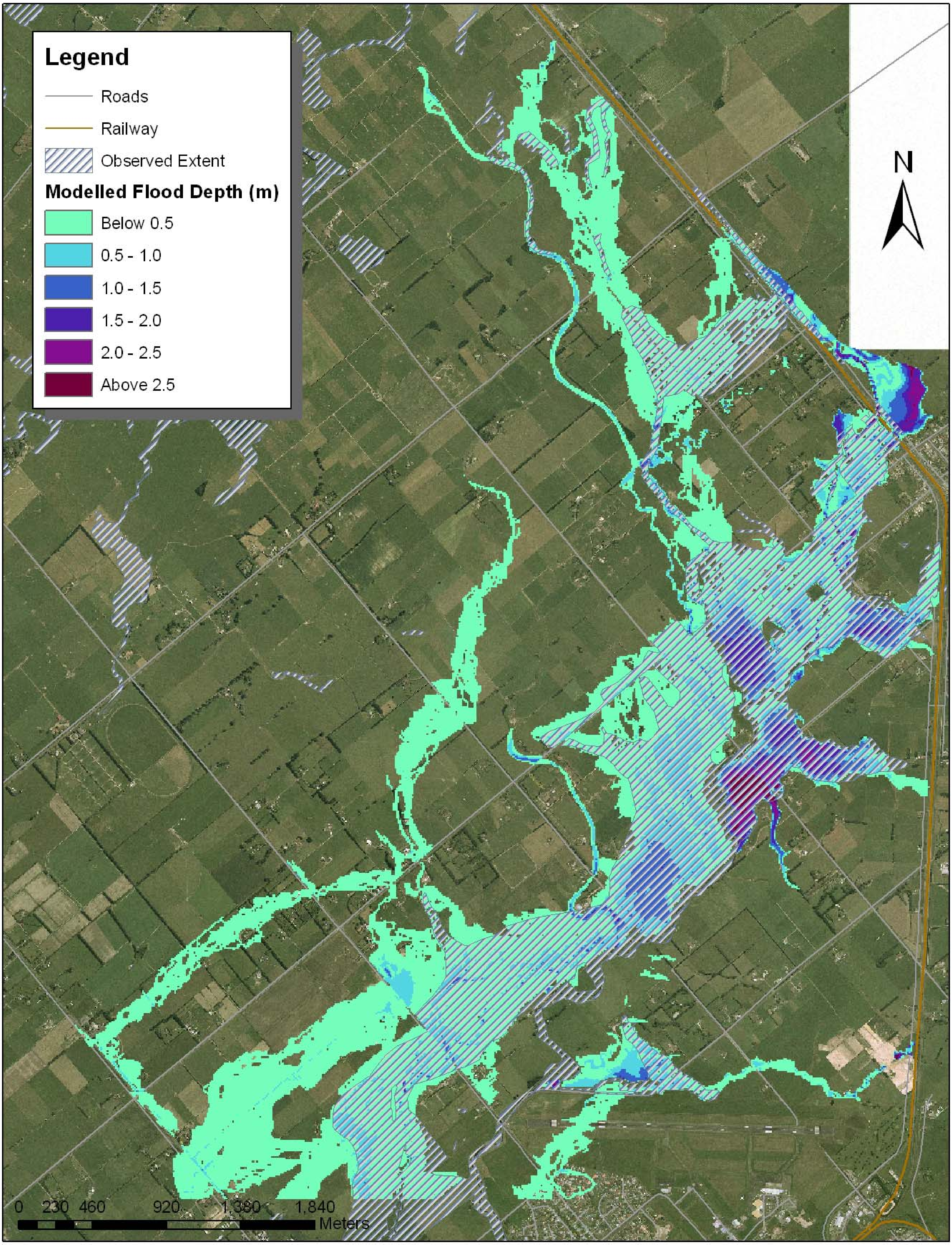
Upper Mangaone Flood Hazard Assessment 1988 Flooding Extent	Location	Upper Mangaone Area
	Drawing No.	6
	Creation Date	19/12/2007
	Prepared By	DHI Water and Environment Ltd.
	Approved By	



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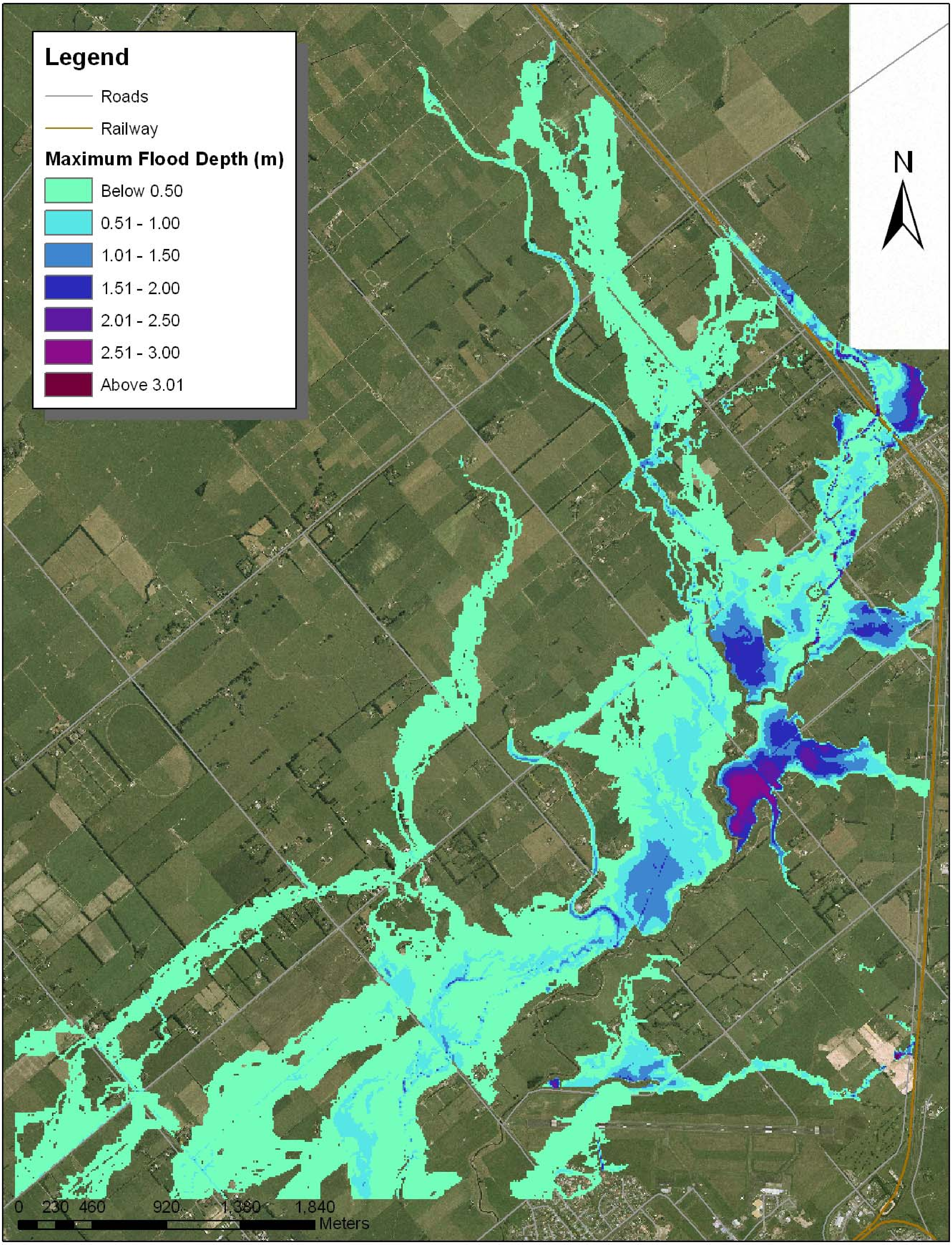
Upper Mangaone Flood Hazard Assessment

2004 Flooding Extent

Location	Upper Mangaone Area
Drawing No.	7
Creation Date	19/12/2007
Prepared By	DHI Water and Environment Ltd.
Approved By	



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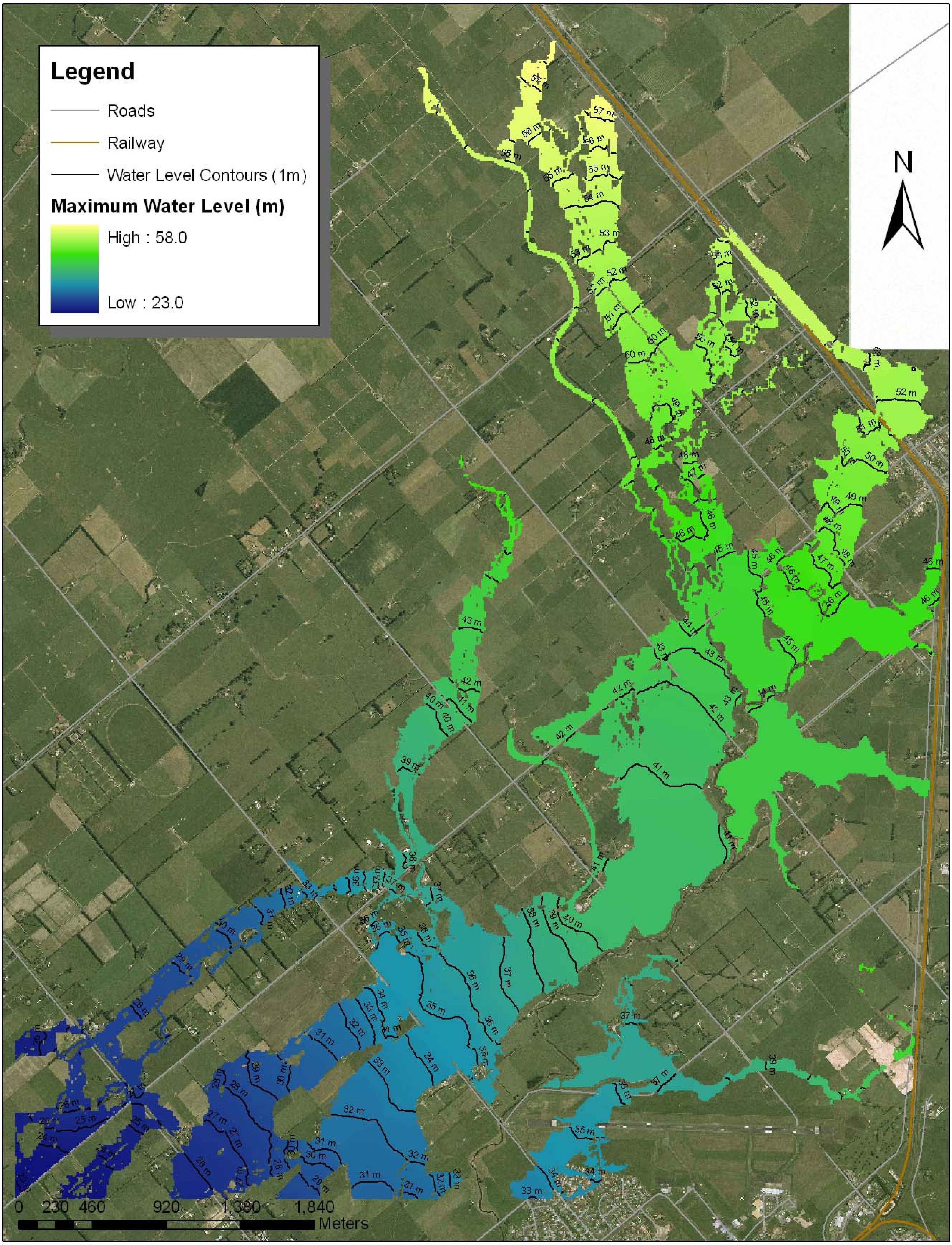
		Approved By	



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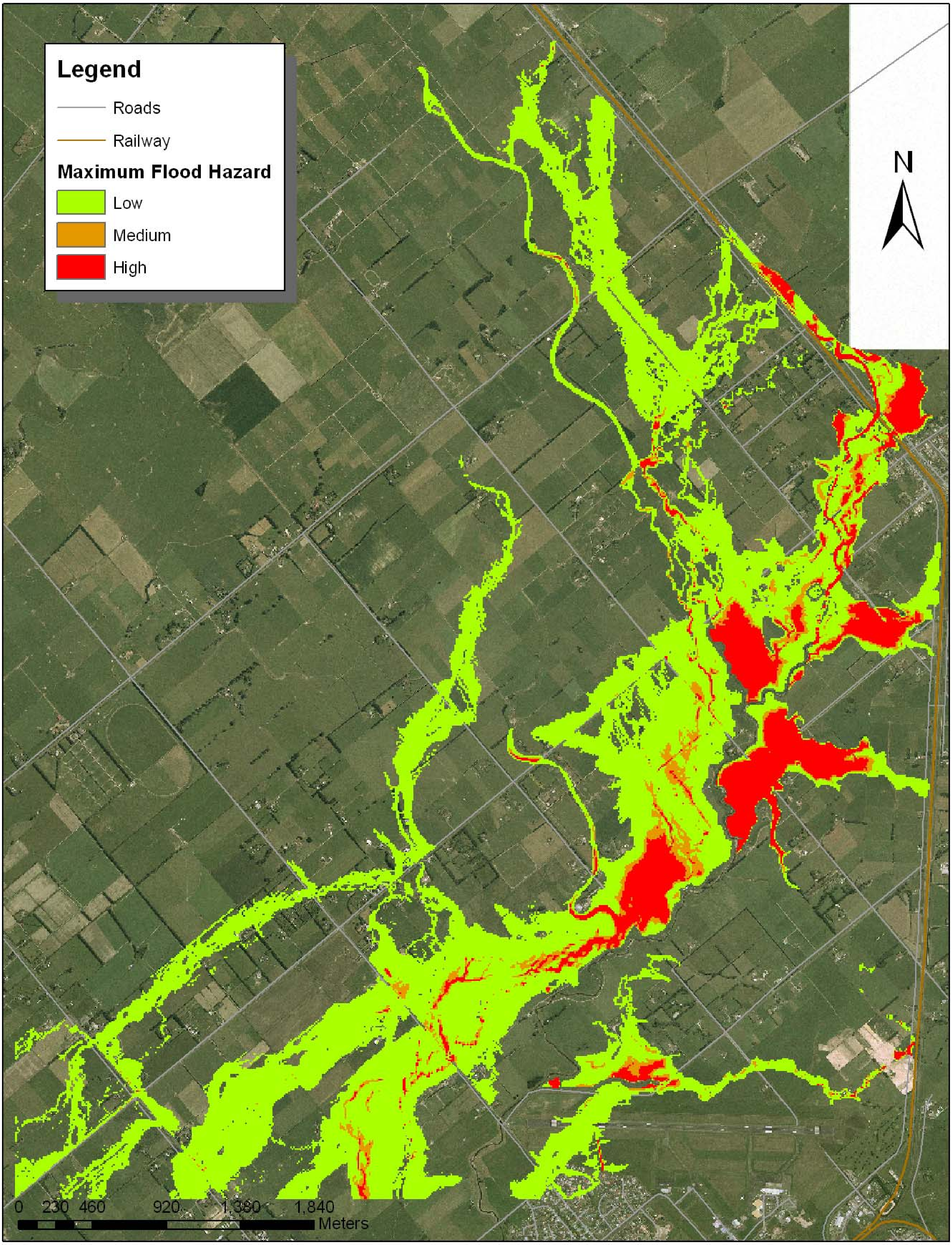
		Approved By	



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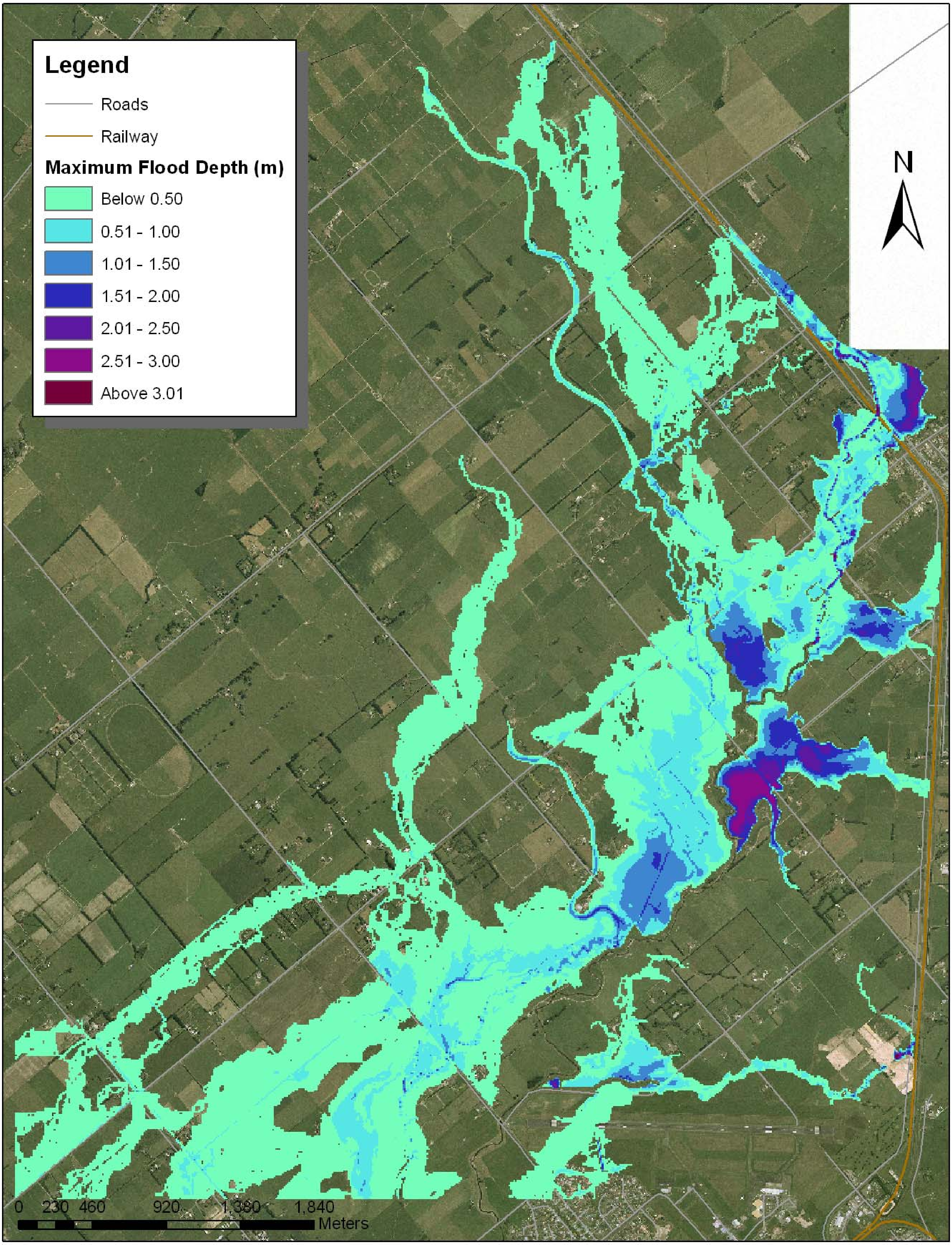
		Approved By	



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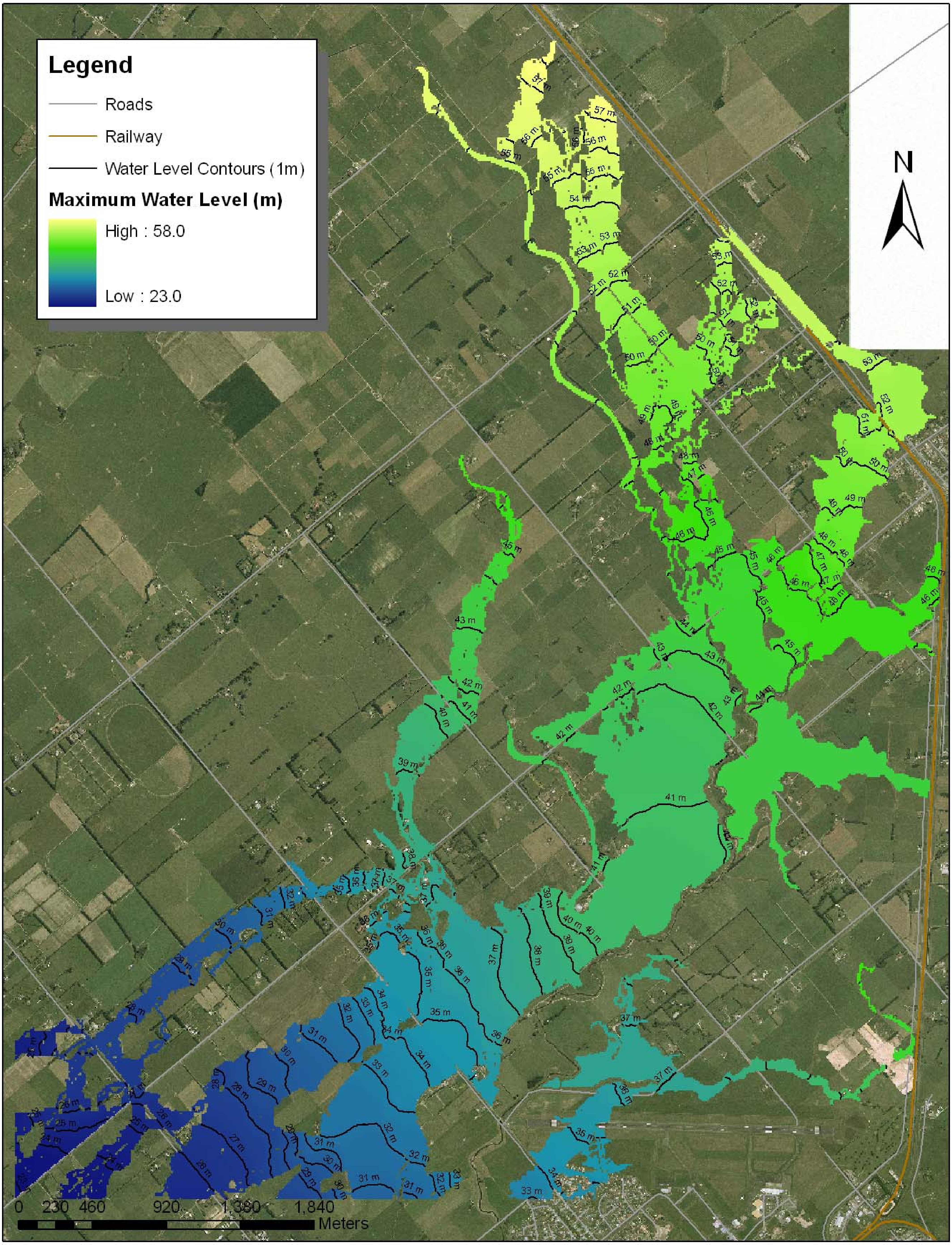
		Prepared By	DHI Water and Environment Ltd.
		Approved By	



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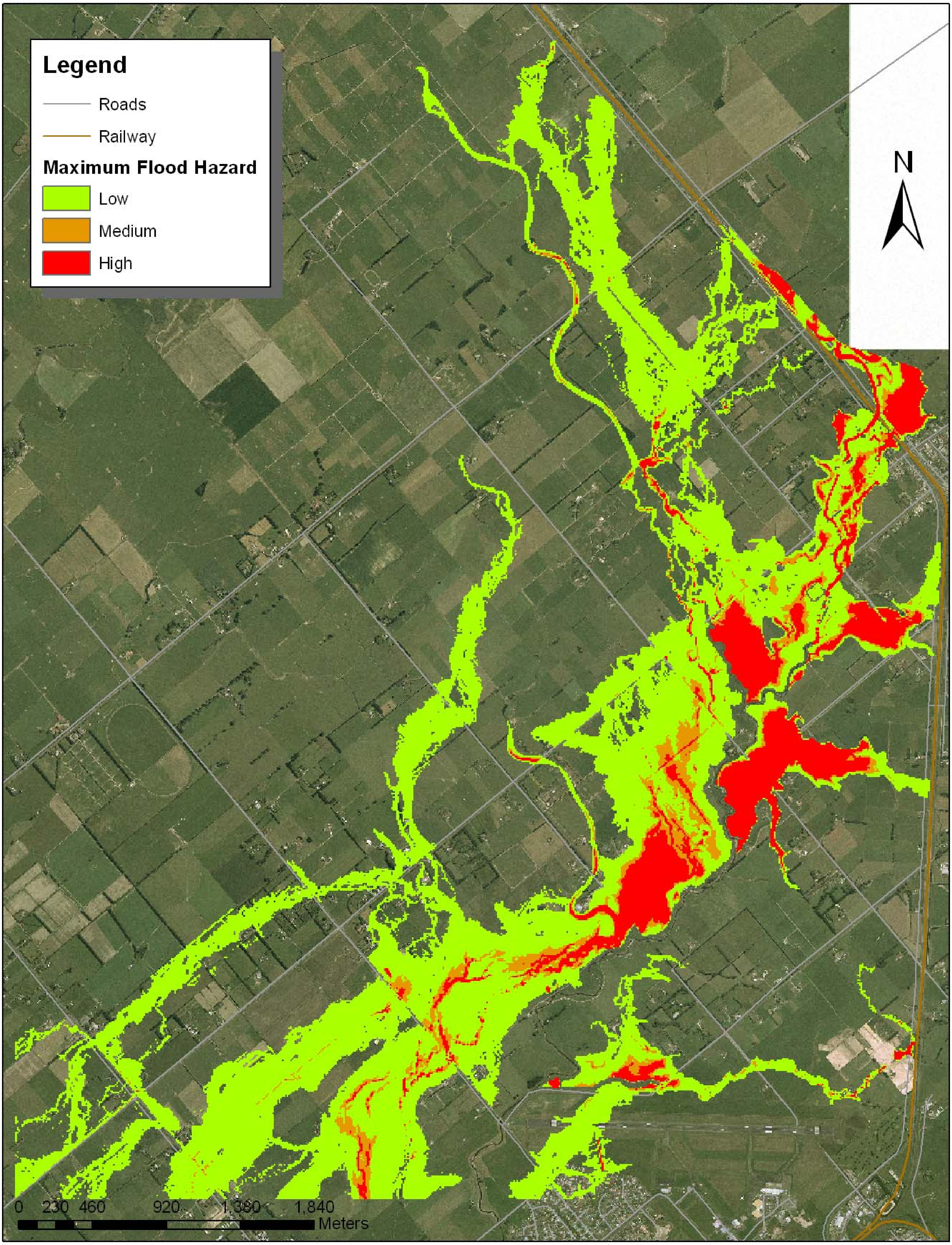
		Prepared By	DHI Water and Environment Ltd.
		Approved By	



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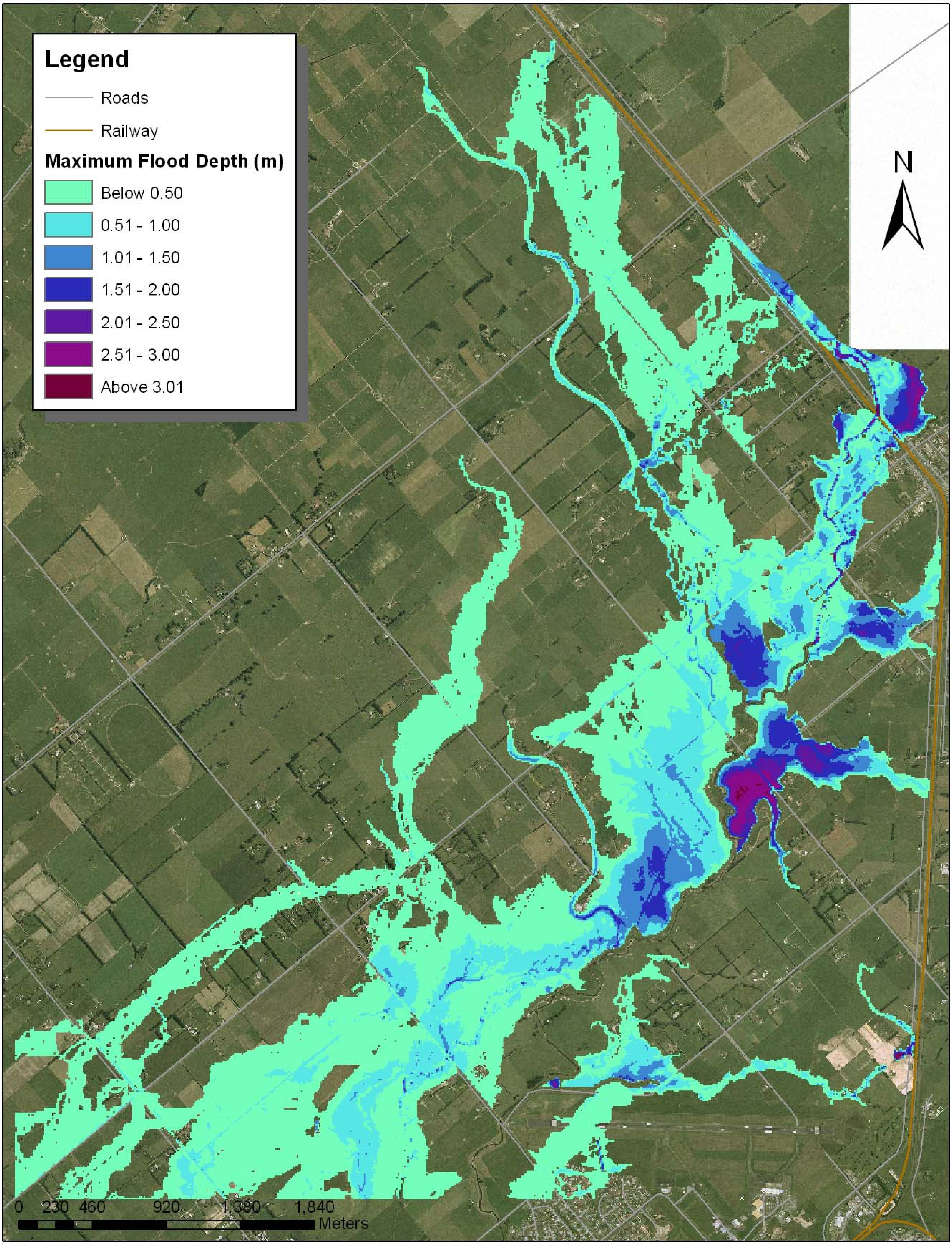
		Approved By	



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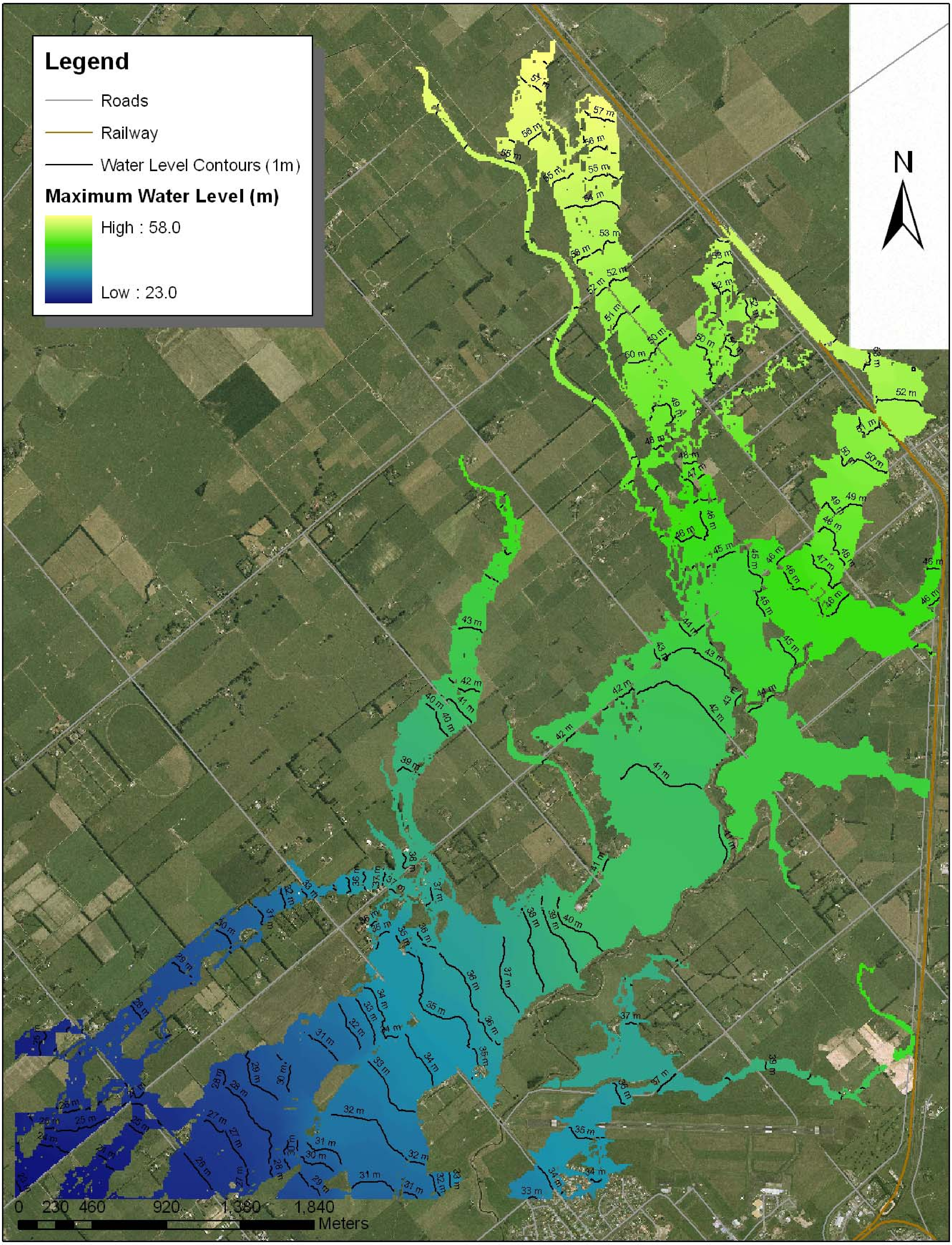
Upper Mangaone Flood Hazard Assessment

Maximum Flood Depth: 200-year ARI - Existing

Location	Upper Mangaone Area
Drawing No.	14
Creation Date	19/12/2007
Prepared By	DHI Water and Environment Ltd.
Approved By	



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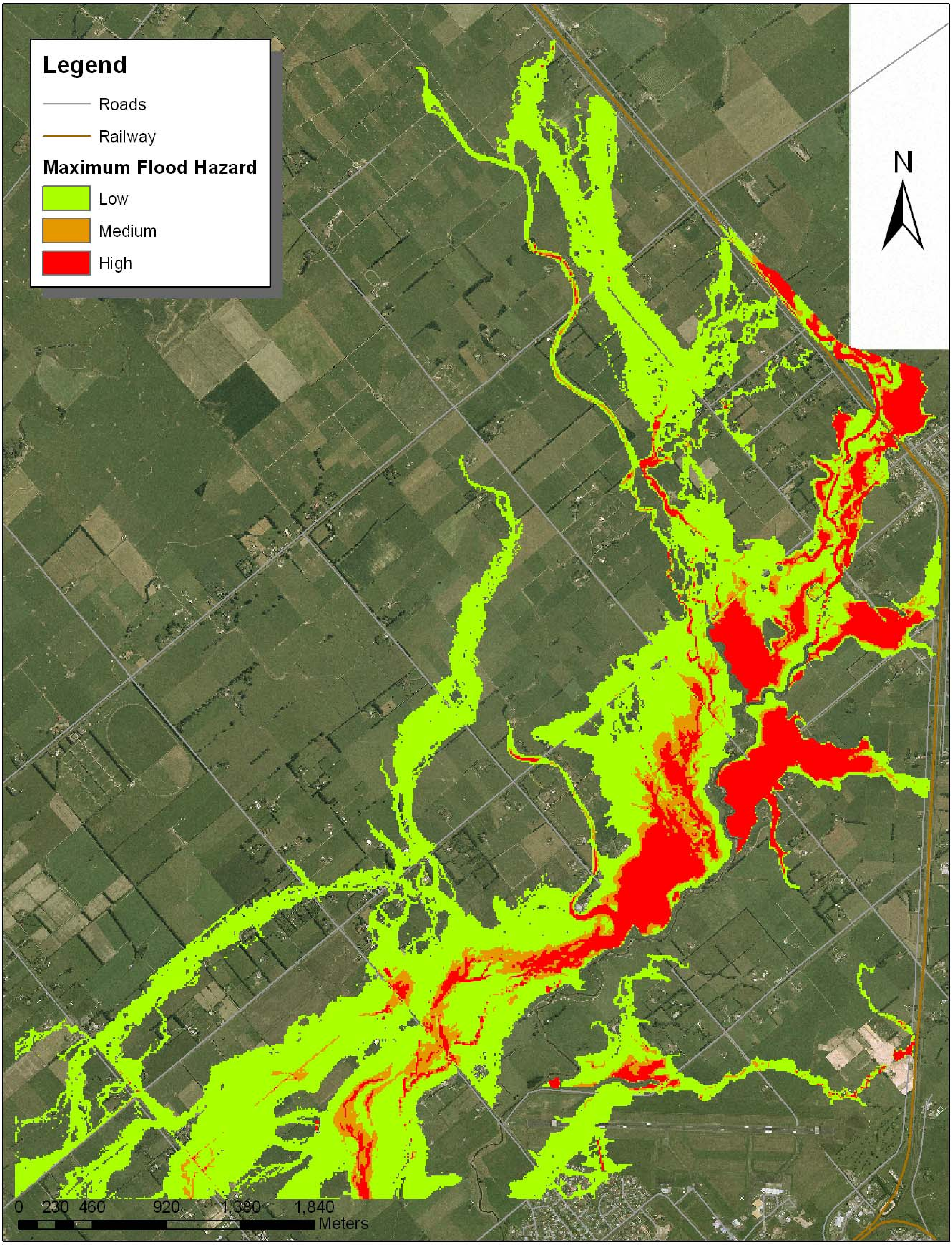
		Drawing No.	15
		Creation Date	19/12/2007
		Prepared By	DHI Water and Environment Ltd.
		Approved By	



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Upper Mangaone Flood Hazard Assessment

Maximum Flood Hazard: 200-year ARI - Existing

Location	Upper Mangaone Area
Drawing No.	16
Creation Date	19/12/2007
Prepared By	DHI Water and Environment Ltd.
Approved By	

A P P E N D I C E S

A P P E N D I X   A

MIKE 11 Structures

See overview in Drawing 3

Bridges

Bridge ID	DHI ID	Stream	Chainage	Waterway length	Bridge width	Top level (Road level)	Bottom level (Soffit)
Milson_Line	31	Mangaone_Stream	7290	15	20	36.5	35.39
Roberts_Line	23	Mangaone_Stream	3358	8	20	44.6	43.61
Te_Nagio	11	Mangaone_Stream	1660	8	8.8	48.2	46.36
Kiranga	60	Mangaone_Stream	1386	12	20	49.5	49
Fielding	4	Mangaone_Stream	554	10	40	52.8	51.78
Jack_Kairanga	61	Maple_St	1050	8	15	49.6	48.9
Jack_Fielding	5	Maple_St	449	8	15	51.5	50.65
Airport	30	Nth_Airport	3340	4	3.7	36.8	36.4
Whisky_low	33	Nth_Whiskey	4441	15	5.2	34.6	34
Whisky_high	59	Nth_Whiskey	1934	17	8.2	41	40.6
Clevely Rd	25	South_Clevely	20	10	5.3	44.5	44.1

Culverts

Culvert ID	DHI_ID	Type	No units	Width (m)	Height(m)	Diameter(mm)	Invert Used(m)
ME-98	3	culvert	1	1.2	1.2		52.7
SB-20	6a	culvert under road	2			1.5	45.1
SB-7	6b	culvert under rail	1			1.6	46.0
PR-20	7a	small pipe in rd	1			1	46.6
PR-7	7b	small box culvert in rail	1	1	1		46.8
EC-19	8a	round culvert under rd	1			1.5	45.8
EC-7	8b	box culvert under rail	1	1.2	1.2		46.4
EC-421	10	square culverts	2	1.6	1.6		43.6
ME-1263	13	Culvert (rectangular)	1	3.6	1.8		47.9
UM-2029	15	Culvert (circular)	2			1.2	50.2
UM-1927	16	Culvert (circular)	2			1.2	50.7
UM-5124	22	Culvert (rectangular)	1	6.6	2		41.8
SC-1164	24	Culvert	1	2.4	2.4		38.8
SC-7	25b	Culvert under rail	2	1.5	1.5		42.8
WC-1165	34	Culvert (rectangular)	1	3.35	2.35		32.0
NW-3103	36	Culvert (rectangular)	1	2.5	2.5		31.1