Fraser Earthmoving Construction Pty Ltd

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Part 3
Flood Risk Assessment

for the

Howlong Sand and Gravel Expansion Project

State Significant Development 17_8804

Prepared by

Water Technology Pty Ltd

December 2019

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Flood risk assessment

Howlong Quarry Expansion

RW Corkery & Co

December 2019

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Water Technology Project Director	Ben Tate
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05 December 2019

Nick Warren
RW Corkery & Co
Via email nick@rwcorkery.com

Dear Nick,

Howlong Quarry Expansion Flood Risk Assessment

The following report documents the findings of the flood risk assessment undertaken for the proposed Howlong Quarry expansion.

Results of the hydraulic modelling indicate that while a slight increase in water levels is likely due to the construction of levees around the proposed pit expansion, this local increase does reduce quickly upstream and does not result in greater flood extents. Details on the model development as well as mapped results are presented in the following report.

Yours sincerely

Sebastien Barriere
Project Engineer

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1 INTRODUCTION

This investigation concerns the proposed expansion to the existing sand and gravel quarry at 4343 Riverina Highway, approximately 4 km south-east of Howlong. The proposal is to increase the current quarry operation from an extraction volume of 30,000 tons per annum to 300,000 tons per annum. The site is within the Murray River floodplain and as such, an understanding of flood behaviour is crucial for the successful construction and operation of the quarry. Water Technology was engaged to undertake a flood risk analysis for the proposed quarry expansion.

This report outlines Water Technology's investigations into flood behaviour at the extraction site. It identifies the risk of flooding, and the impact of the proposed earthworks on the flood regime of the Murray River. A hydraulic model of the Murray River, anabranch creeks and surrounding floodplain adjacent to the site has been developed, simulating design flood scenarios for existing and proposed conditions.

1.1 Site description

Figure 1-1 and Figure 1-2 show the site locality and the topography. The Murray River floodplain through Howlong is an anabranching system, with creeks leaving the Murray and flowing back in further downstream. There are many cut off meanders and billabongs through the floodplain, formed from old river courses. Despite the complex topography of the river and anabranches, the floodplain is well defined, and in large floods inundates to the floodplain margins.

The quarry site is located in close proximity to Howlong, just upstream of Common Creek and between the Murray River and the Black Swan Anabranch.

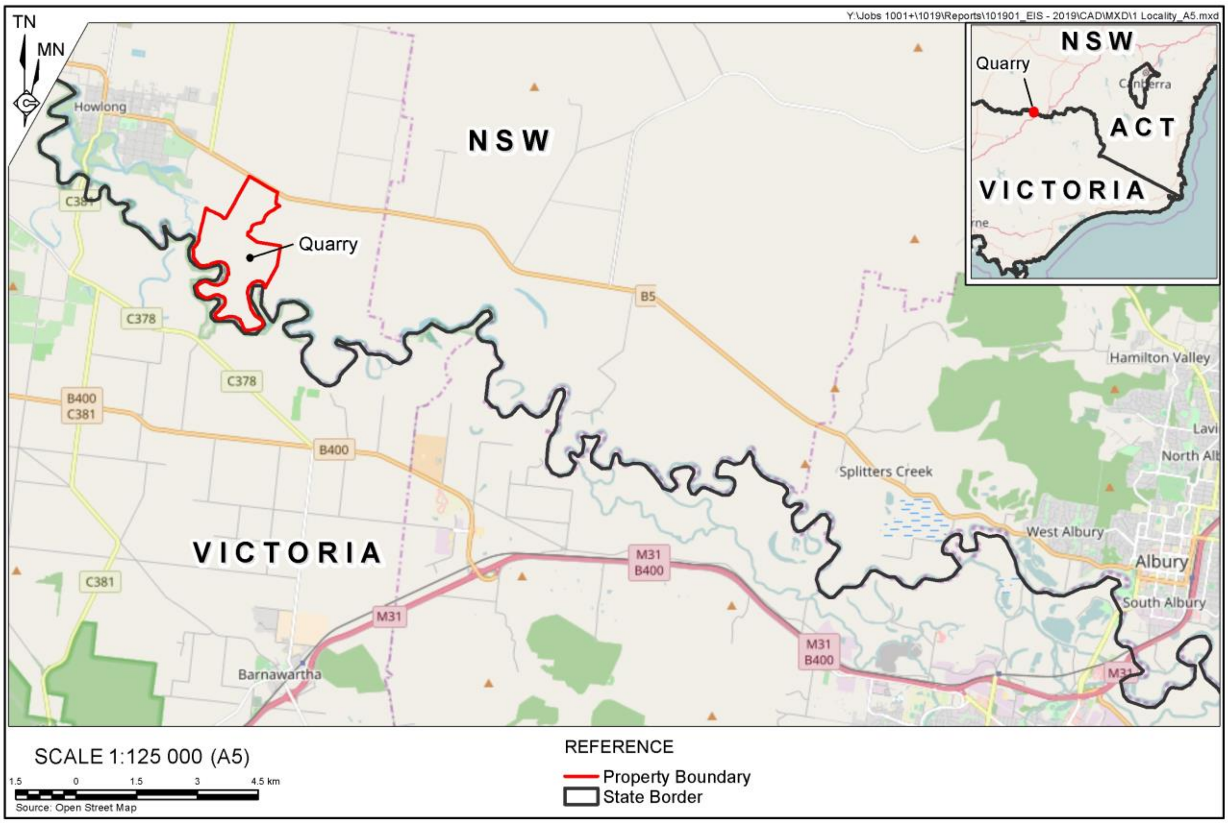

FIGURE 1-1 SITE LOCATION

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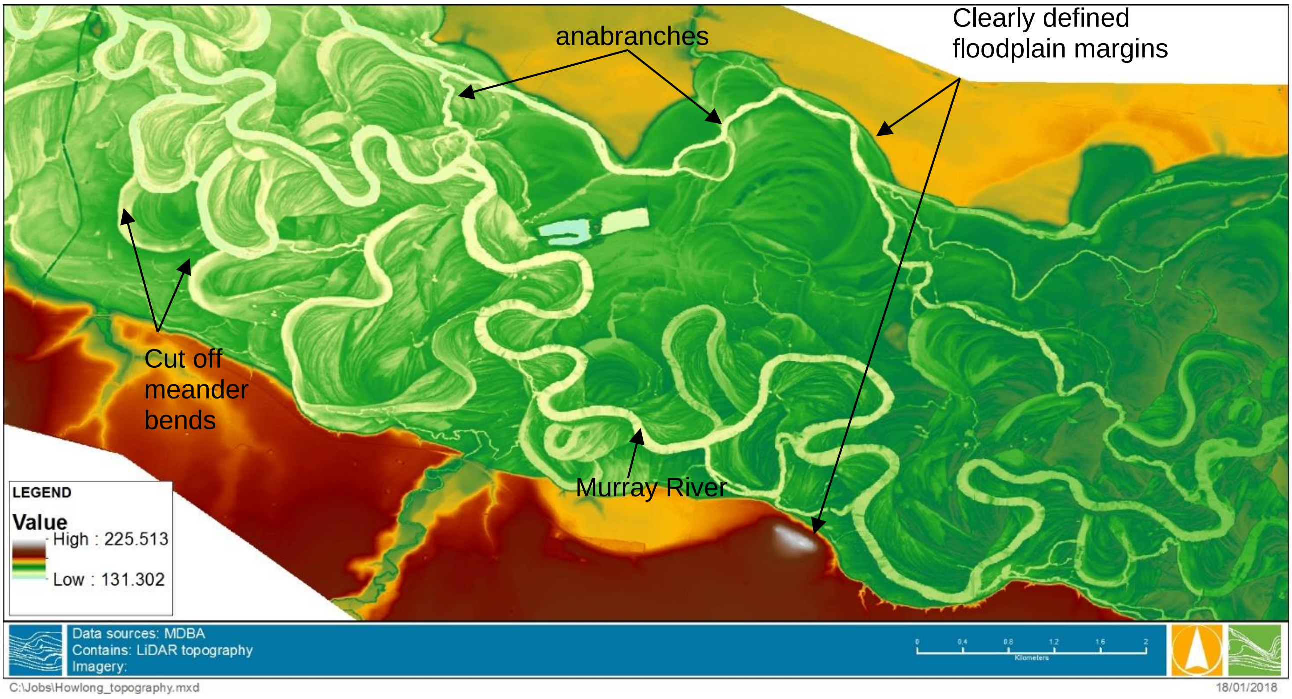

FIGURE 1-2 FLOODPLAIN TOPOGRAPHY

1.2 Quarry Expansion

The following provides a summary of the key components of the Project for which development consent is being sought. The proposed Quarry layout is presented in Figure 1-3

- Ongoing extraction of sand and gravel resource across four stages of development, commencing in the existing disturbed areas and progressively expanding to new areas in later stages.
- Production of no more than 300,000 tonnes per annum (tpa).
- Ongoing use of screening equipment and wash plant to process raw materials to meet client specifications. Occasional use of mobile crushing plant (once or twice per year) to provide primary shaping of the resource before screening.
- Ongoing transportation of material from the Quarry, via Howlong, to various destinations. Transportation would be limited to a maximum of 40 laden loads per day.
- Progressive placement of overburden or fine materials in completed pits and rehabilitation areas.
- Land previously disturbed within 100m of the Murray River would be regenerated.
- Progressive and final rehabilitation of the Quarry to develop a landform suitable for native vegetation conservation and as a wetland.
- Ongoing operation for a period of 30 years and associated employment of eight to ten personnel. Transportation operations would be contracted, or trucks and drivers would be supplied by clients.

With regard to the surface water risk assessment, the main impact on the hydraulic behaviour of the area will be the result of the additional levees constructed around the pits. The purpose of this assessment is to confirm the acceptable elevation of levees required to limit flood incursion to operating areas and to assess the likely changes to flood behaviour and extent as a result of the levee construction.

The proposed levee height would be set to block flood waters up to the 1% AEP (Annual Exceedance Probability) event. The location of the levees is shown in Figure 1-3.

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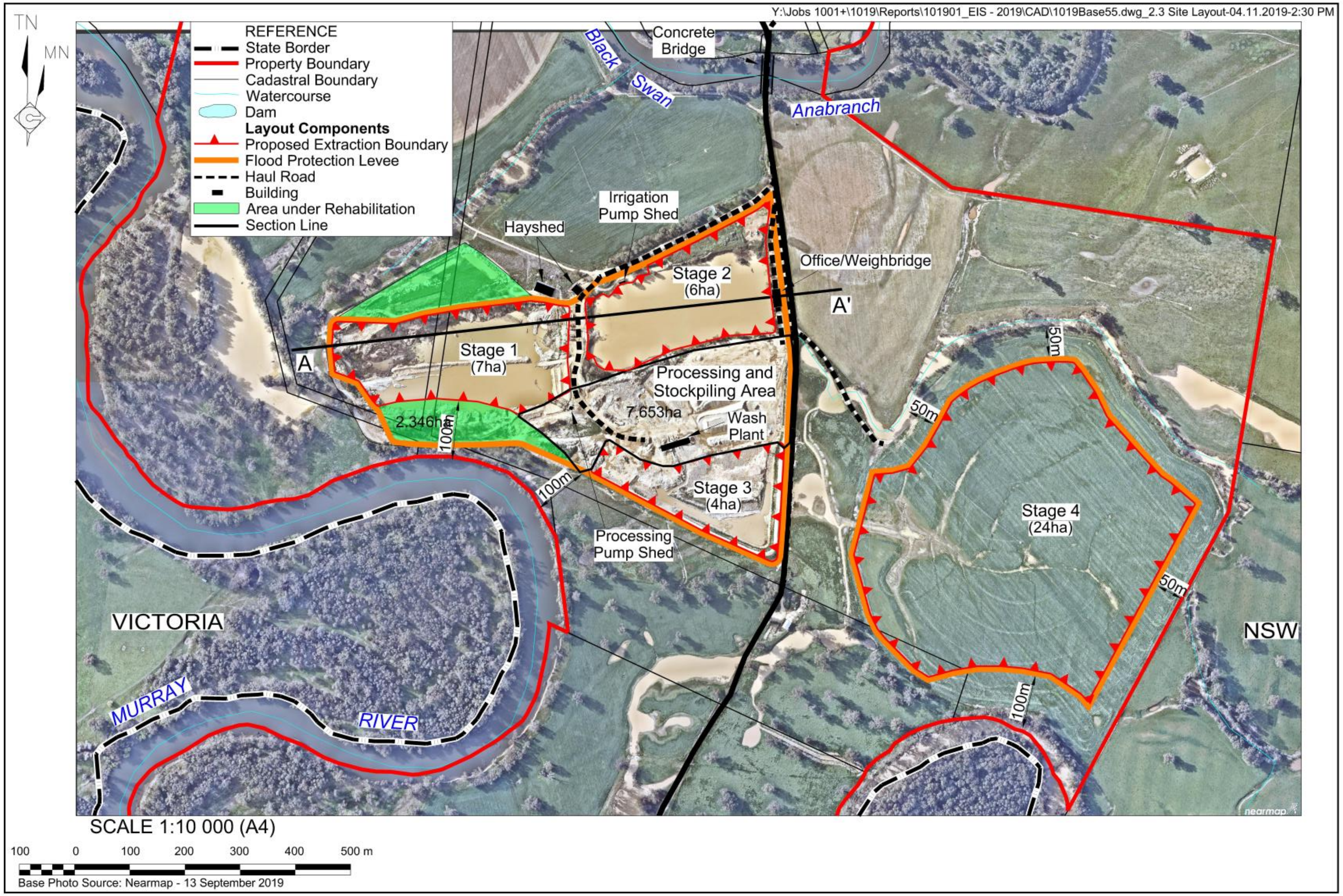

FIGURE 1-3 SITE LAYOUT

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2 DATA COLLATION

2.1 Topographic data

A LiDAR (Light Detection and Ranging) data set with a 1 m horizontal resolution captured by AAM Geoscan for MDBA (Murray Darling Basin Administration) in 2001, was the primary source of topographic data for the hydraulic model.

Detailed bathymetric survey was carried out during the Common Creek Hydraulic Investigation undertaken by Water Technology in 2009. The continuous bathymetric data was collected for:

- The entire length of Common Creek.
- The Murray River, approximately 300 m upstream and 300 m downstream of the Common Creek offtake.
- Black Swan Anabranch, approximately 300 m upstream and 300 m downstream of the Common Creek confluence.

FIGURE 2-1 THE EXTENT OF THE DETAILED BATHYMETRY SURVEY REACH WITHIN COMMON CREEK, THE MURRAY RIVER AND BLACK SWAN ANABRANCH. THE LIMIT OF THE DETAILED BATHYMETRY SURVEY IS REPRESENTED BY THE ORANGE LINES

In addition to the detailed bathymetric survey along Common Creek, to describe the channel capacity of the Murray River and the surrounding creeks, existing cross sectional bathymetric survey of the waterways was used as the basis for the 1D hydraulic model set-up. The different data sources are presented in Figure 2-2.

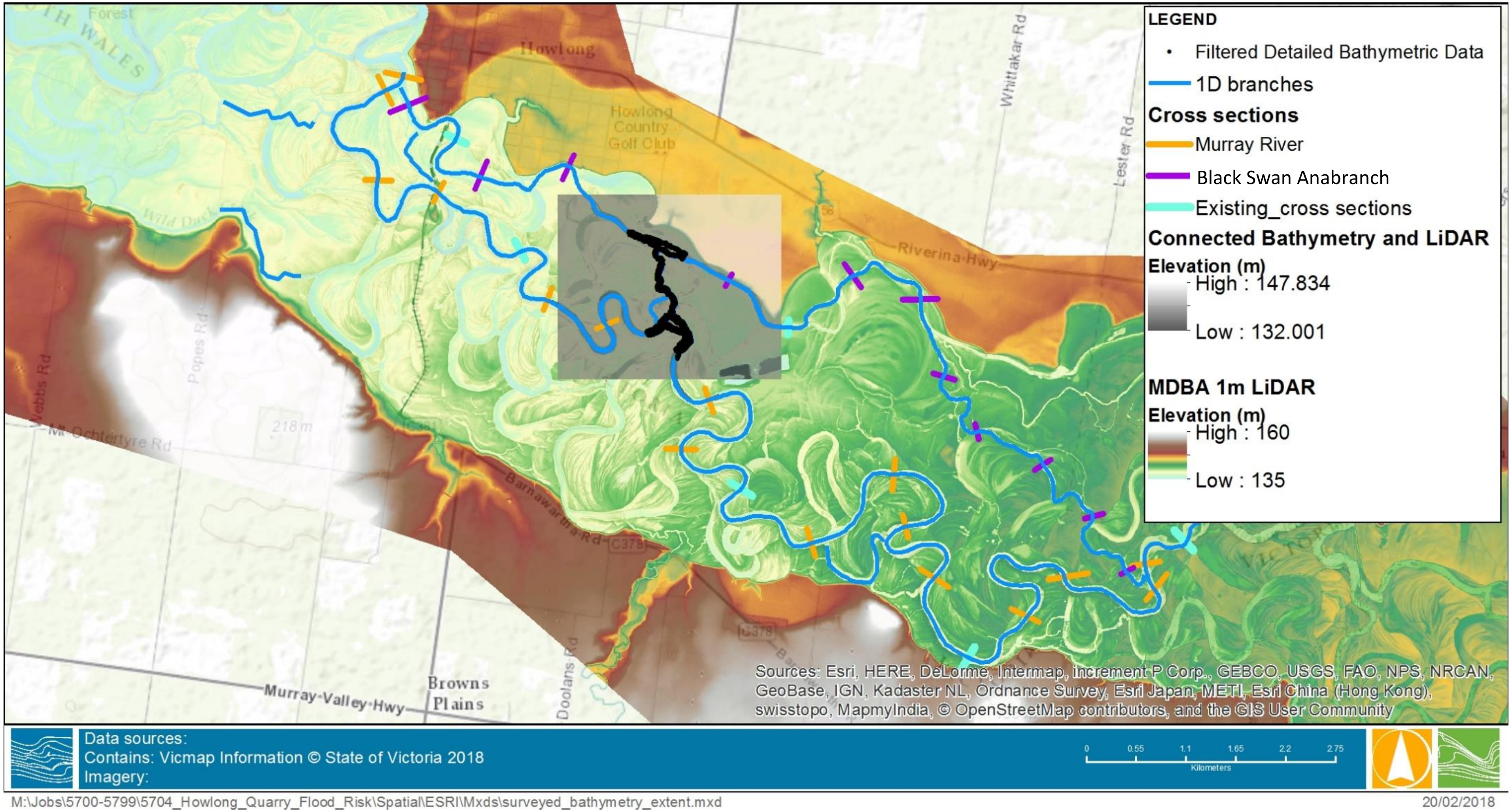

FIGURE 2-2 TOPOGRAPHY AND BATHYMETRY INPUT DATA

2.2 Hydrology data

GHD (2012) undertook a flood frequency analysis on 130 years of streamflow records at the Doctors Point gauge (409017) on the Murray River, Table 2-1. The Doctors Point gauge is upstream of the quarry site, but downstream of the Kiewa River junction, and hence provides a reasonable representation of flow at the boundary of the hydraulic model.

It is noted that a gauge downstream of the site at Howlong is available, and it has recorded data from 1967. The Bureau of Meteorology provide a rapid flood frequency analysis of the gauge data on their website, which gives a 10% AEP flow of 1,200 m³/s and a 1% AEP flow of 2,300 m³/s. These flows are in the vicinity of the detailed analysis from GHD (2012), so it was decided to adopt the GHD flows for this assessment.

The results of the flood frequency analysis were used to define the upstream boundary to the hydraulic model.

TABLE 2-1 HYDROLOGIC DATA ADOPTED FROM GHD (2012)

Design Flood Annual Exceedance Probability	Total inflow, m^3/s
50%	463
20%	868
10%	1,273
5%	1,678
2%	2,373
1%	2,894
0.5%	3,819
0.2%	5,093
PMF	14,900

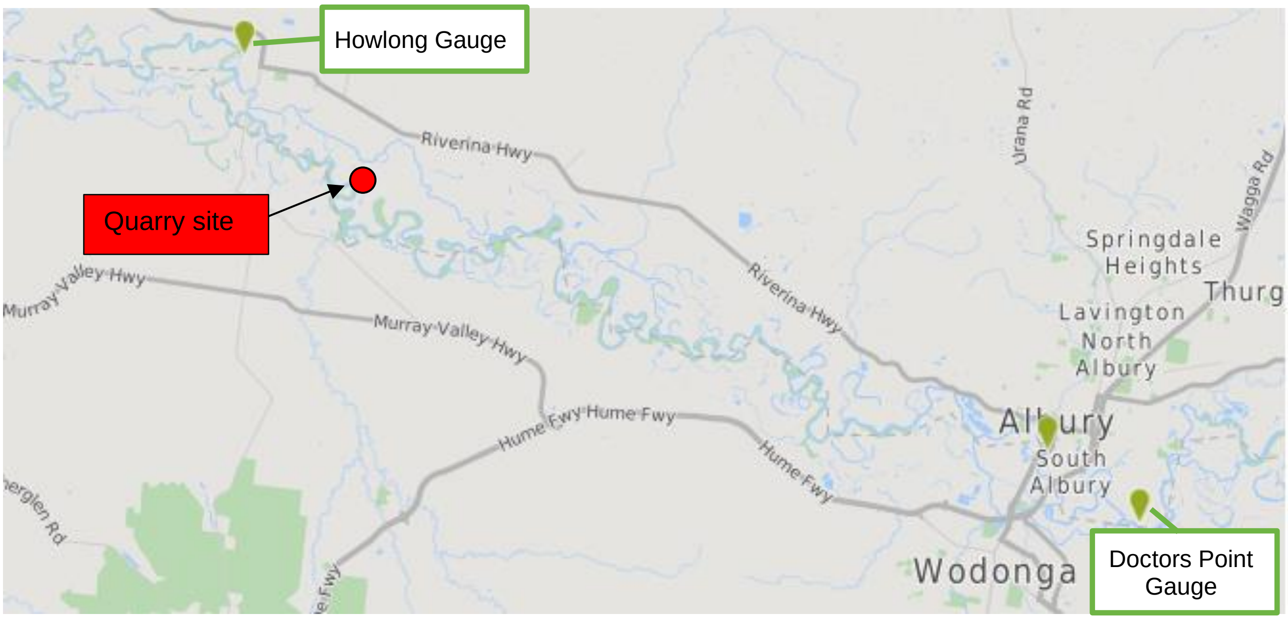

FIGURE 2-3 STREAMFLOW GAUGES

3 HYDRAULIC MODEL

The hydraulic model was required to simulate the flow behaviour for flood events for the Murray River floodplain in the vicinity of the subject site under existing and developed conditions.

The investigation involved hydraulic modelling of the Murray River, Black Swan Anabranch and Common Creek. The selected hydraulic modelling approach was to develop a combined one and two dimensional hydraulic model. This approach involved:

- Developing a standalone one-dimensional MIKE 11 model of the entire Black Swan Anabranch, Common Creek and Murray River within the study area;
- Developing a two-dimensional MIKE 21 model of the floodplain;
- Linking the 1D and 2D models along the waterways to describe overflowing from the waterways onto the floodplain and back to the rivers.

3.1 Scenarios

In order to assess the flood risk and the impact of the proposed development, the following model scenarios were developed:

- Existing conditions under 5% AEP, 1% AEP, 0.5% AEP, 0.2% AEP and the PMF (Probable Maximum Flood).
- Developed conditions with proposed levees and new extraction areas for the same design events.

3.2 1D model

Using the previous model for the Common Creek Hydraulic Investigation, a 1D model of the Murray River, Black Swan Anabranch and Common Creek was developed. The available cross sections, LiDAR data set and detailed bathymetric survey were used to update and build the 1D model for the current flood risk assessment of the Howlong Quarry site. Figure 3-1 presents the extent and components of the 1D model developed using MIKE HYDRO.

To accurately describe the overflow between the waterways and floodplain, additionnal cross sections were extracted from the DEM (Digital Elevation Model), ensuring the river bank levels were correctly taken into account.

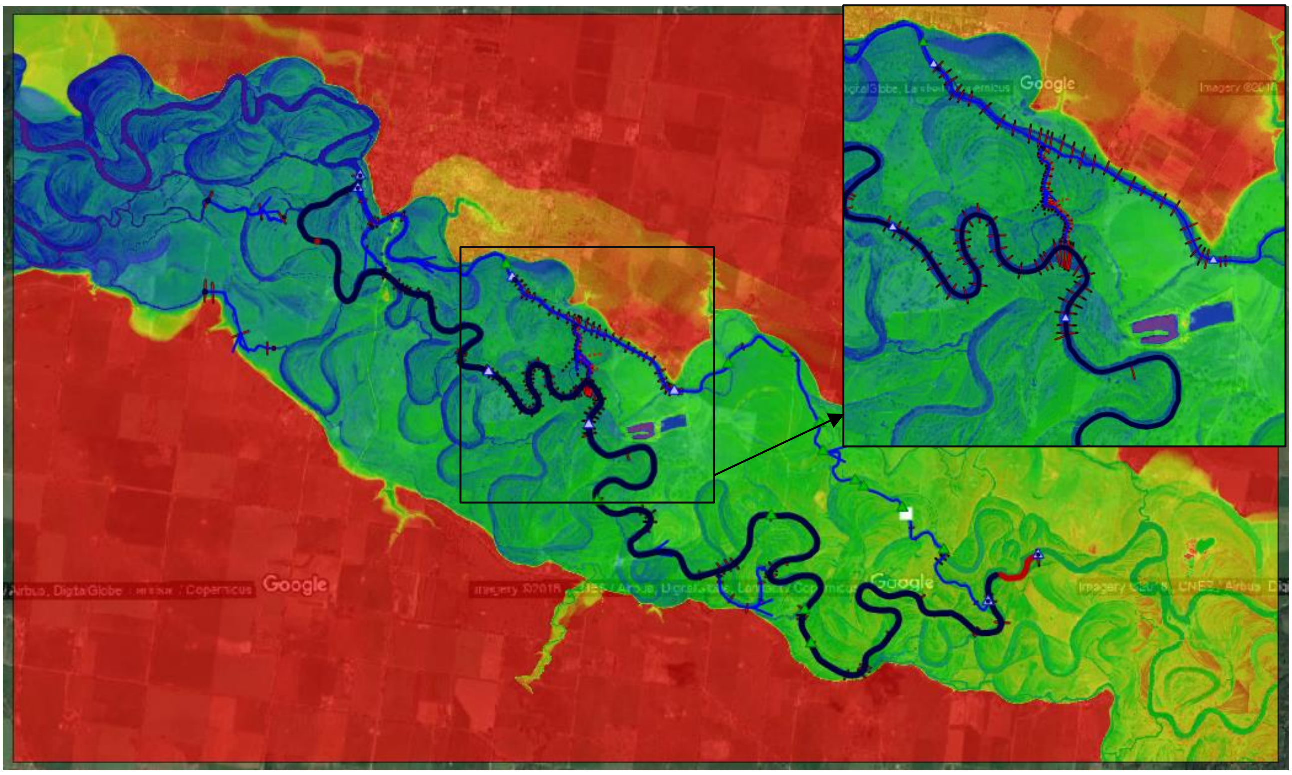

FIGURE 3-1 MURRAY RIVER, BLACK SWAN ANABRANCH, COMMON CREEK, SAWYERS AND PUNT CREEK 1D MODEL BRANCHES.

3.3 2D model

The main component of the MIKE 21 model is the DEM. As a compromise between high-resolution and run-time, a 10 m grid resolution was used in the 2D model, the topography data was resampled from the LiDAR data set.

A roughness map based on land use was applied to the 2D model. The roughness coefficients for each land type are the same as those adopted in a previously calibrated model developed for the Murray River floodplain west of Wodonga.

Hydraulic roughness within the 2D model was expressed as Manning's n, based on land use and vegetation cover. Hydraulic roughness values adopted for the 2D hydraulic model are summarised in Table 3-1 below.

TABLE 3-1 ROUGHNESS VALUES

Description	Manning's n
Murray River and anabranch channels	1D model calibration
Grass	0.05
Scattered vegetation	0.1
Thick vegetation	0.15
Built-up and rural residential areas	0.3

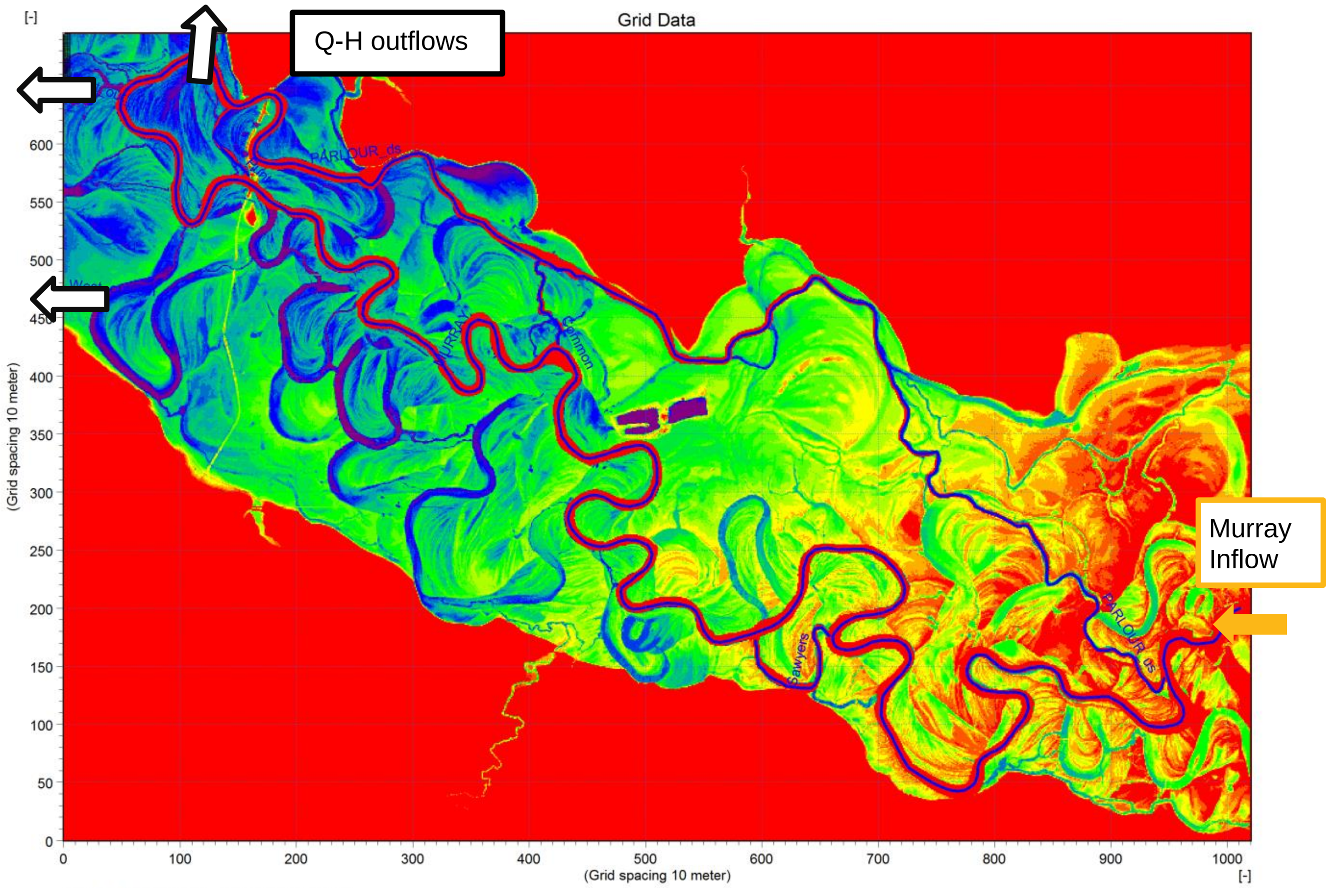

FIGURE 3-2 MIKE21 GRID AND BOUNDARY LOCATIONS (APPLIED TO 1D MODEL)

3.4 Boundaries

Inflows from the Murray River were applied to the upstream end of the 1D river branch. Inflow was constant for each design flood event, to simulate steady state conditions (flood periods in the Murray River can be a number of weeks so this assumption is reasonable).

Several Q-H boundaries were applied at the downstream end of the model to ensure that flood flows left the model appropriately and did not cause artificial backwater impacts on the site. The Q-H relations were calculated based on the channel geometry and floodplain topography.

The location of the boundaries can be seen in Figure 3-2 and inflows for design flood events are detailed in Section 2.2.

3.5 Hydraulic model validation

The model developed for this study is based on the previous calibrated model built in 2009 (Water Technology). The main difference with the previous model is the addition of lateral links along the waterways and Common Creek represented by a 1D channel instead of a 2.5 m grid in a 2D model.

The calibrated 1D model roughness coefficients were maintained. During the previous study the coefficients were calibrated using the flow rate during which the survey data was captured in January 2009. The calibration process made use of the measured water surface elevations, whilst also using the flow split measurements to assist the calibration process.

The measurement occurred during a four-day period between the 12th to the 16th of January 2009, with the flow rate varying between 10,077 ML/day to 10,655 ML/day. The flows correspond to a low flow rate, when no flooding occurred, but this is still valuable information to confirm the model reproduces in-bank flows correctly.

Results in terms of water levels are shown in the following graphs. The difference between observed and calculated levels indicates the model matches the survey well.

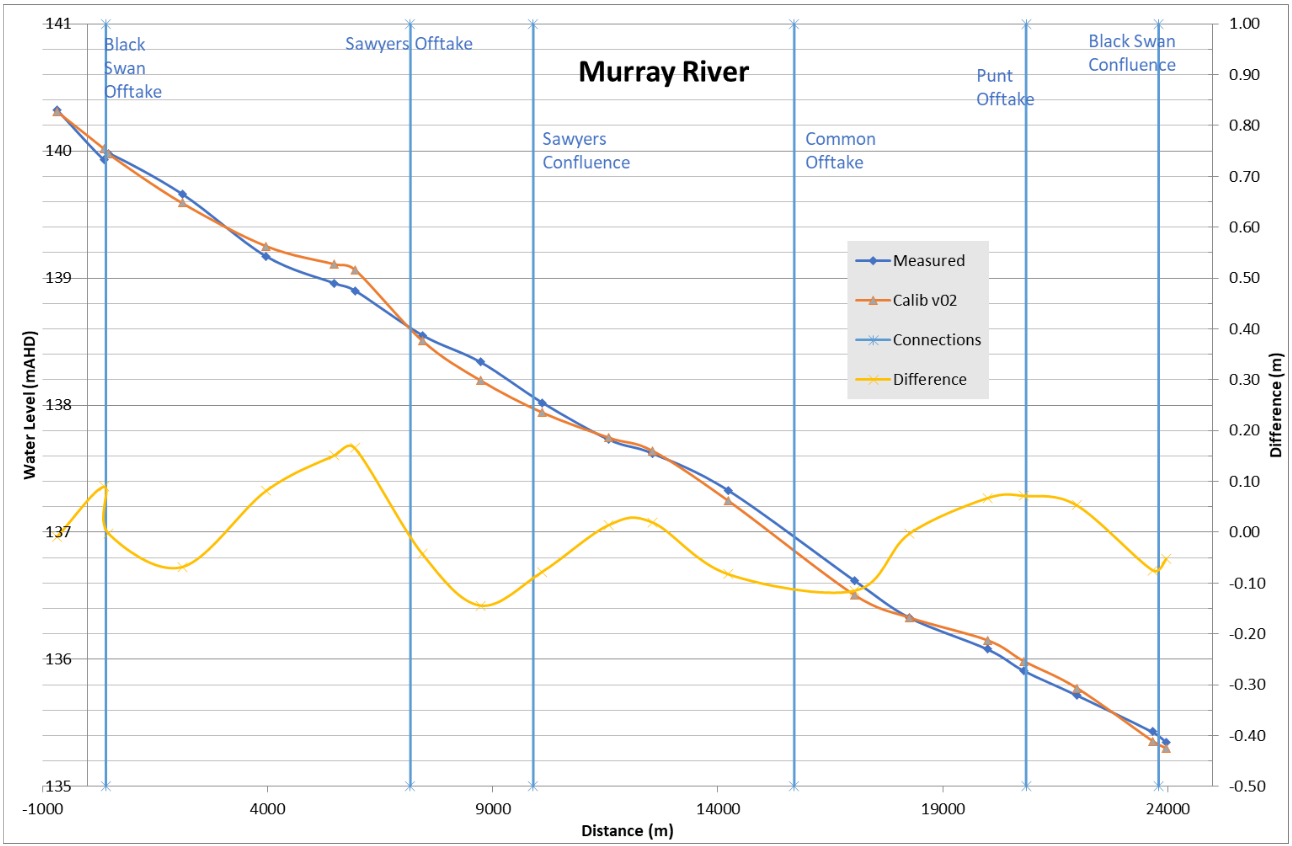

FIGURE 3-3 THE WATER SURFACE ELEVATIONS ALONG THE MURRAY RIVER FOR THE CALIBRATION EVENT.

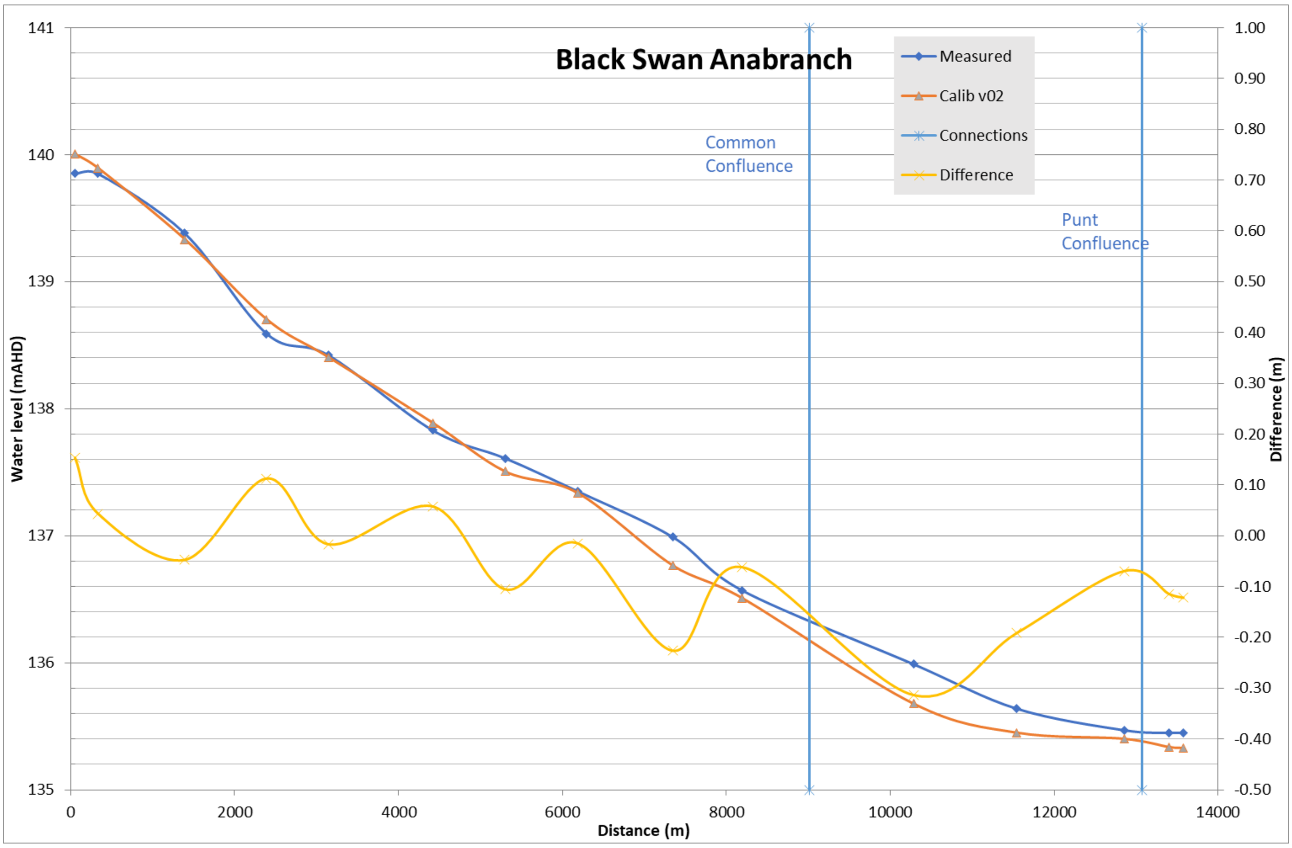

FIGURE 3-4 THE WATER SURFACE ELEVATIONS ALONG BLACK SWAN ANABRANCH FOR THE CALIBRATION EVENT.

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4 EXISTING CONDITIONS

The model was run under existing conditions for the 5%, 2%, 1%, 0.5%, 0.2% AEP and PMF flows in the Murray River. The site is inundated for the 5% AEP flood event, with significant water depths around the site ranging from 20 cm to over a meter.

For the different flood events, the levels reached around the quarry are listed in the table below. Figure 4-1 presents the location of the different extraction points around the subject site.

FIGURE 4-1 REPORTING LOCATIONS

TABLE 4-1 EXISTING CONDITION WATER LEVELS AT REPORTING LOCATIONS AROUND THE QUARRY SITE

	Water Levels (m AHD) at Reporting Locations							
AEP	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
5%	141.40	141.40	141.32	141.33	141.25	141.24	140.87	141.10
2%	142.06	142.04	141.95	141.98	141.88	141.85	141.57	141.70
1%	142.32	142.30	142.21	142.24	142.14	142.11	141.86	141.96
0.5%	142.74	142.71	142.63	142.65	142.55	142.52	142.29	142.37
0.2%	143.25	143.22	143.13	143.16	143.05	143.01	142.80	142.86
PMF	146.13	146.12	146.04	146.03	145.94	145.87	145.67	145.69

The highest levels are found on the upstream end at locations 1 and 2.

The 1% AEP event results were compared to water levels in the Victoria Flood Database (VFD). Figure 4-2 shows the results are very close to the VFD contour lines at the quarry site. The latest modelling yields levels around 10 cm higher than those mapped in the VFD data-set at reporting location 1. The model shows a level

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of 142.32 m AHD is reached whereas the VFD data provides a level of 142.2 m AHD for the 1% AEP event in the Murray River at reporting location 1.

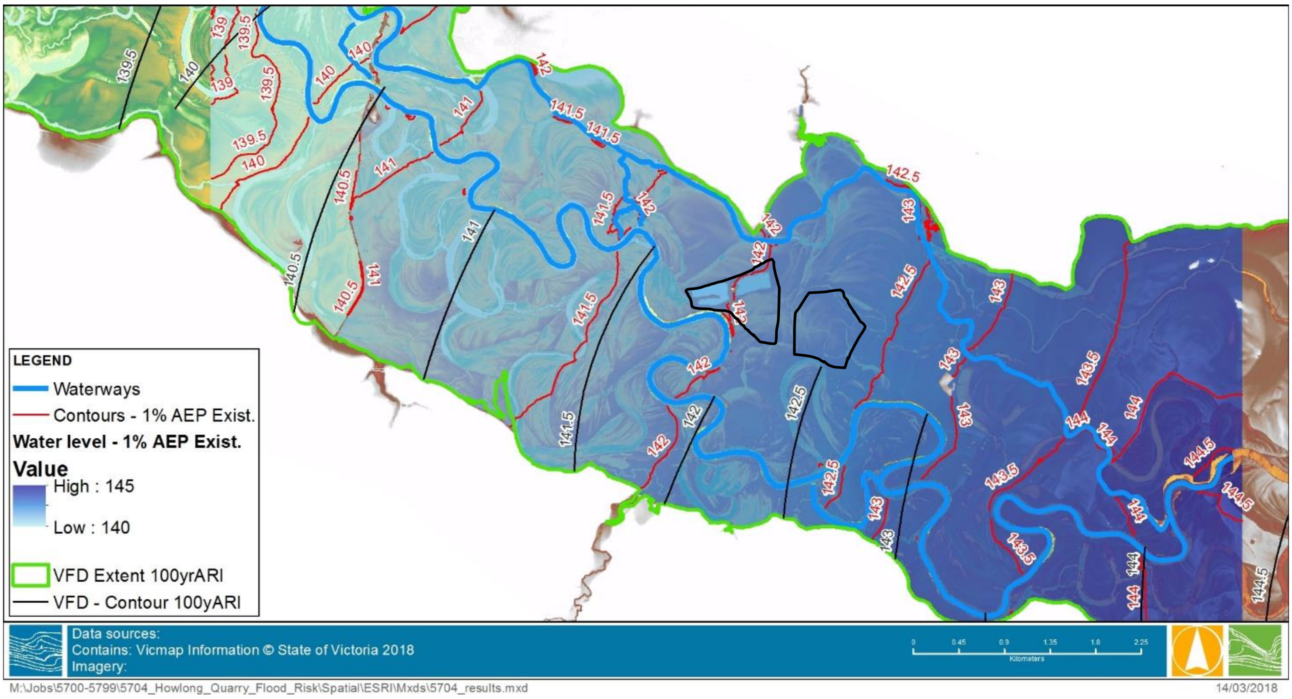

FIGURE 4-2 1% AEP EVENT MODEL RESULTS AND VFD DATA VERIFICATION

Maps for each design event (water levels and depths) are available in the Appendix of this document.

5 DESIGN CONDITIONS: QUARRY EXPANSION

As mentioned previously in this report, the developed conditions are represented in the model by the addition of levees around the quarry site. The crest level of the levee was set to protect the site from flooding in the occurrence of a 1% AEP flood event in the Murray River. The maximum 1% AEP flood level was calculated to be 142.7 m AHD, however it is noted that there is a slope on the water surface profile, so the final finished crest height of the levee could vary according to the modelled water levels plus appropriate freeboard.

It should be noted that the following modelling results were obtained using a levee layout provided in 2018. The most recent quarry expansion layout, shown in Figure 1-3 differs very slightly from the previous in terms of the proposed levee alignment. As shown in the figure below, the areas protected by the levees are reduced.

Hence, the developed conditions calculated previously are conservative with regards to the impact of the levees on flood levels around the quarry site. However, the change in flood levels due to the modification of the levee alignment will likely be minimal. For practical reasons the model has not been re-run and the levels presented here-after correspond to the initial levee alignment.

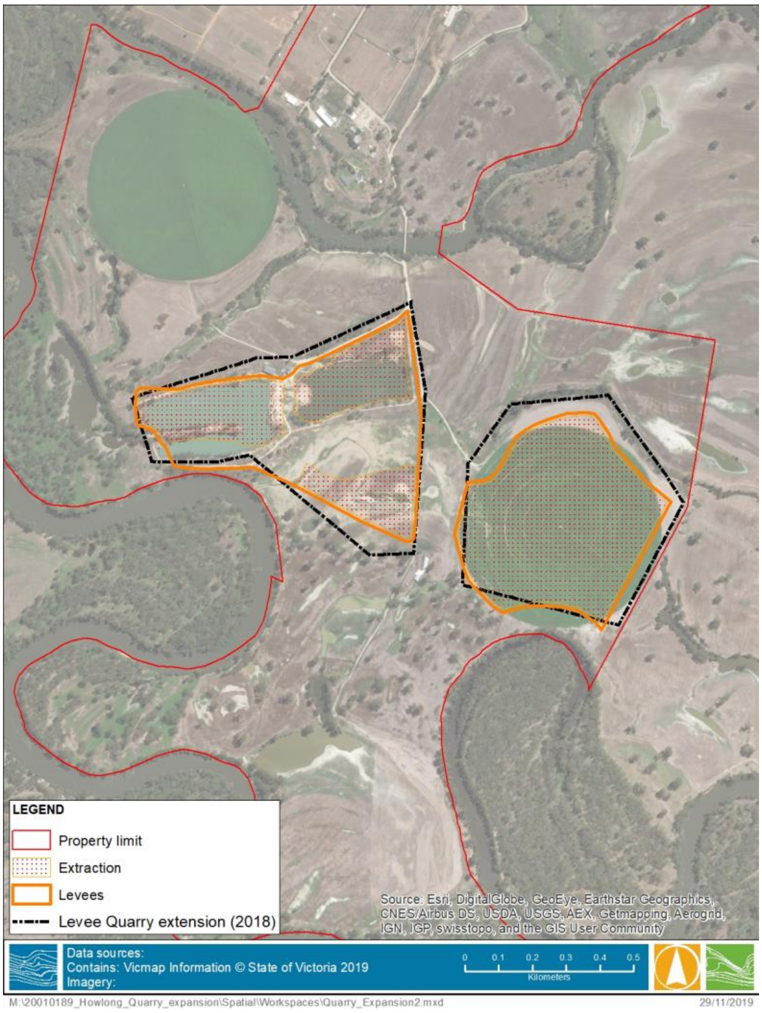

FIGURE 5-1 REVISED LEVEE ALIGNMENT AROUND EXTRACTION PITS

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The maximum 1% AEP flood level under developed conditions (142.7 m AHD) is slightly higher than the 1% AEP flood level calculated under existing conditions due to the impact of the levees on the surrounding water levels.

In Table 5-1 below, the water levels around the quarry site under developed conditions are reported for the same locations as previously.

TABLE 5-1 DEVELOPED CONDITION WATER LEVELS AT REPORTING LOCATIONS AROUND THE QUARRY SITE

	Water Levels (m AHD) at Reporting Locations (see Figure 4-1)							
AEP	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
5%	141.74	141.62	141.48	141.56	141.40	141.39	140.95	140.95
2%	142.38	142.29	142.12	142.19	142.07	142.05	141.56	141.63
1%	142.67	142.57	142.41	142.46	142.36	142.35	141.83	141.91
0.5%	143.04	142.98	142.87	142.89	142.82	142.81	142.26	142.36
0.2%	143.44	143.38	143.30	143.32	143.22	143.21	142.78	142.89
PMF	146.17	146.13	146.05	146.07	145.94	145.91	145.66	145.67

Due to the impact of the levees on the floodplain, the levels are increased east of the levees and conversely, are decreased west of the levees (points 7 and 8).

TABLE 5-2 DEVELOPED CONDITION WATER LEVEL DIFFERENCES AT REPORTING LOCATIONS AROUND THE QUARRY SITE

	Water Level Differences (m) at Reporting Locations							
AEP	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
5%	0.34	0.22	0.16	0.23	0.15	0.14	0.08	-0.14
2%	0.32	0.25	0.17	0.21	0.19	0.20	-0.01	-0.07
1%	0.34	0.27	0.20	0.22	0.22	0.24	-0.03	-0.05
0.5%	0.30	0.27	0.24	0.24	0.27	0.30	-0.03	-0.01
0.2%	0.19	0.16	0.16	0.16	0.17	0.20	-0.03	0.02
PMF	0.04	0.01	0.01	0.03	0.00	0.04	-0.01	-0.02

The following pages present water level difference maps showing the impact of the levees on the surrounding water levels. Results show the levels are higher under design conditions upstream, by 10 to 20 cm, depending on the event, for approximately 1 km upstream of the site. Further east the levels are also increased slightly but no more than 10 cm. The impact on levels reduces as we move farther from the site.

Levels downstream (west) of the site are reduced locally, the model indicates impact further downstream is negligible.

These differences are presented in both map figures with colours representing the difference in the water levels, and a series of water surface elevation longitudinal sections that show the water surface level profiles under existing conditions and developed conditions across the floodplain. As shown profiles 1 and 2 have a negligible difference in water level in the 1% AEP event before and after development, with profile 3 showing a 20 to 30 cm increase in water level, and profile 4 showing an increase of around 10 cm.

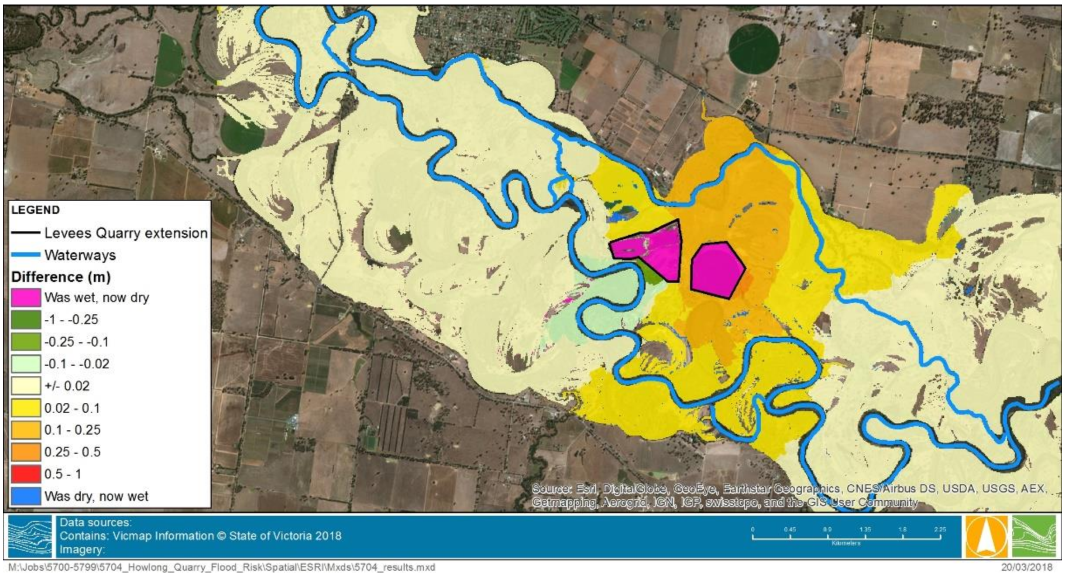


FIGURE 5-2 DIFFERENCE MAP – 5% AEP FLOOD EVENT

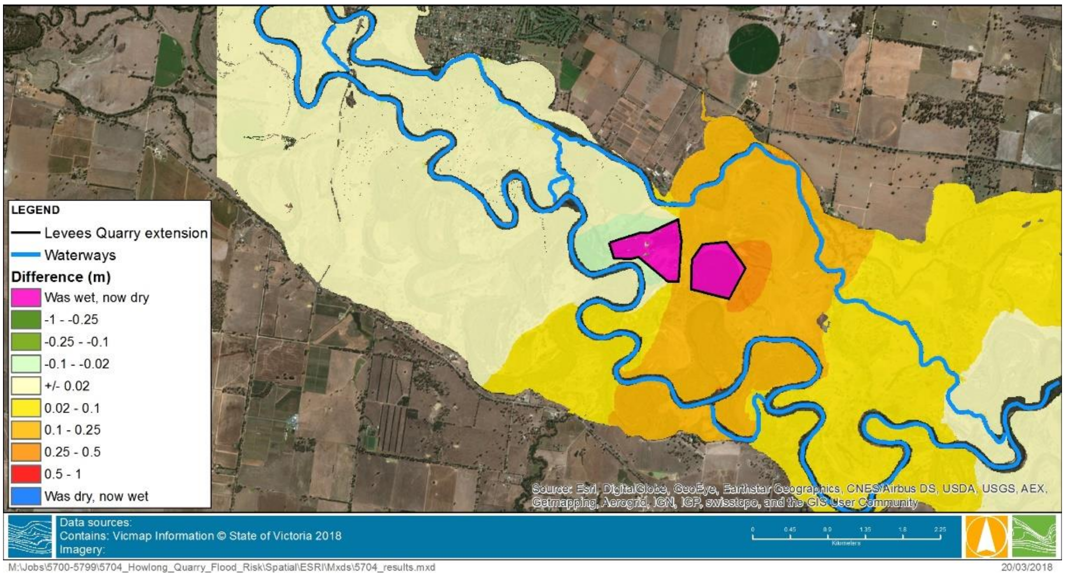


FIGURE 5-3 DIFFERENCE MAP – 1% AEP FLOOD EVENT

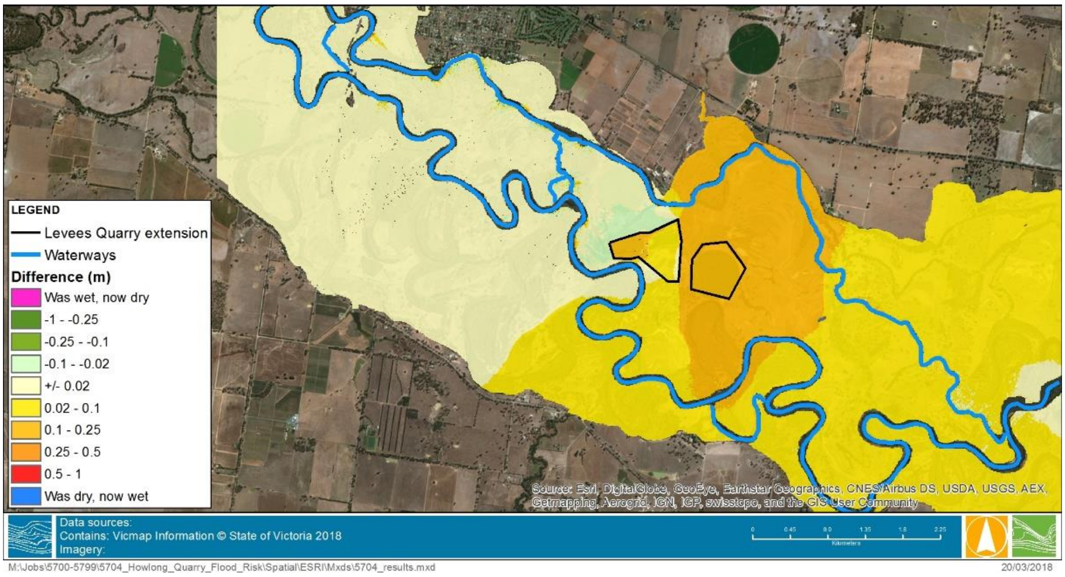


FIGURE 5-4 DIFFERENCE MAP – 0.2% AEP FLOOD EVENT

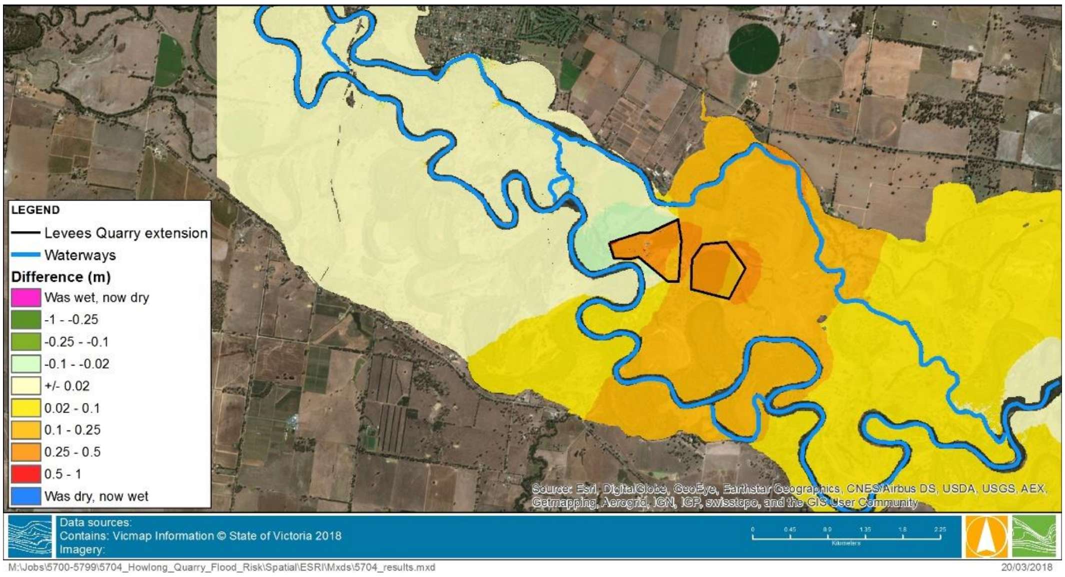


FIGURE 5-5 DIFFERENCE MAP – 0.5% AEP FLOOD EVENT

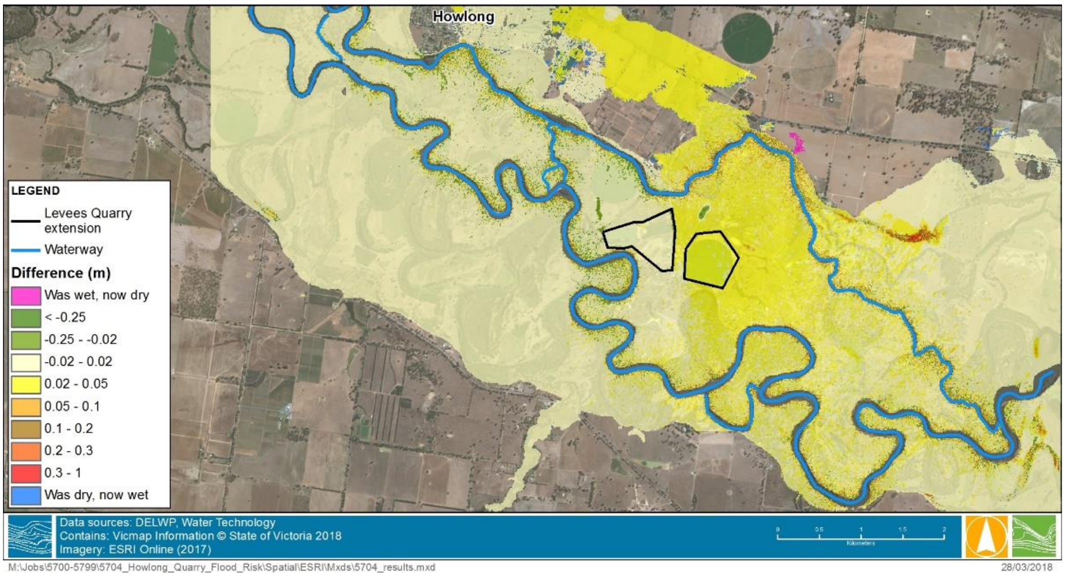


FIGURE 5-6 DIFFERENCE MAP – PMF EVENT

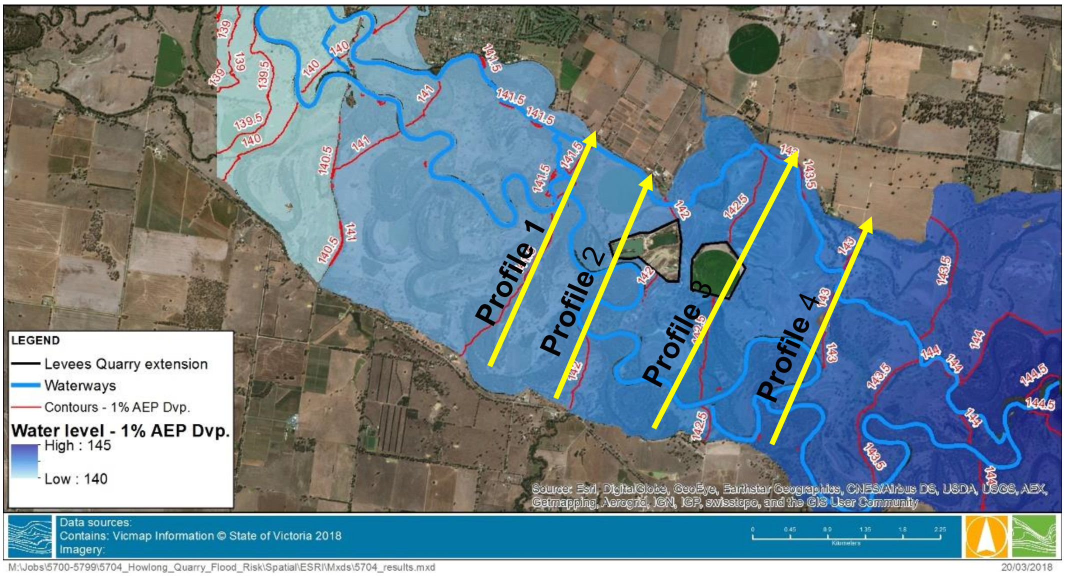


FIGURE 5-7 LOCATION OF WATER SURFACE ELEVATION PROFILES

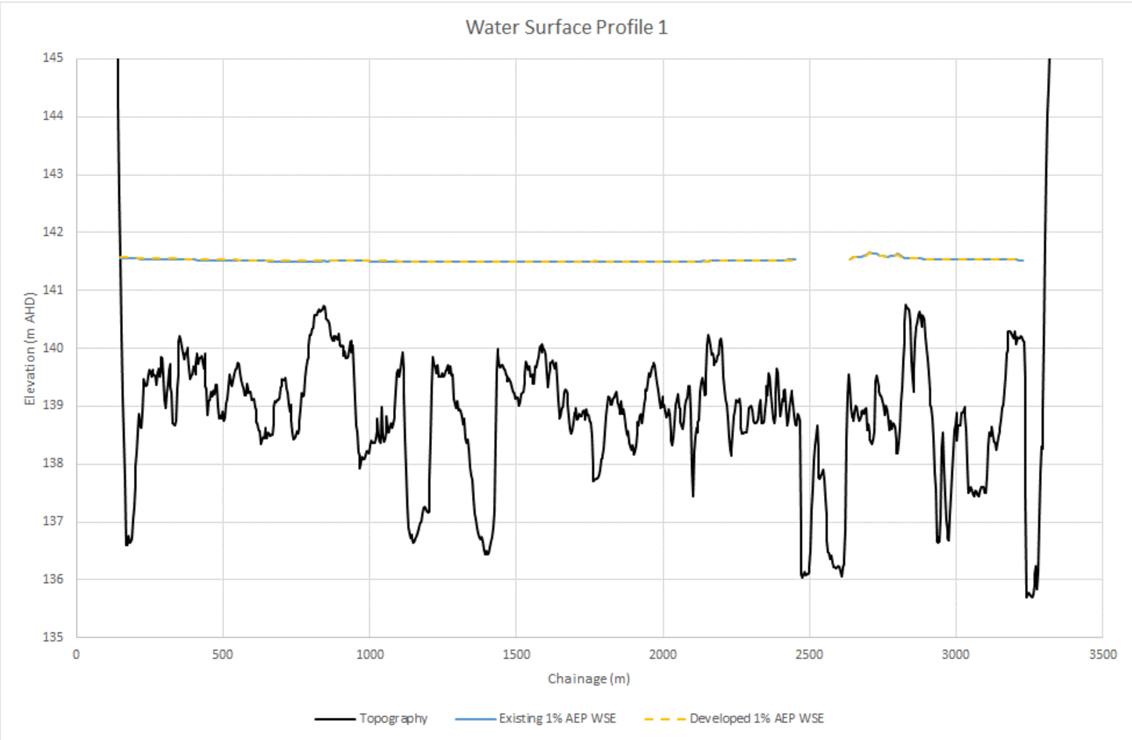


FIGURE 5-8 WATER SURFACE ELEVATION PROFILE 1

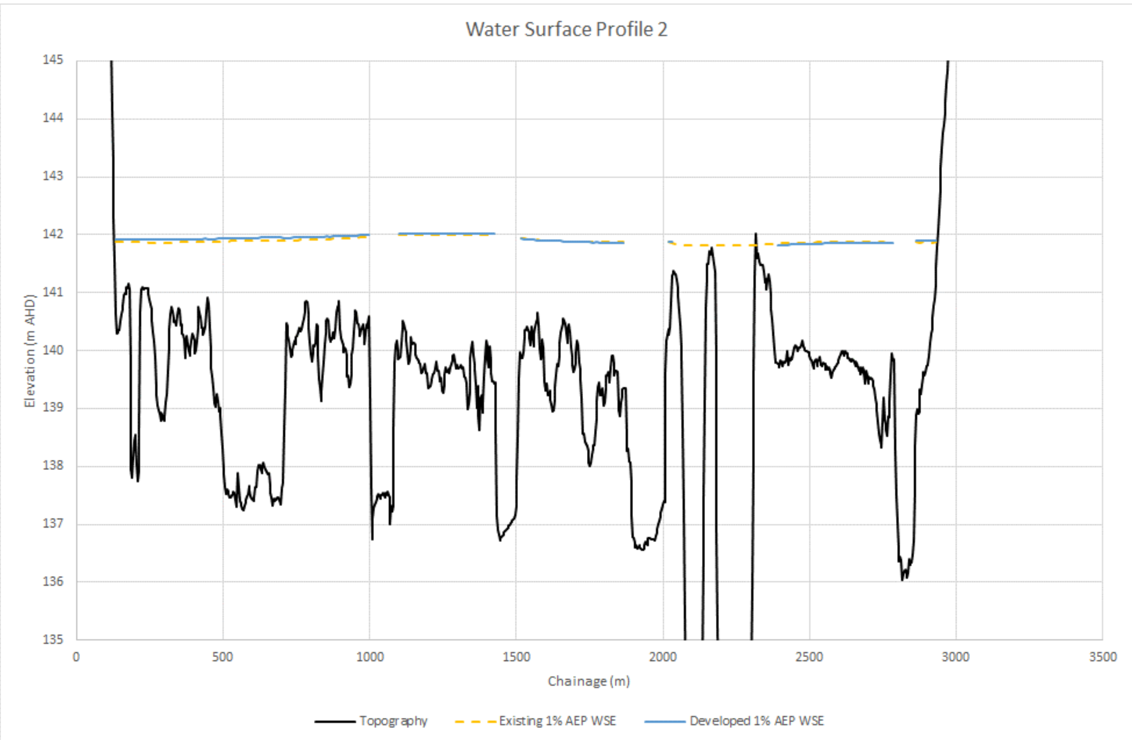


FIGURE 5-9 WATER SURFACE ELEVATION PROFILE 2

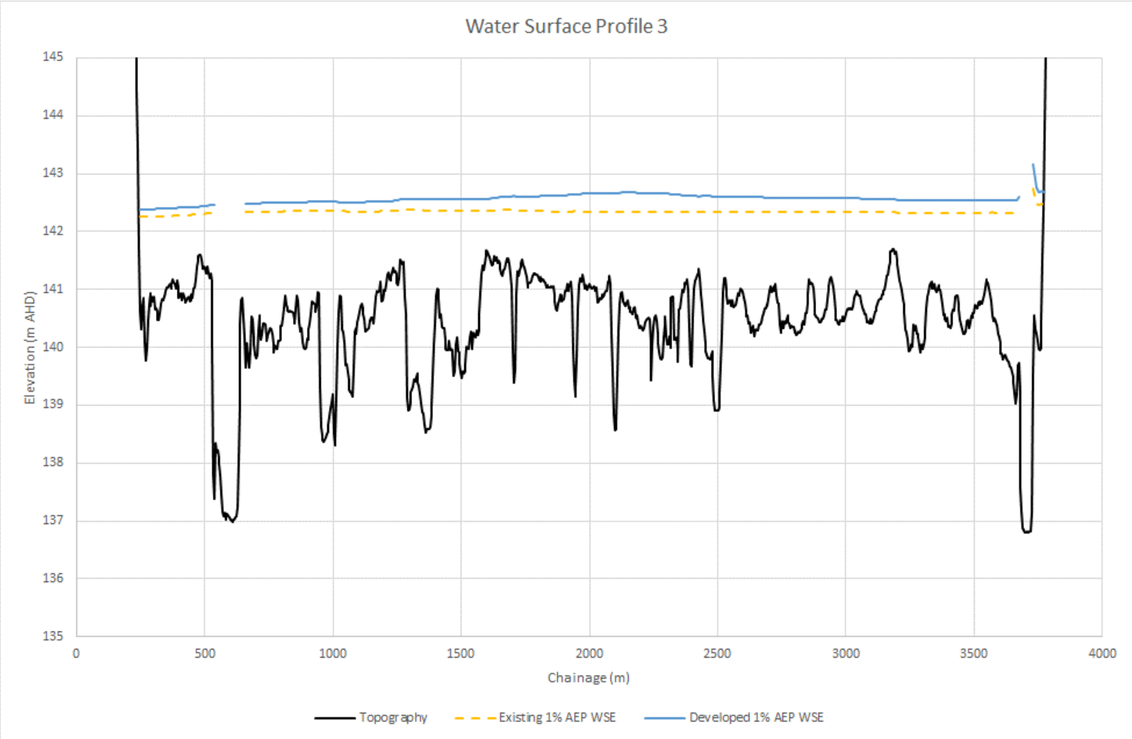


FIGURE 5-10 WATER SURFACE ELEVATION PROFILE 3

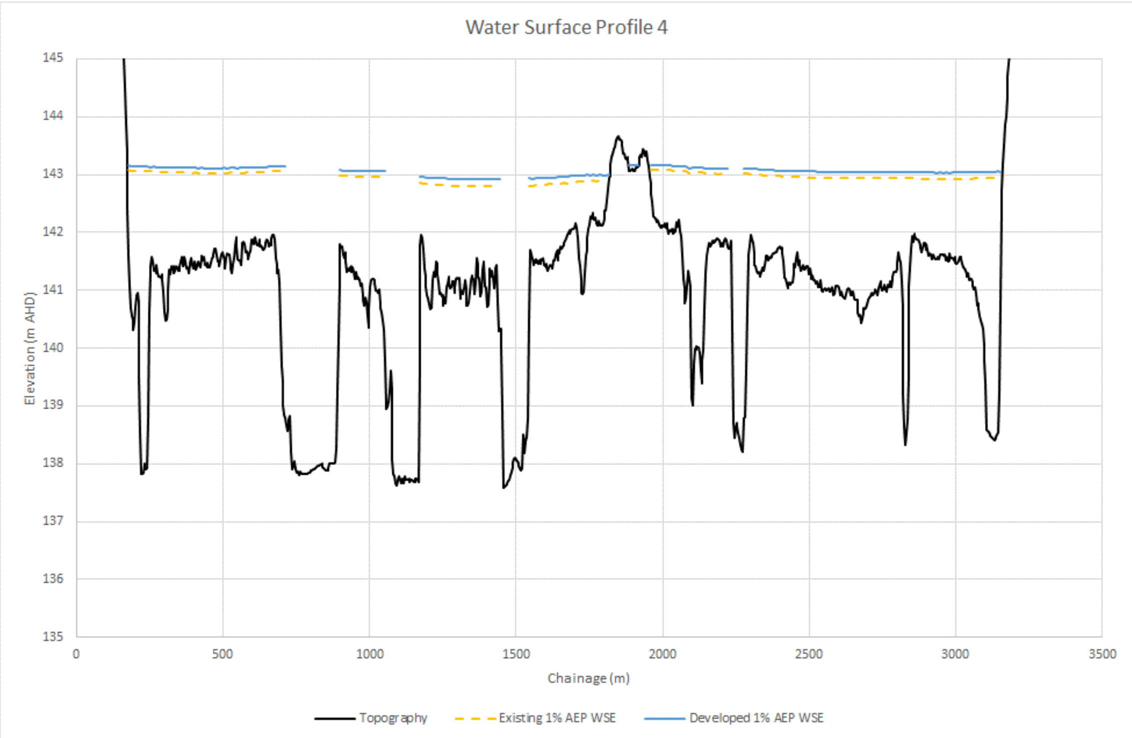


FIGURE 5-11 WATER SURFACE ELEVATION PROFILE 4

6 SUMMARY

The flood risk associated with the expansion of the Quarry site at Howlong has been investigated through the development of a hydraulic model.

Several design flood events of the Murray River were tested and the impact of the expansion of the quarry on surrounding water levels has been calculated and mapped.

Modelling indicates the implementation of a levee to prevent the expansion pits from flooding up to a 1% AEP flood event, when compared to existing conditions, could result in a minor increase in water levels up to 4 km upstream of the site. The calculated increase in maximum water levels varies from 30 cm at the site, gradually reducing to 5 cm 3 km east, with variations depending on the event considered. These results are conservative given that the modelling is based on a levee alignment that protects slightly larger areas than the latest proposed layout. Flood risks presented in this analysis have not been underestimated.

It should be noted that for none of the design events tested, has the flood extent increased as a result of the new levees proposed for the quarry expansion project. This is due to the confined nature of flooding within the floodplain.

Result maps for water levels and depths have been provided in pdf and GIS format.

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

APPENDIX A
WATER LEVEL RESULT MAPS

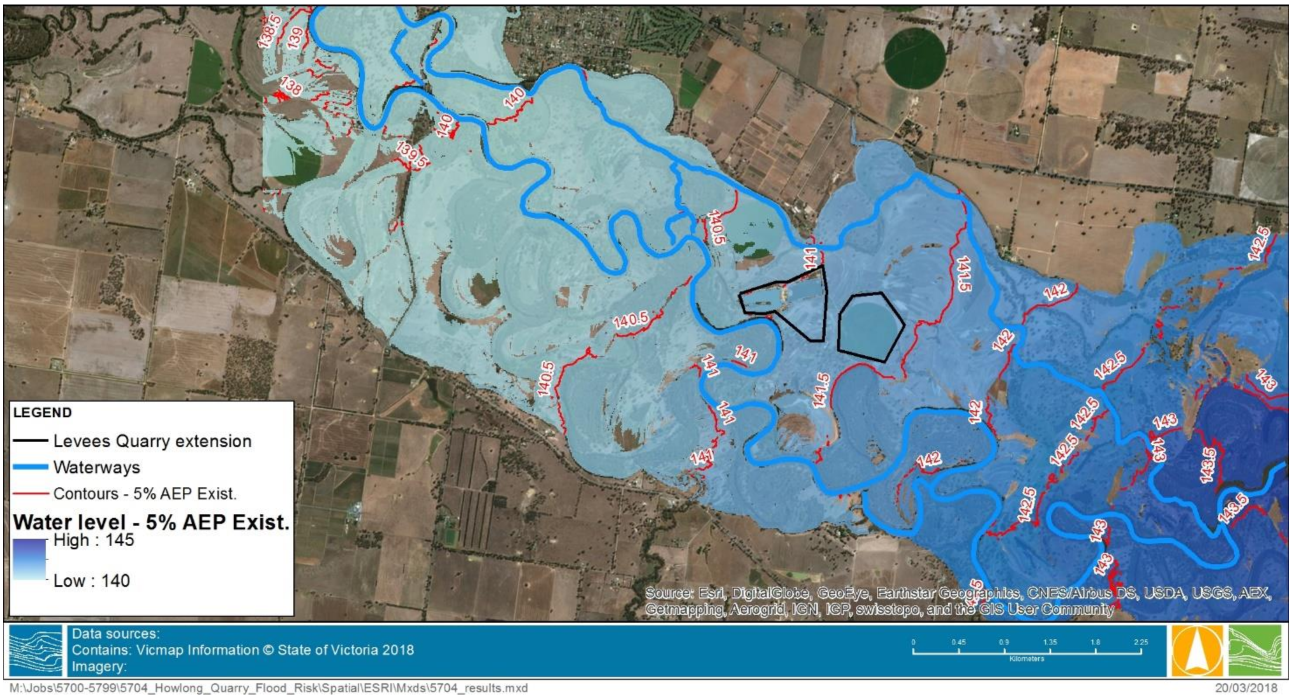


FIGURE 6-1 WATER LEVEL – 5% EXISTING

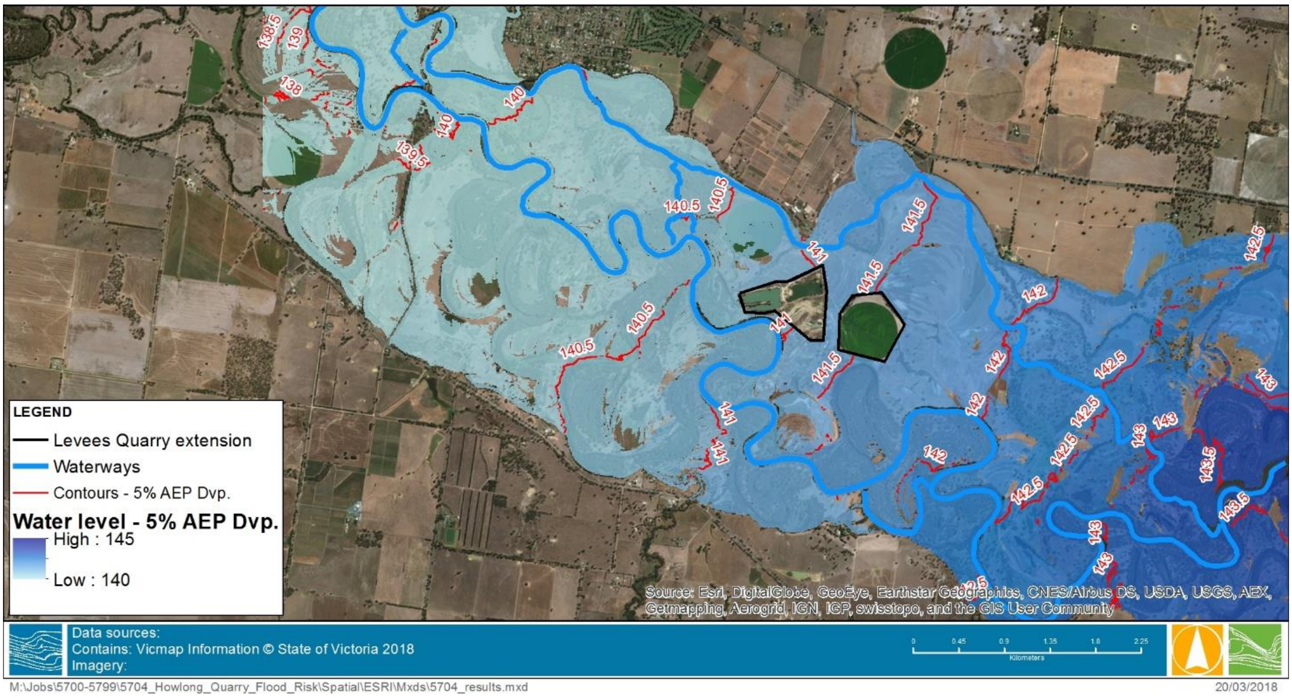


FIGURE 6-2 WATER LEVEL – 5% DEVELOPED

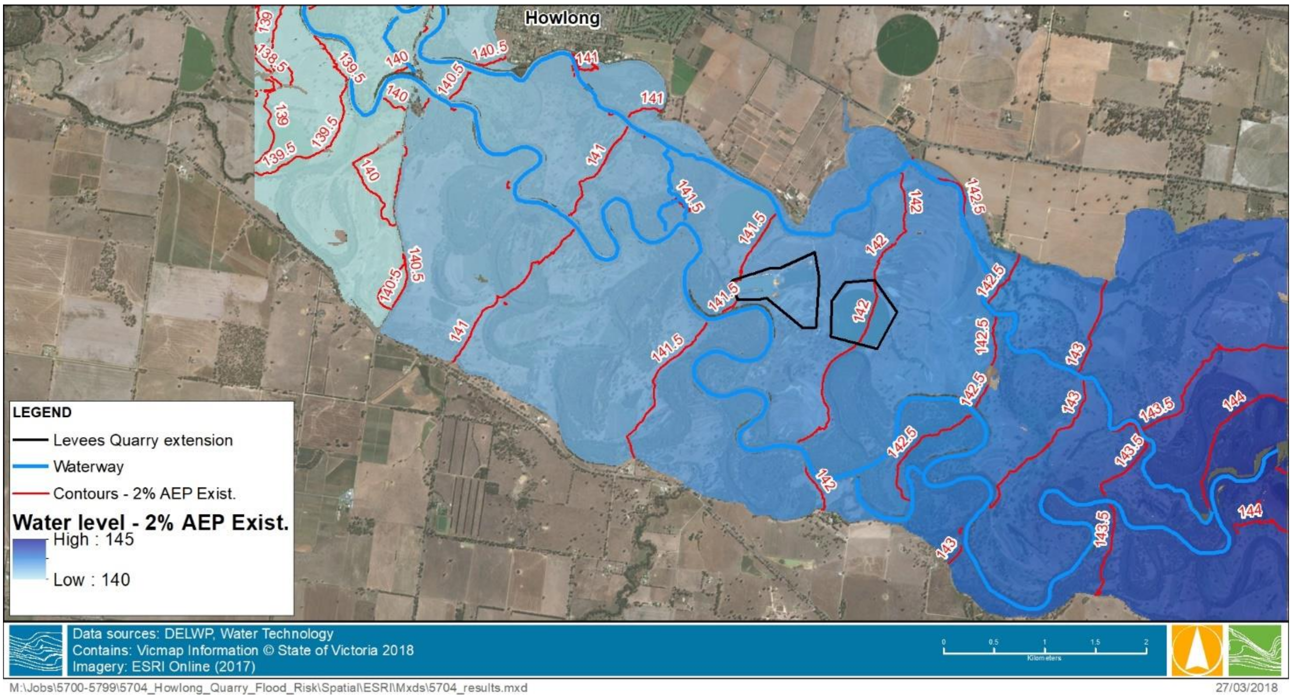


FIGURE 6-3 WATER LEVEL – 2%AEP EXISTING

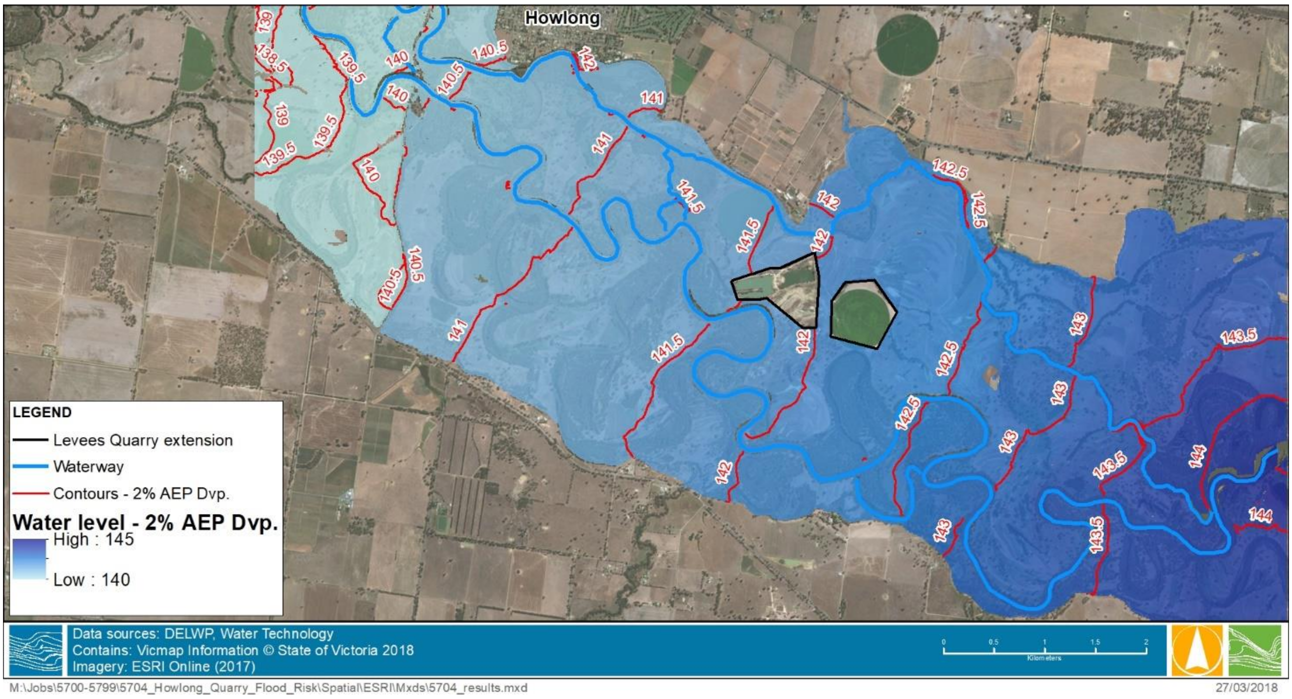


FIGURE 6-4 WATER LEVEL – 2% AEP DEVELOPED

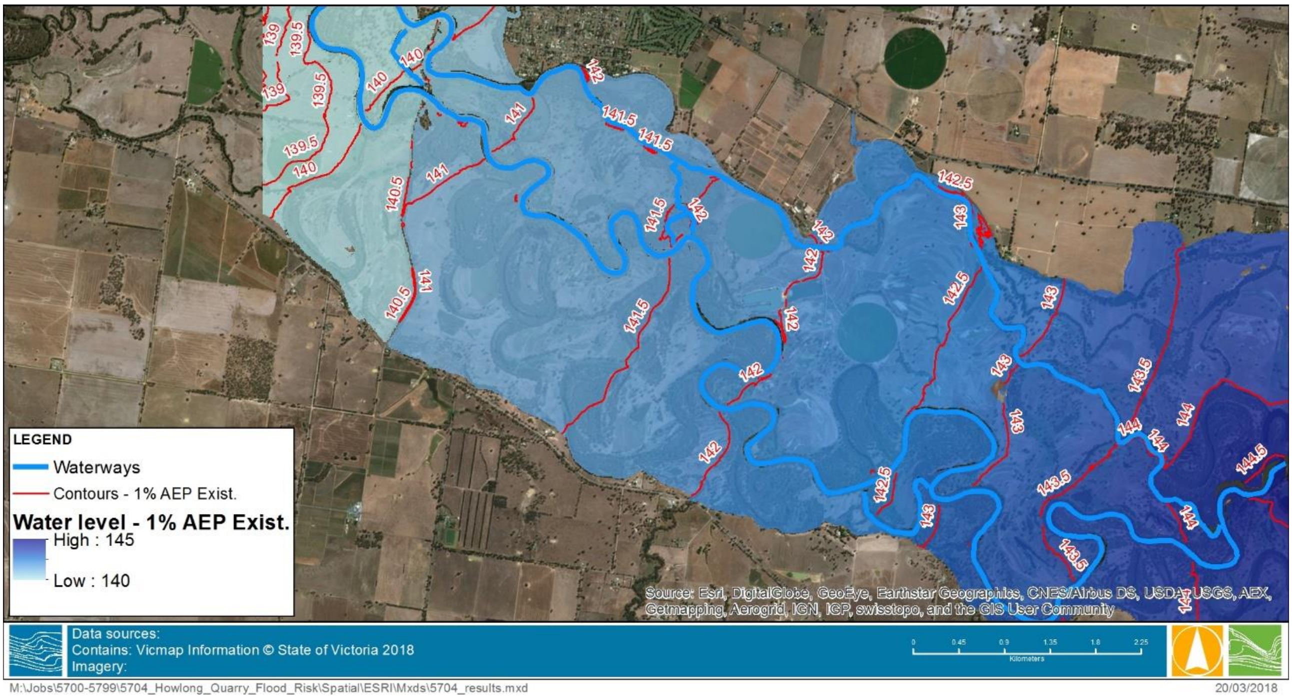


FIGURE 6-5 WATER LEVEL 1%AEP EXISTING

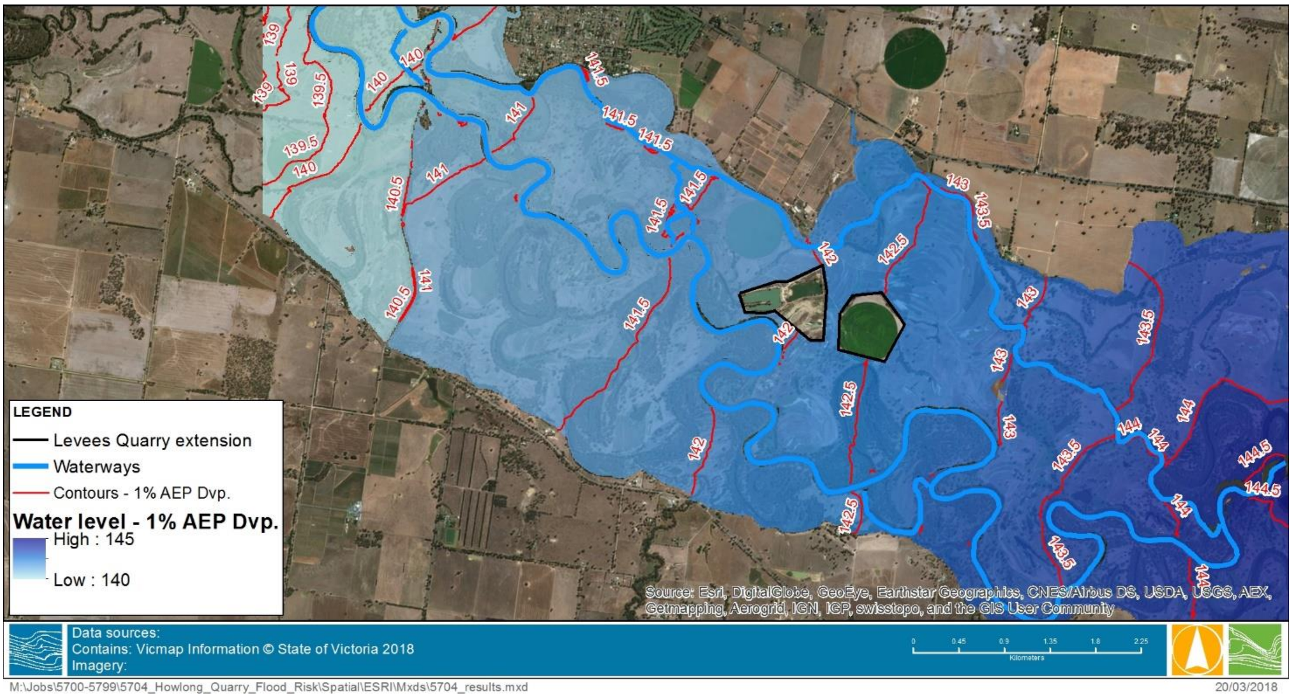


FIGURE 6-6 WATER LEVEL – 1%AEP DEVELOPED

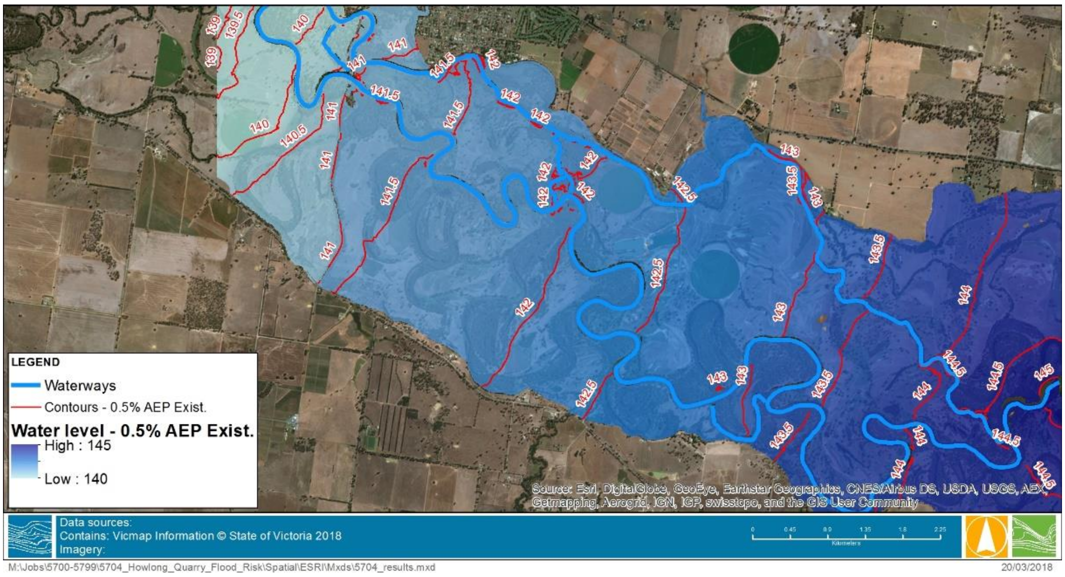


FIGURE 6-7 WATER LEVEL – 0.5% AEP EXISTING

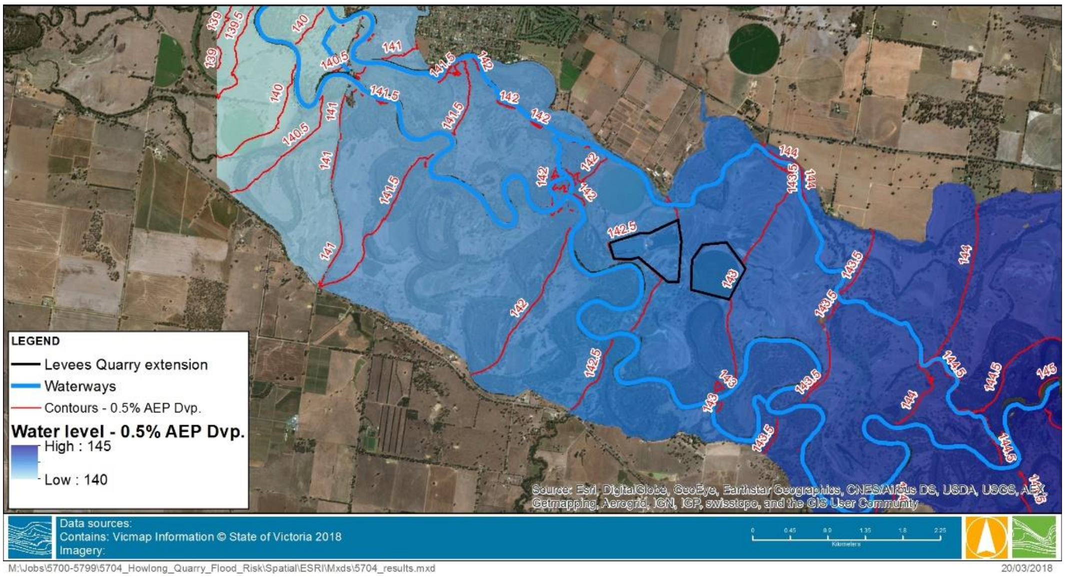
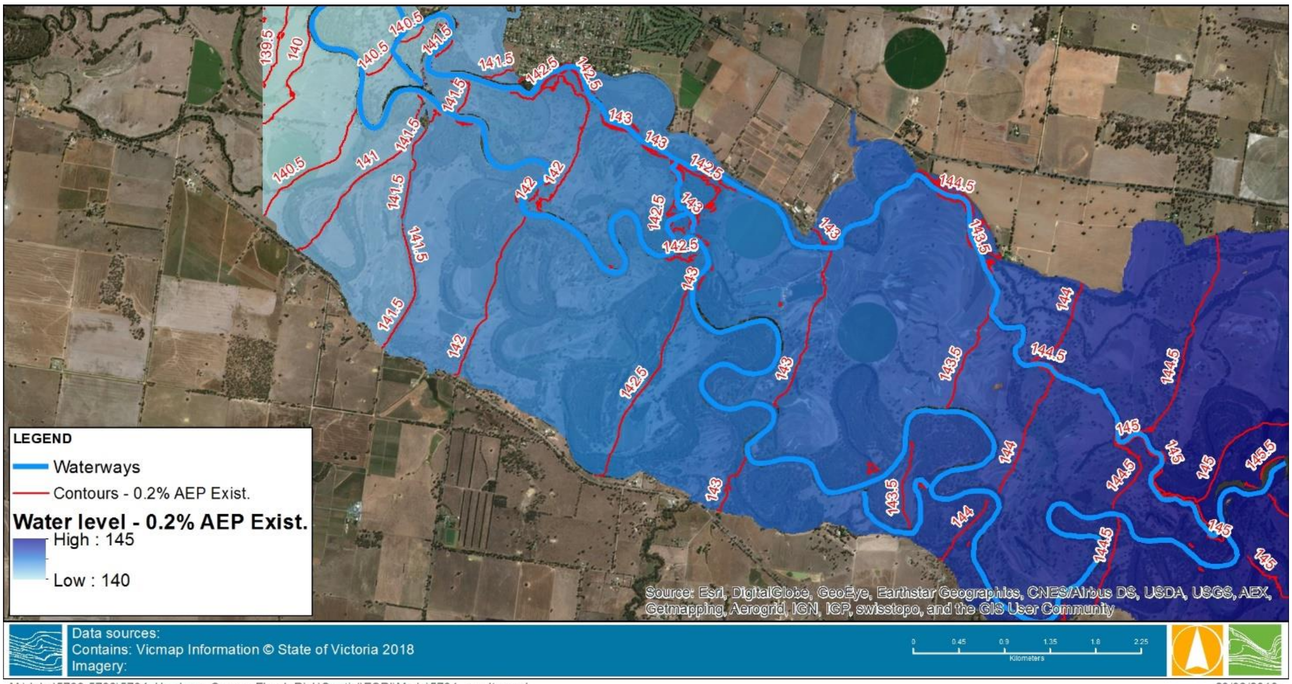


FIGURE 6-8 WATER LEVEL – 0.5% AEP DEVELOPED



M:\Jobs\5700-5799\5704_Howlong_Quarry_Flood_Risk\Spatial\ESRI\Mxds\5704_results.mxd 20/03/2018

FIGURE 6-9 WATER LEVEL – 0.2% AEP EXISTING

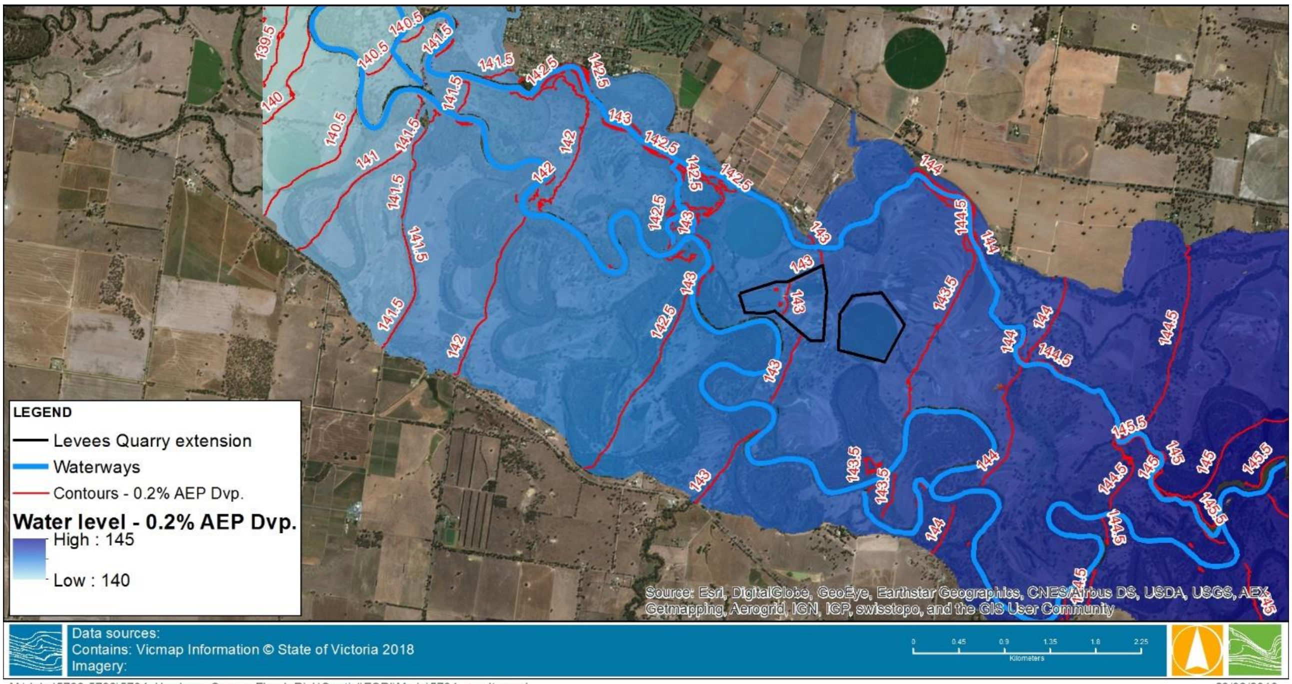


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FIGURE 6-10 WATER LEVEL – 0.2%AEP DEVELOPED

WATER TECHNOLOGY
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APPENDIX B
DEPTH RESULT MAPS

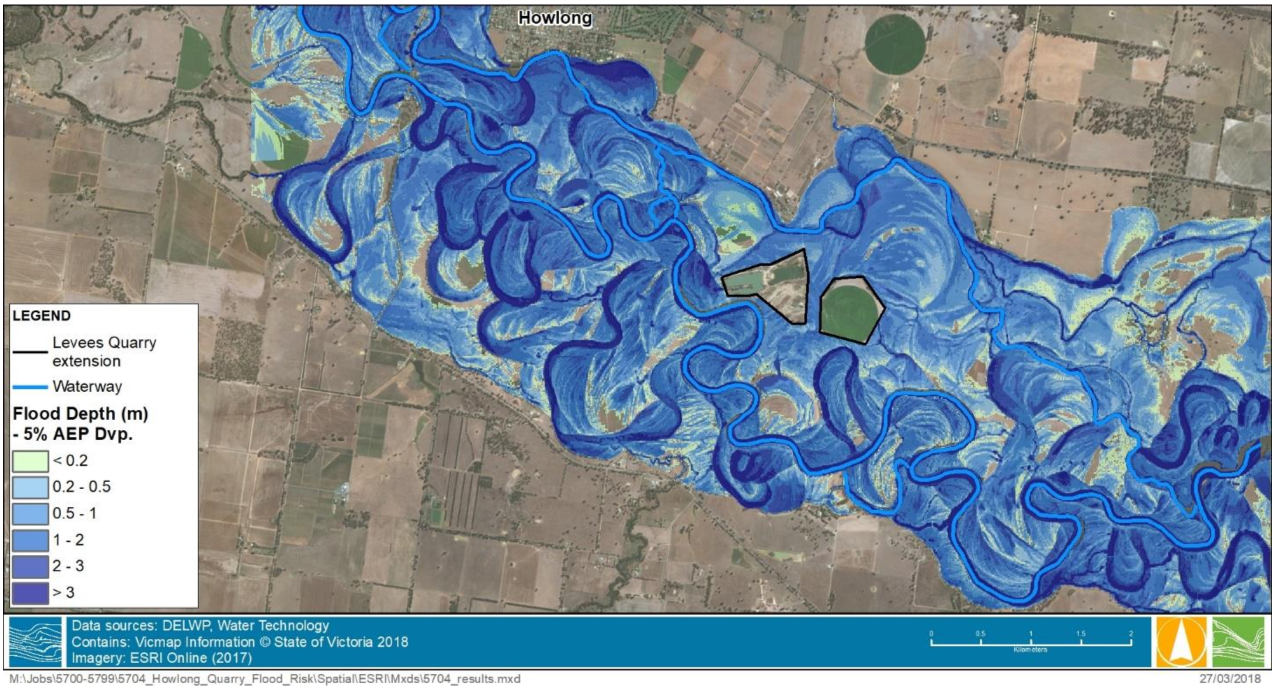

FIGURE 6-11 DEPTHS – 5%AEP DEVELOPED

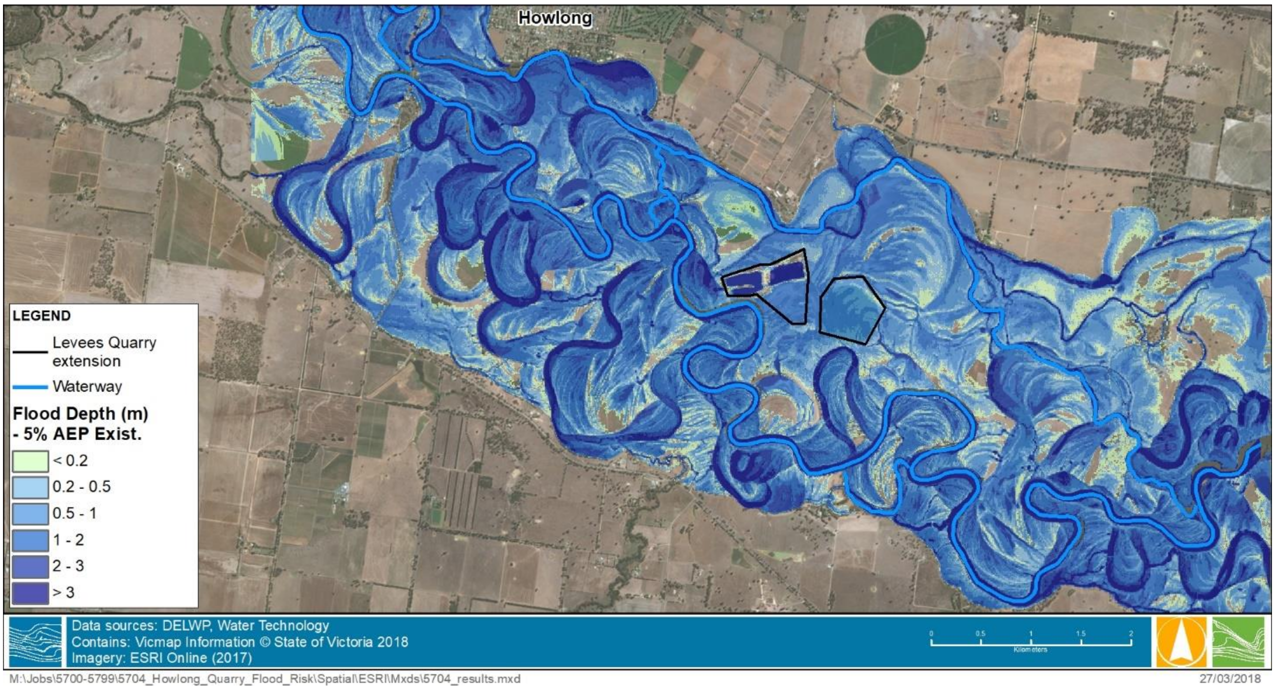

FIGURE 6-12 DEPTHS - 5% AEP EXISTING

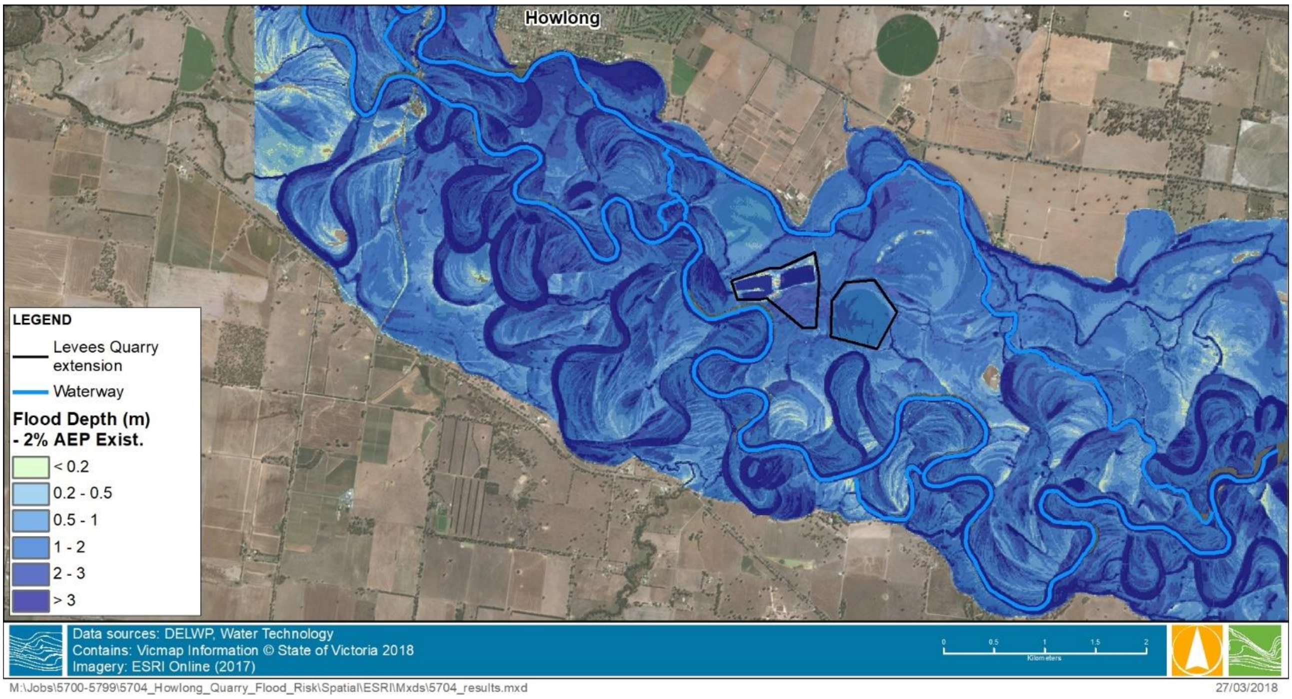

FIGURE 6-13 DEPTHS - 2% AEP EXISTING

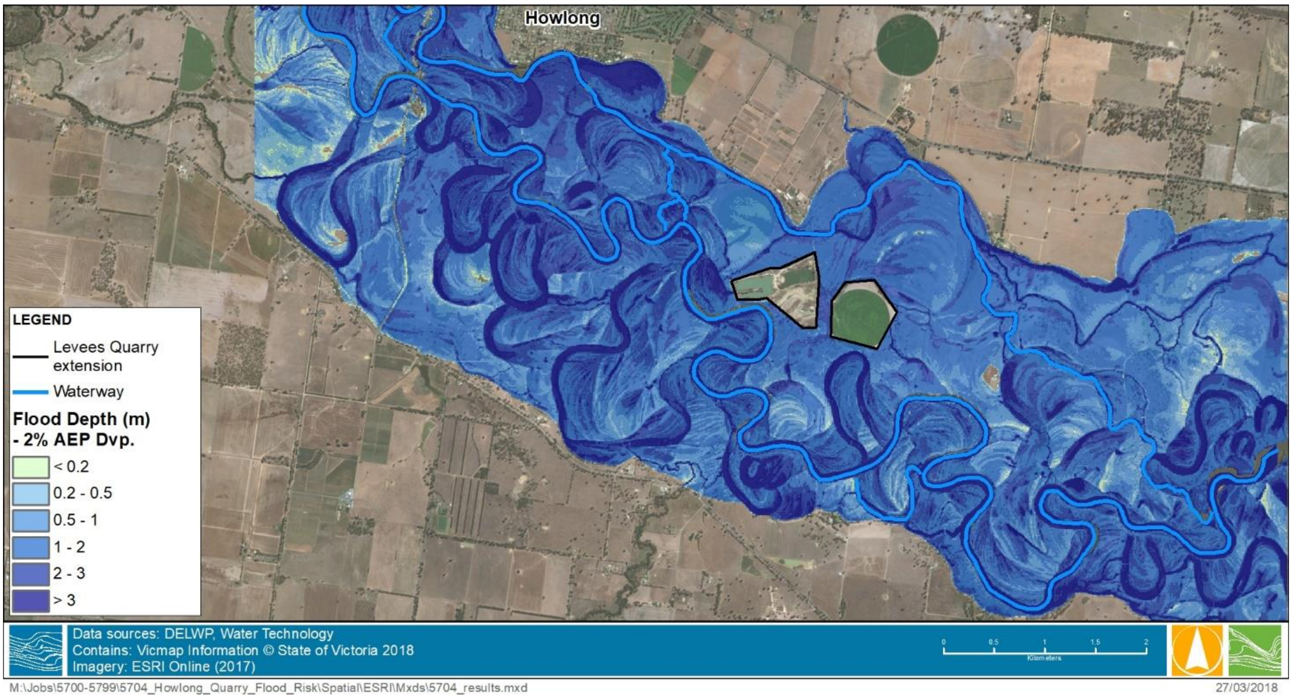

FIGURE 6-14 DEPTHS – 2% AEP DEVELOPED

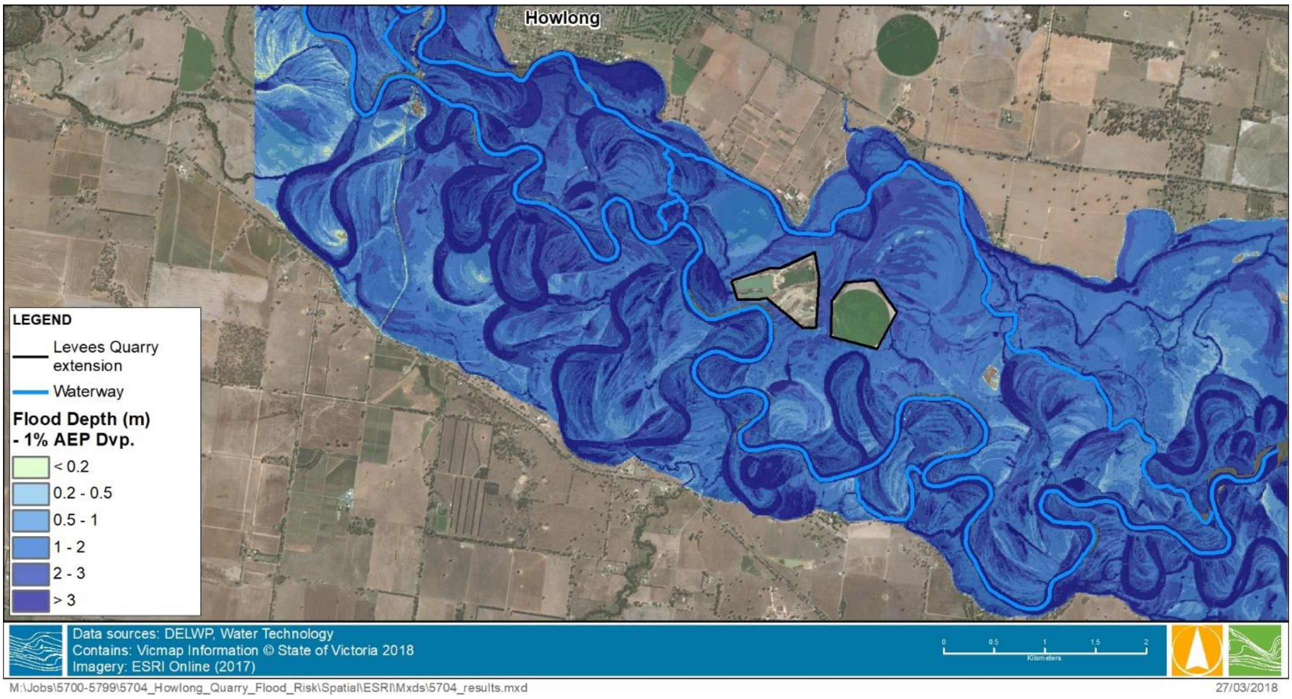

FIGURE 6-15 DEPTHS - 1% AEP DEVELOPED

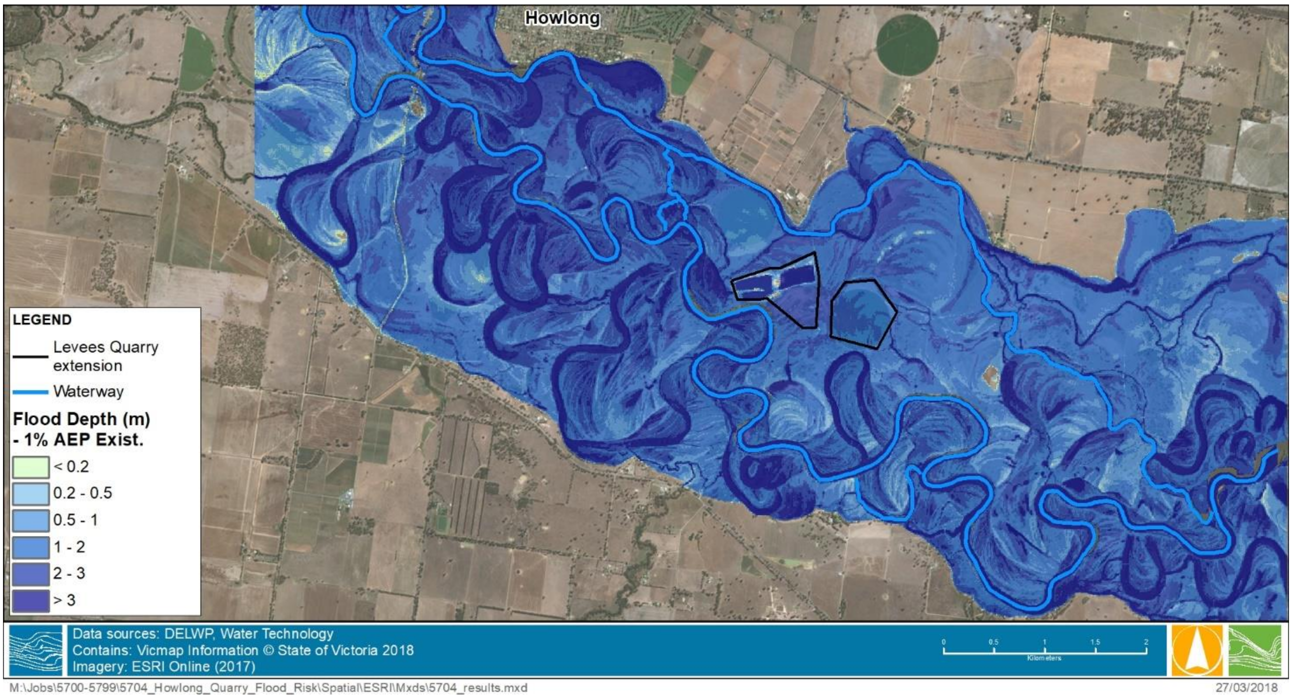

FIGURE 6-16 DEPTHS - 1% AEP EXISTING

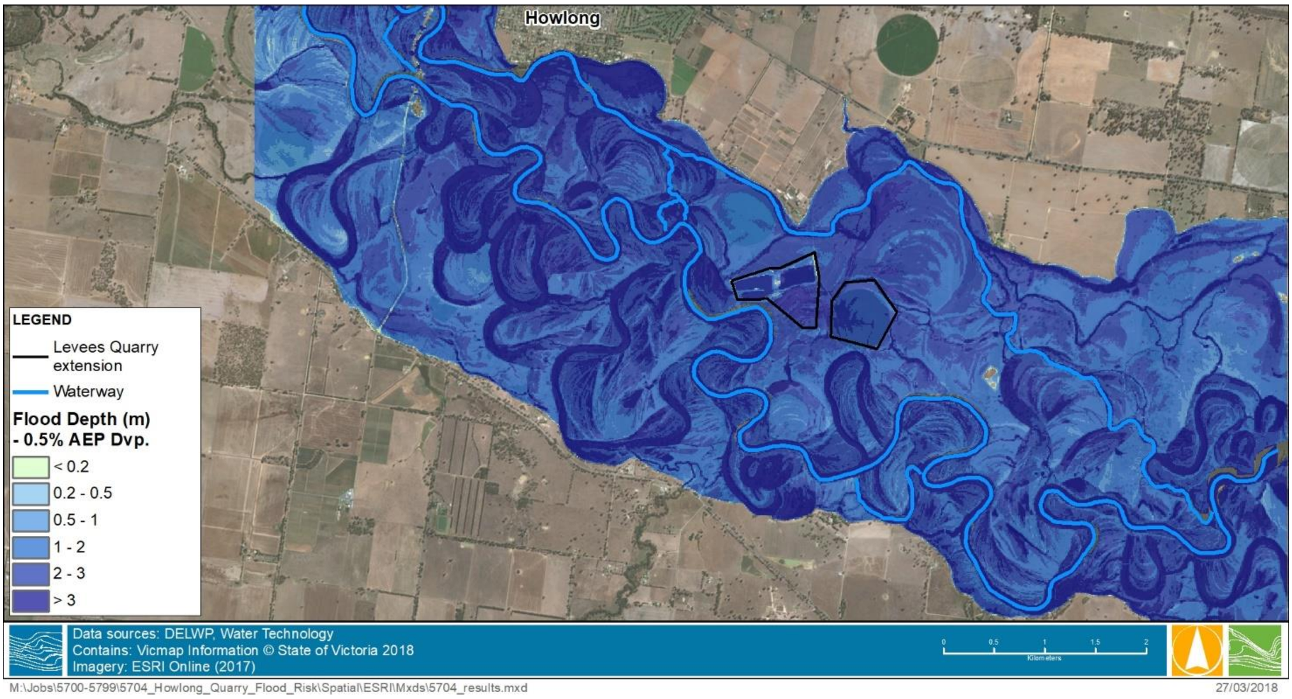

FIGURE 6-17 DEPTHS – 0.5% AEP DEVELOPED

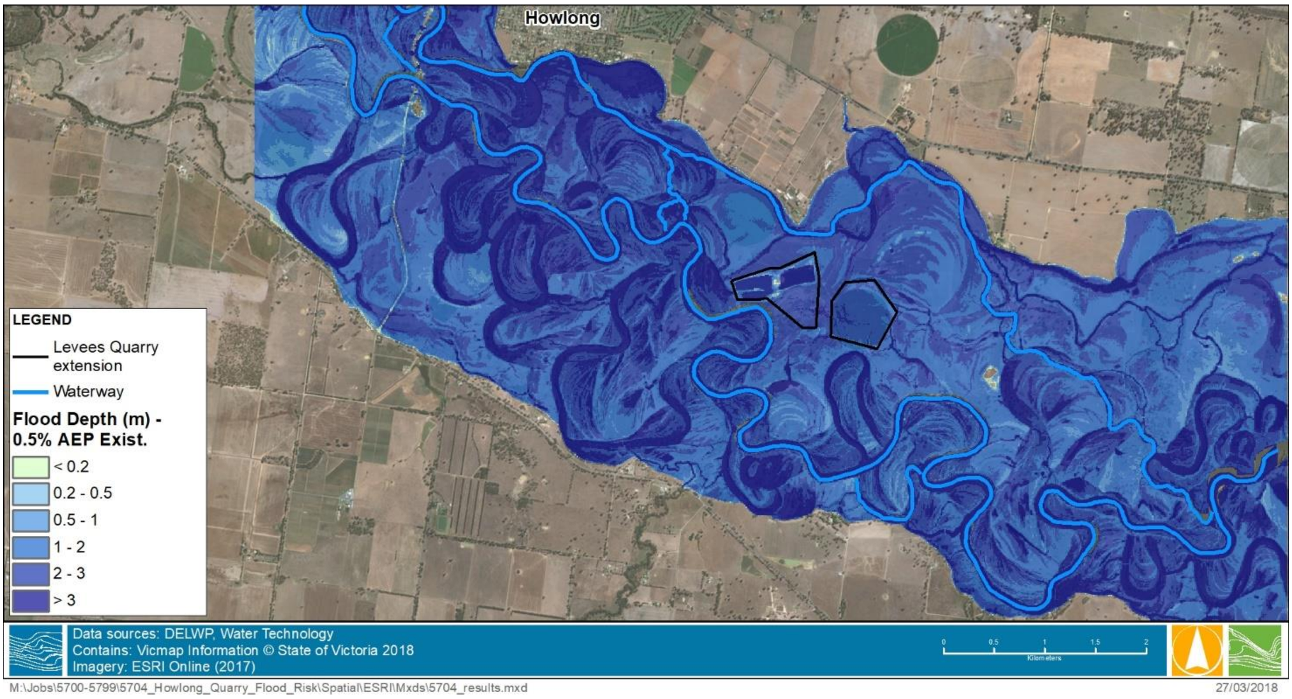

FIGURE 6-18 DEPTHS – 0.5% AEP EXISTING

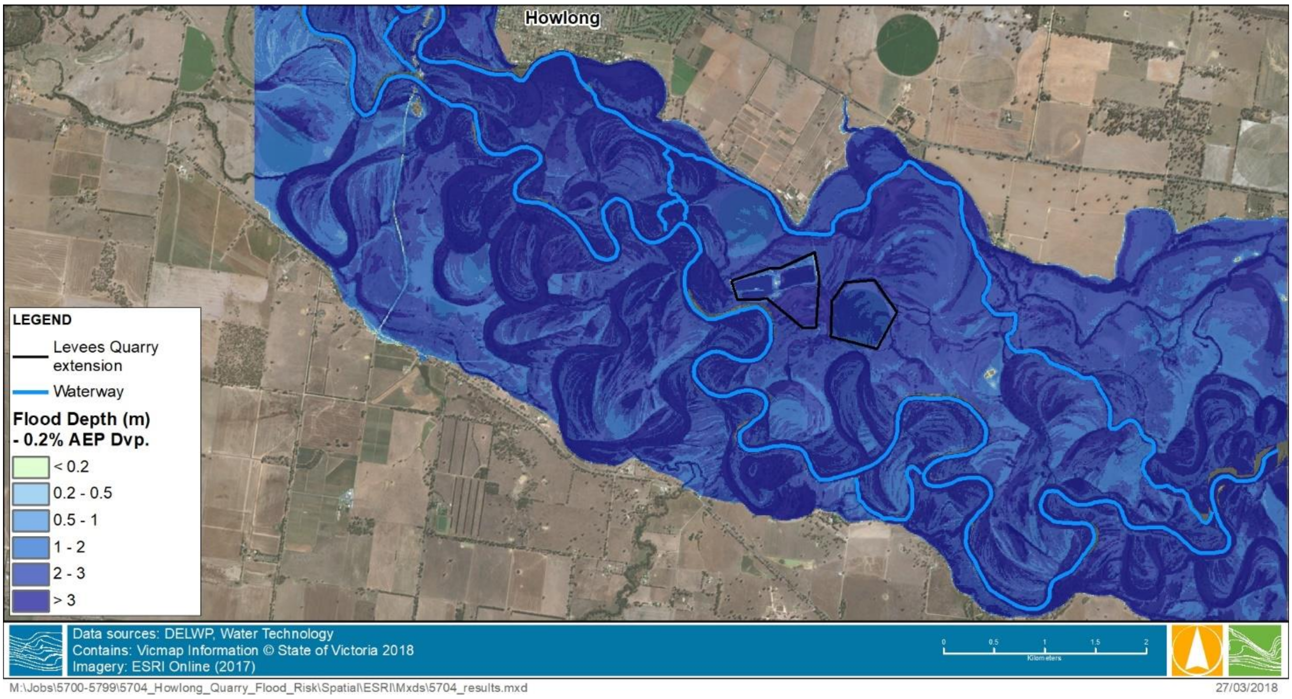

FIGURE 6-19 DEPTHS – 0.2% AEP DEVELOPED

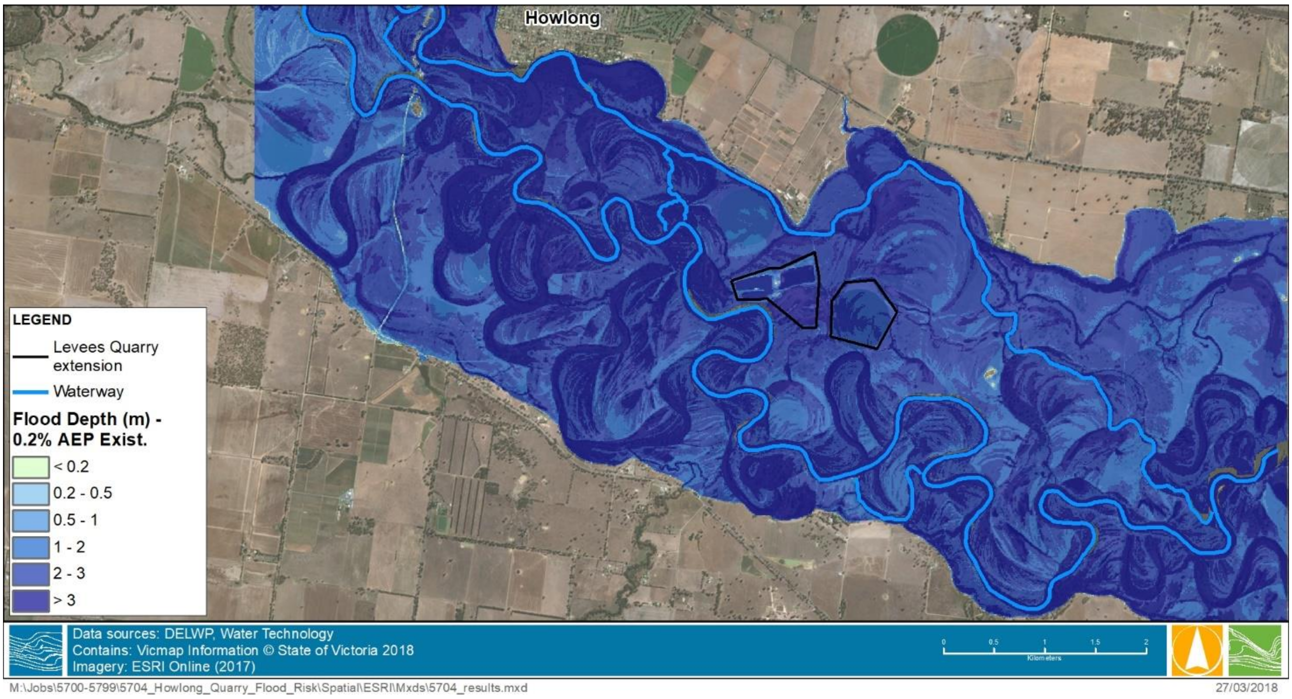

FIGURE 6-20 DEPTHS – 0.2% AEP EXISTING

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