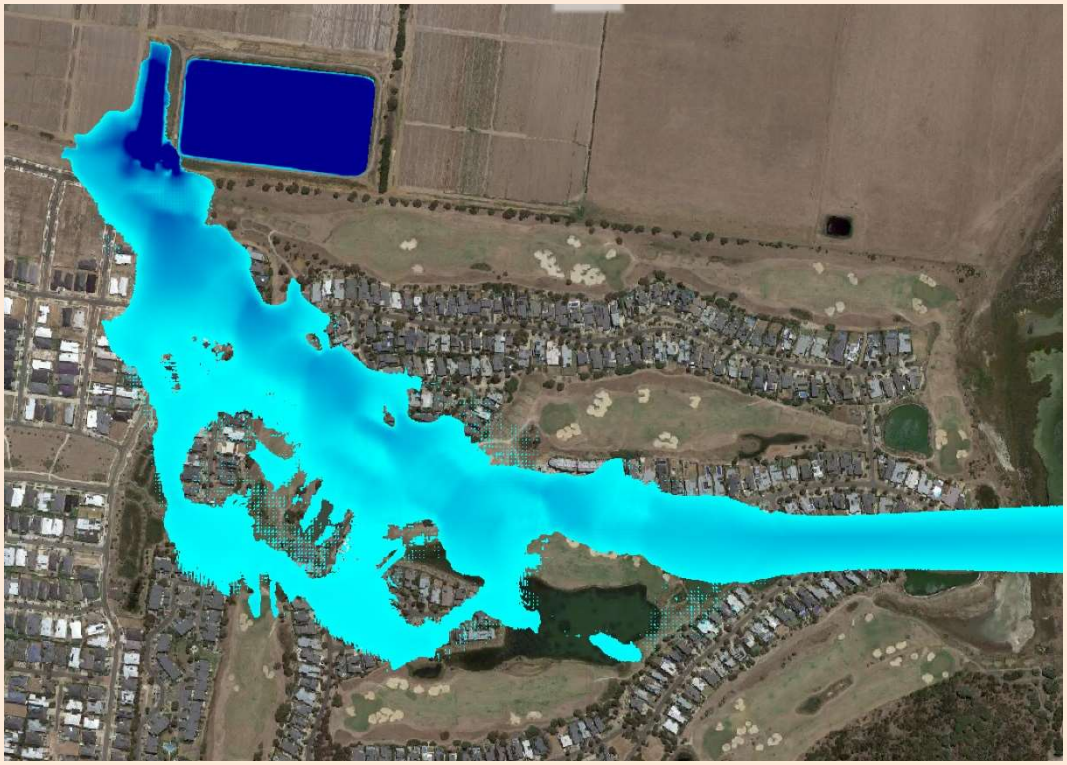
Dam Break Analysis

Project: Torquay Farm Dam – Horse Bend Shoe Road
Report No: AGTE20249-4 Rev 1

| Geotechnical Investigation and Design | Pavement Investigation and Design | Residential |
| Earthworks Specification's, Level 1 Supervision, | Retaining Walls | Slope Stability Assessment |
Adelaide, Queensland, Melbourne, Warrnambool



Prepared for:

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30 January 2021

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2 Introduction

2.1 General

This report provides a summary of a hydraulic analysis as a result of "Dam Break" of Torquay Farm Dam. The results of the dam break are used to determine the extent of flooding and create an inundation map. The dam break has been modelled in a finite element two dimensional model where flood depth and velocity is calculated during a dam break.

2.2 Location

The Torquay farm dam is located at 1075 Horseshoe Bend Rd, Torquay VIC, -38.303 latitude and 44.348 longitude (Figure 1).

Figure 1 - Torquay Farm Dam

2.3 Purpose

The purpose of this project is to identify the potential hazard introduced by the Torquay dam break. A number of residential properties are located on the south side of the dam. A sunny day dam break is modelled with the extend of inundated areas determined using HEC-RAS 2D modelling software.

3 Methodology

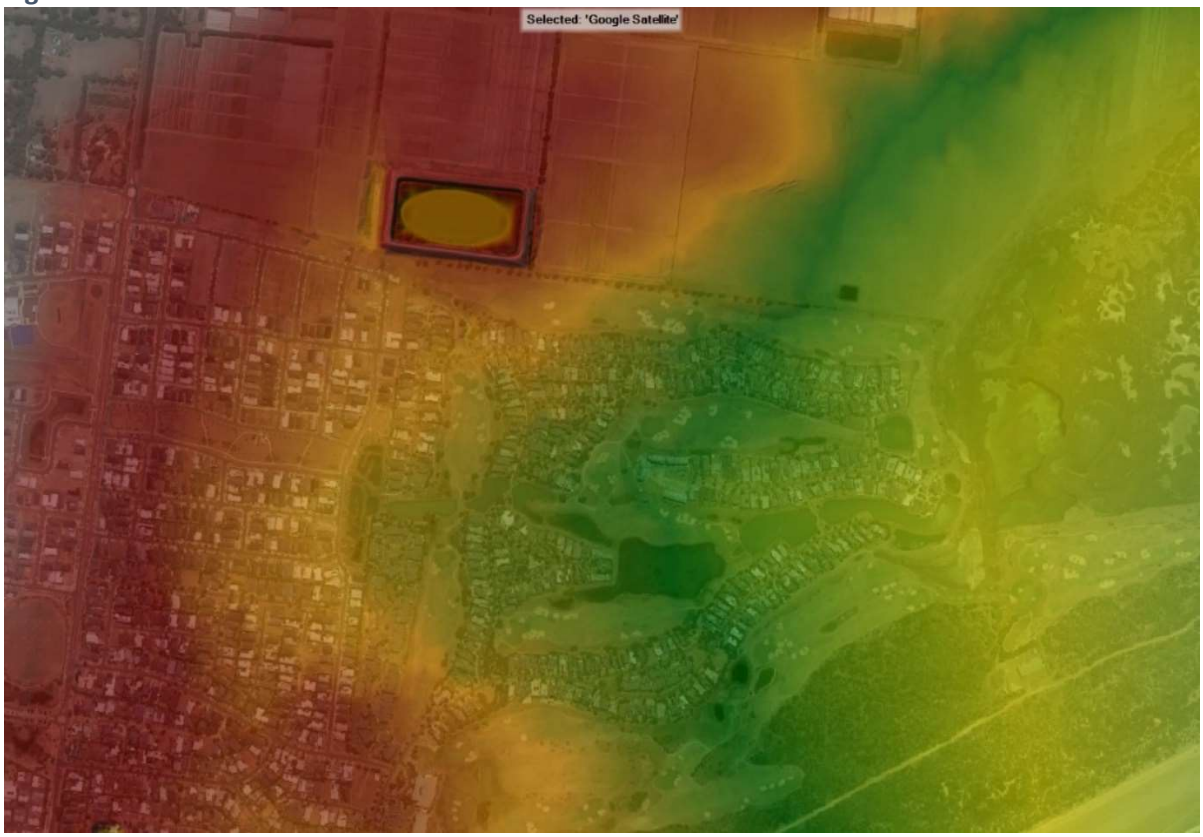
3.1 HEC-RAS

HEC-RAS performs 1D and 2D computations using the St. Venenat equations of Conservation of Mass and Conservation of Momentum. While 1D models solve the St. Venant equations along one dimension, a 2D model solves the St. Venant equations along two dimensions. For 2D modeling, HEC-RAS uses the diffusion wave equation by default because this simplification helps the model run faster. To model the unsteady dam break flooding event in HEC-RAS the following steps are taken.

3.1.1 Digital Elevation MAP (DEM)

The Digital Elevation Map (DEM) of the area needs to be imported as the simulation terrain in the RAS mapper (Figure 2).

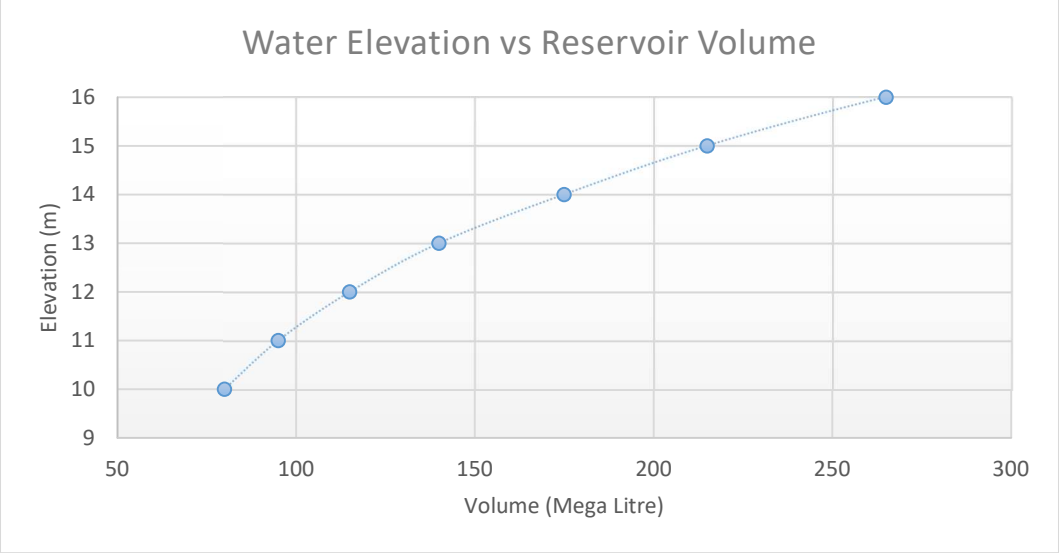
Figure 2 – Terrain model



3.1.2 Storage Area

The Storage Area (SA) is added to the map and edited in the Geometry editing interface. The dam's top elevation is 16 metres ASL where water level is at 14 metres. The bottom elevation of the reservoir is 9 metres ASL. Accordingly, the volume-elevation curve of the dam is as in Figure 3.

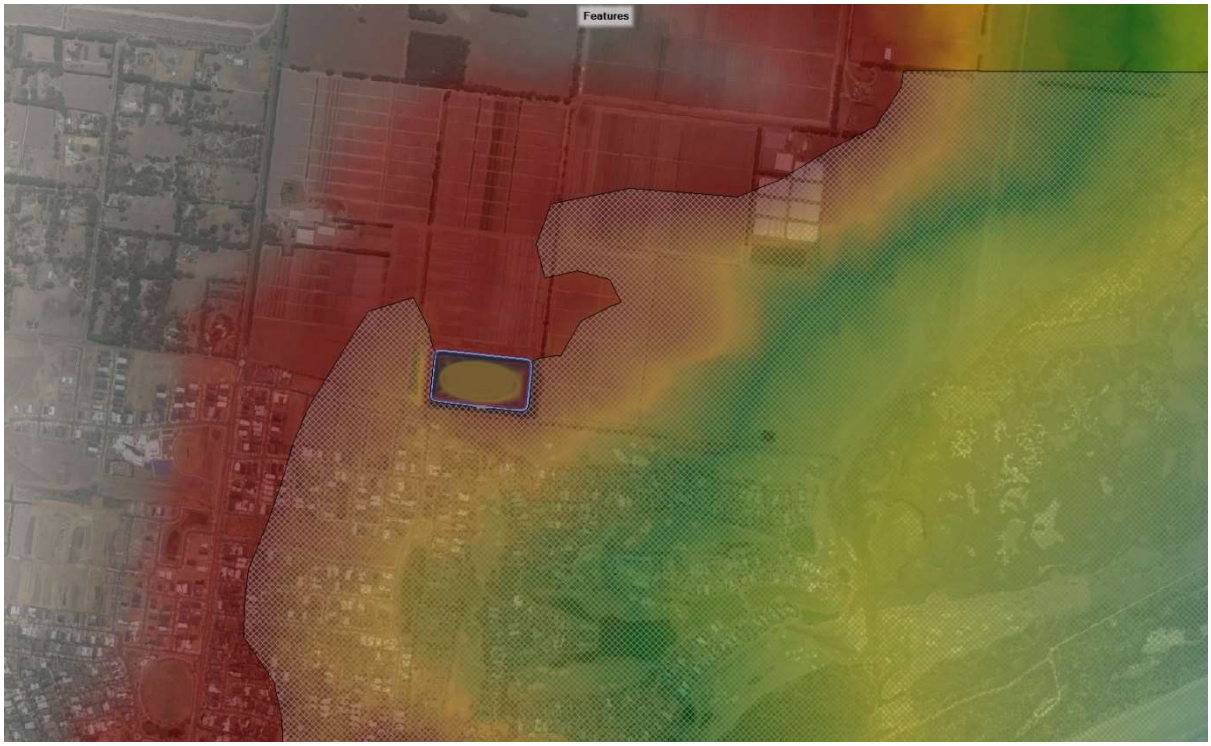
Figure 3 – Volume - Elevation curve



3.1.3 Potential Flood Area

A mesh-grid area based on the potential flooding area on dam's downstream is defined as in Figure 4 and a computational mesh-grid is set accordingly. The hydraulics of flood dynamics and extensions are simulated grid by grid on top of the mesh-grid.

Figure 4 – Flood Area mesh-grid



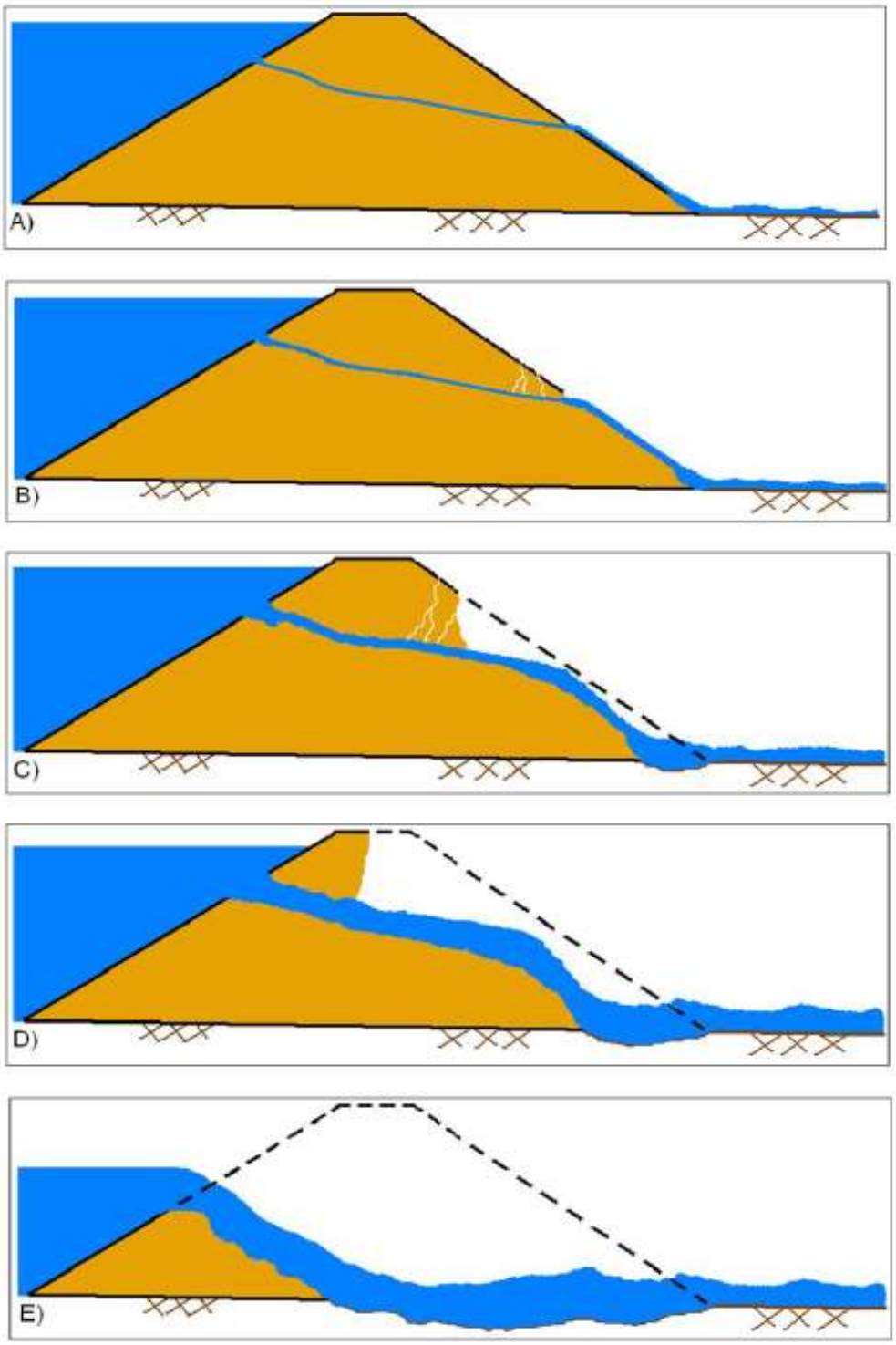
3.1.4 Dam Break

The dam break at Torquay's dam is considered in a sunny day dam break scenario presumably due to piping. Piping failure occurs when water seepage through the embankment or foundation is significant enough to

erode the material and cause a larger hole to form. The erosion continues as more water is carried out alongside materials until the materials above the hole can no longer be maintained and mass caving of materials will occur. This will result in a large rise in the outflow through the breach and would accelerate the process. At this stage, the flow transitions from a pressure/orifice type flow to an open-air weir type flow.

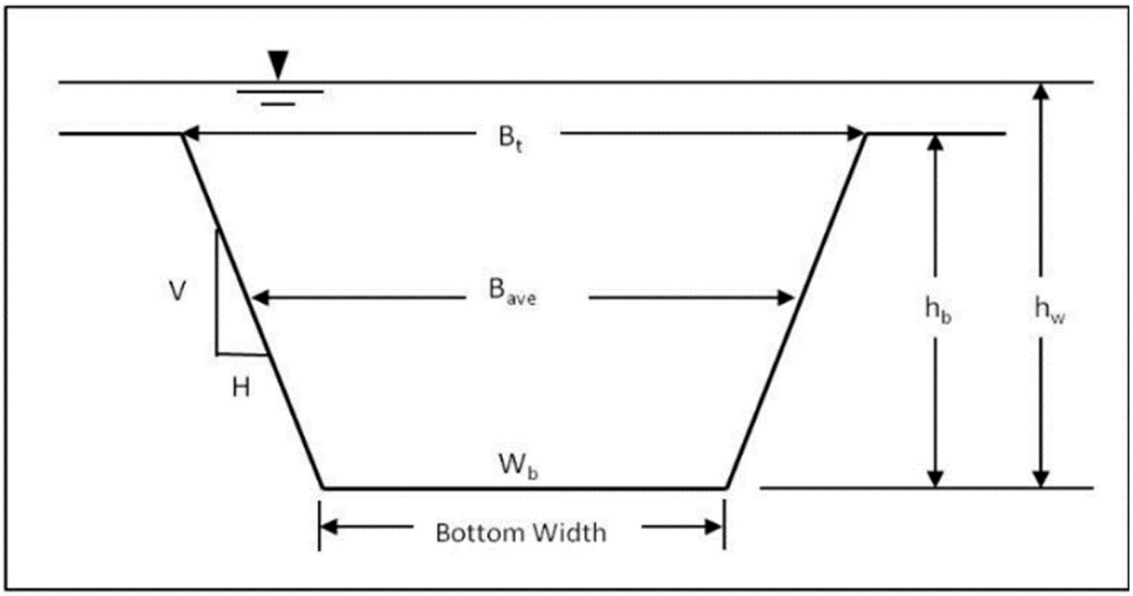
Figure 5, represents the process of the dam break through piping failure.

Figure 5 – Example Breach Process for a piping failure (HEC-RAS)



This process is simulated by HEC-RAS considering the dimensions of the dam break. However, break dimensions and breaking time should be calculated separately as input parameters for modelling. The break is modelled simply, in the shape of a trapezoid that is defined by its final height, base width or average width, and side slopes as in Figure 6, along with the time needed for the opening to form completely.

Figure 6 - Breach parameters



In 2008, a study of 74 earthen, zoned earthen, earthen with a core wall (i.e., clay), and rockfill dam breaks by Dr Froehlich resulted in the following empirical equation for estimating average break width and failure time (Froehlich 2008).

$$B_{ave} = 0.27 K_0 V_w^{0.32} h_b^{0.04} \quad \text{Eq. 1}$$

$$t_f = 63.2 \sqrt{\frac{V_w}{g h_b^2}} \quad \text{Eq. 2}$$

Where K_0 is a constant equal to 1 for piping failures. V_w is the maximum volume considered as 175 megalitre at water level of 14 metres and h_b is the height of the final breach equal to 6 metres. t_f is the time of failure in seconds and in this case is 20 minutes. Table 1, shows the dam breach parameters in extreme conditions.

Table 1 – Dam break parameters

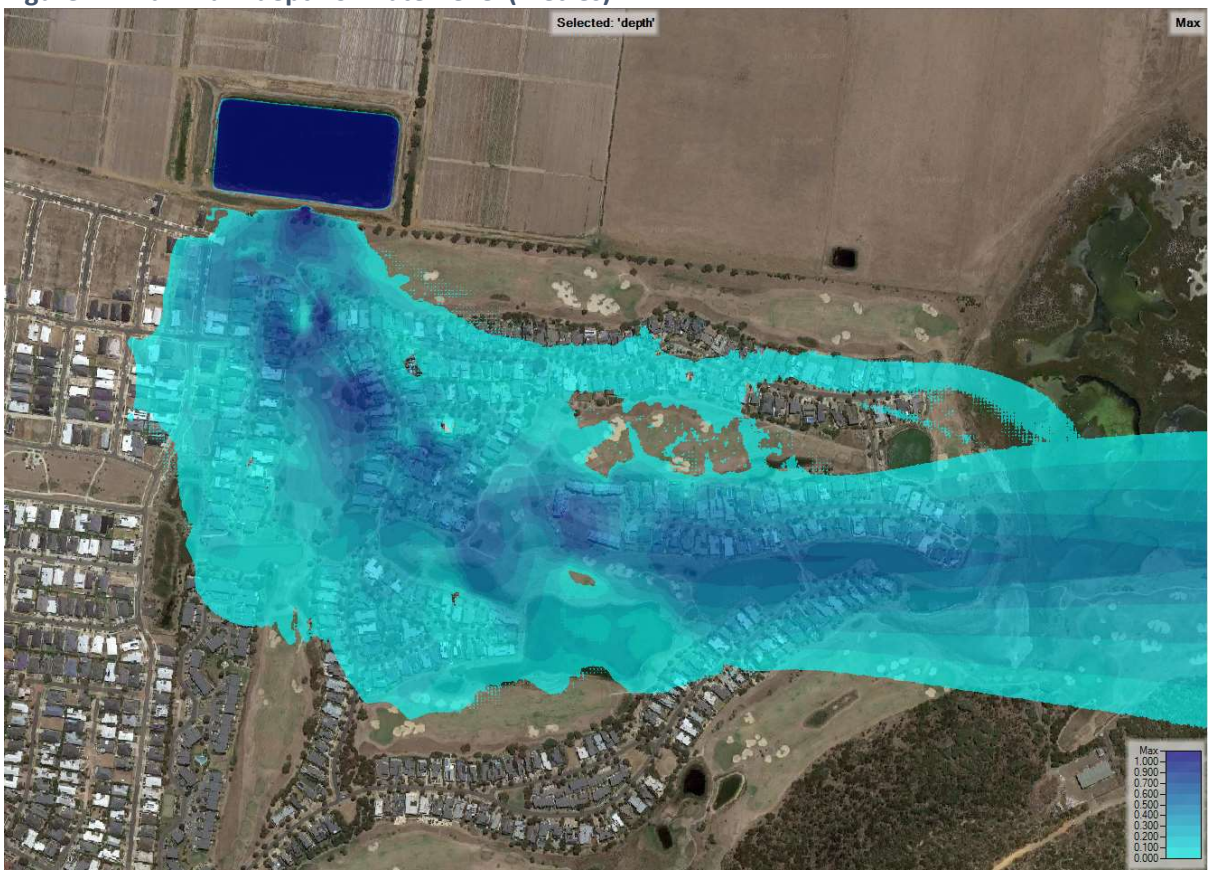
Parameter	Value	Description
W_b	1 m	Bottom width
B_t	7 m	Top width
B_{ave}	4 m	Average break width (Eq. 1)
V:H	1:1	Breach slope
h_b	6 m	Breach height
t_f	20 minutes	Dam failure time (Eq. 2)

4 Results

The simulation results show after the dam break, water flows towards the south and after 30 minutes towards southeast and east and finally into the sea. The event would happen within 6 hours. The flood depth will reach its maximum at most locations in the first hour of failure. Figure 7, shows the maximum depth of water level through the event.

4.1 Inundation Area – Reservoir Level at RL14mAHD and Breach at Centre South

Figure 7 - Maximum depth of water level (metres)



The flood would reach a maximum depth of 20 to 75 cm at properties closer to the dam (on the south side) within 20-25 minutes after failure and then continues towards southeast and east. Maximum depth of 75 cm would be closer to properties on the east side of Druids Glen street and Ballyliffen Cres, on the west side of Links Drive and in between Loch Lomond Cres and Links Drive. Flood inundation maps within various times after the dam break are shown in Figures 8 to 17.

Figure 8 - 5 minutes after dam break

Figure 9 - 10 minutes after dam break

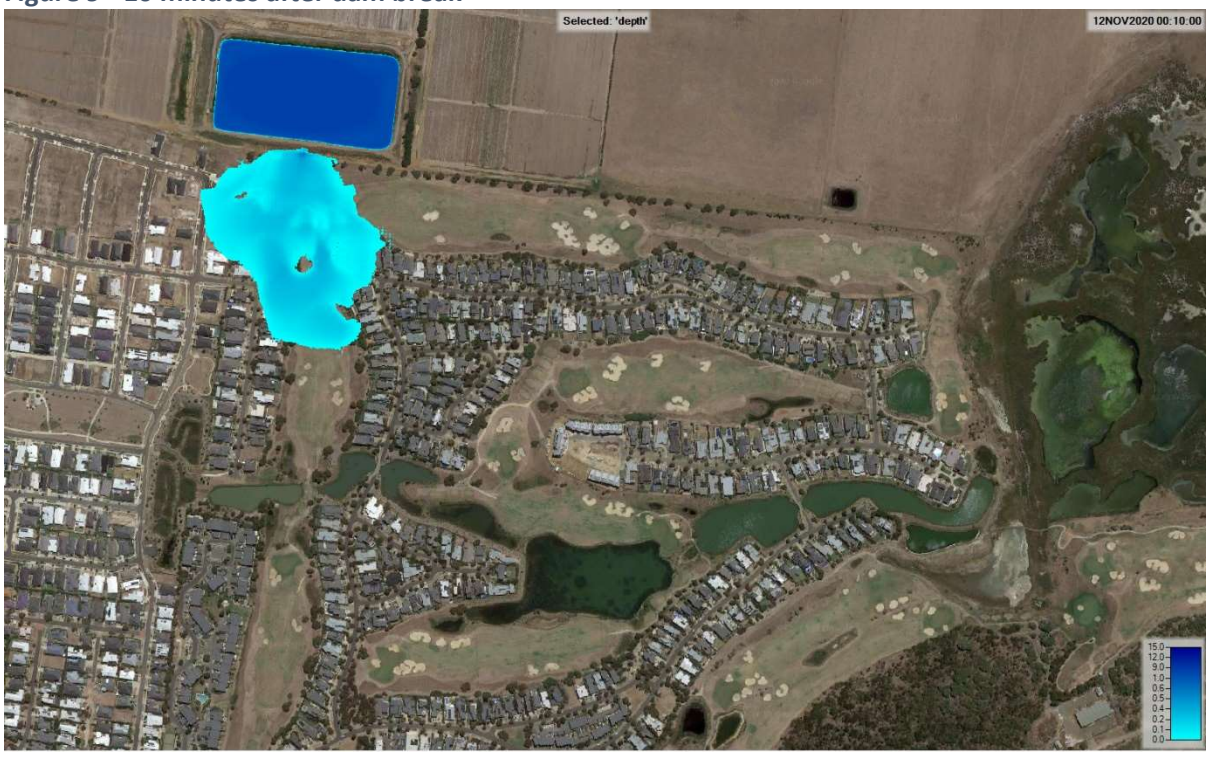


Figure 10 - 15 minutes after dam break

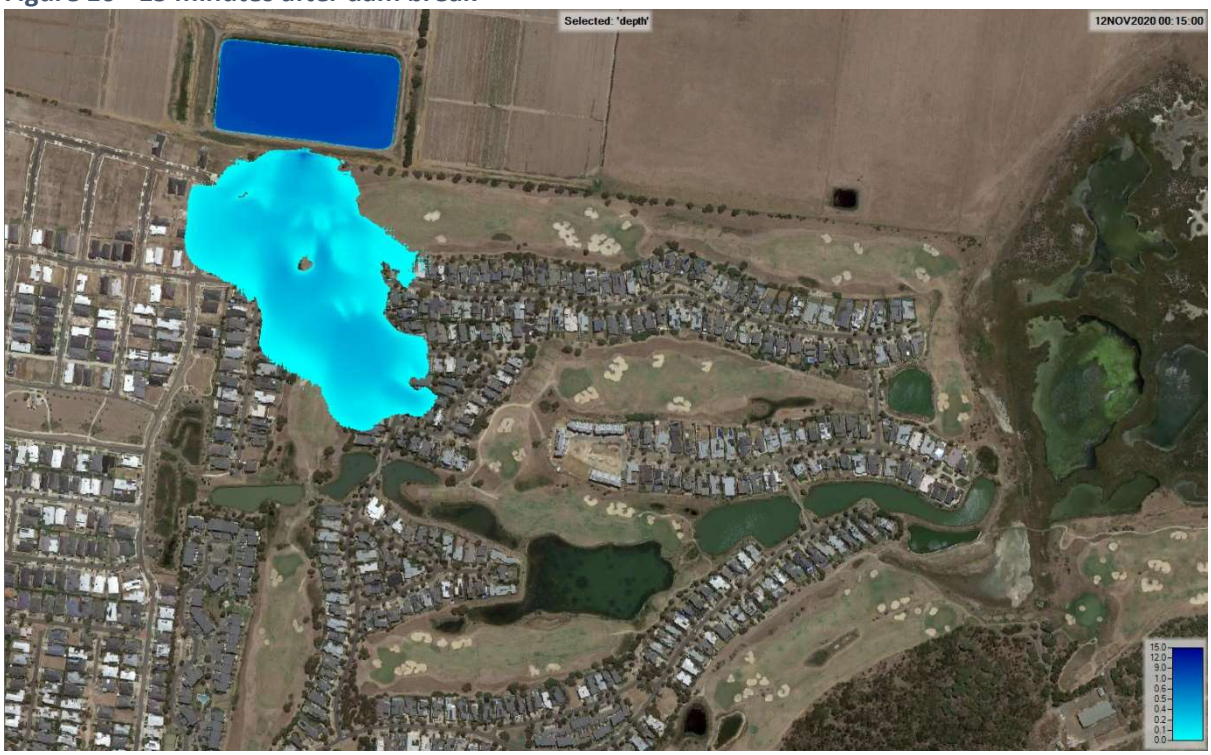


Figure 11 - 20 minutes after dam break

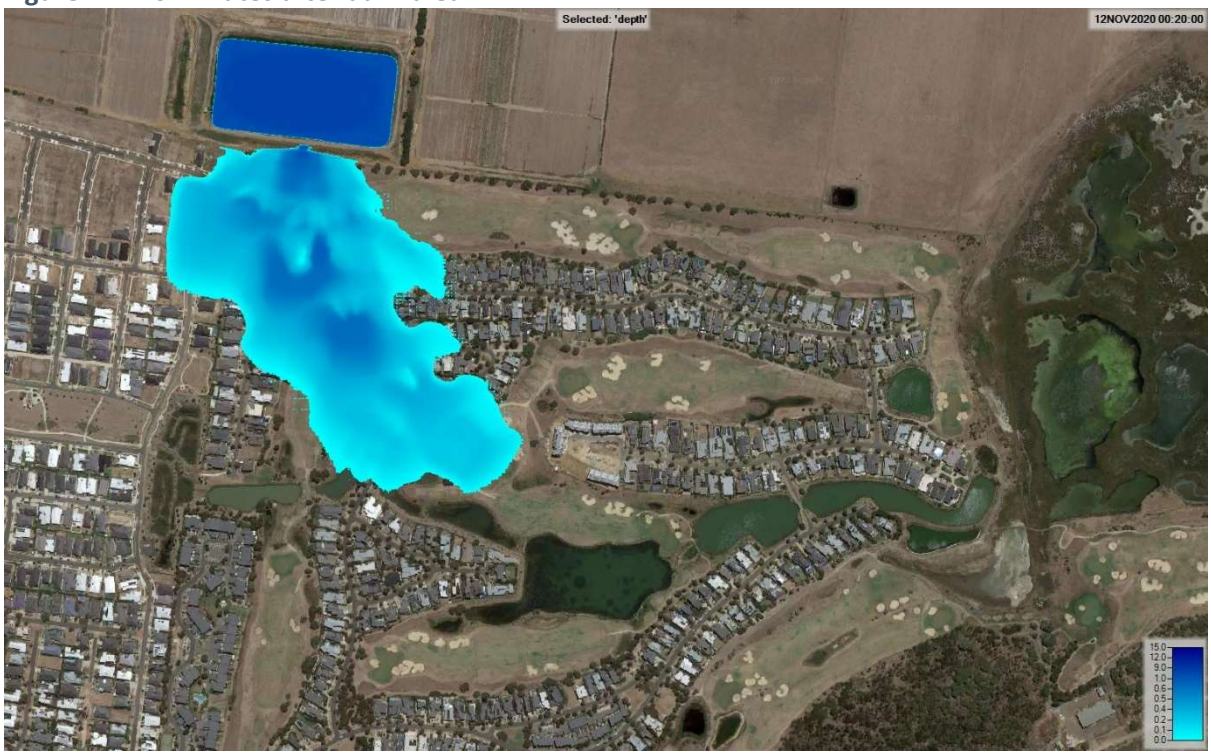


Figure 12 - 25 minutes after dam break

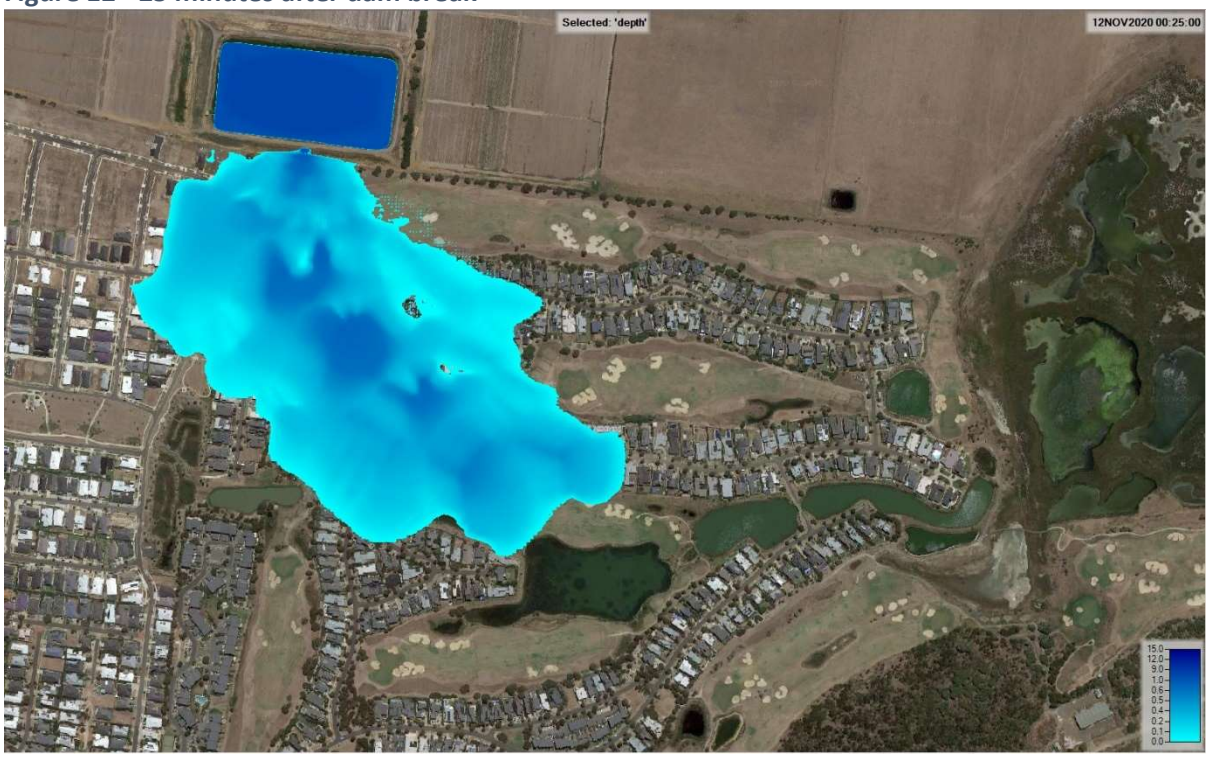


Figure 13 - 30 minutes after dam break

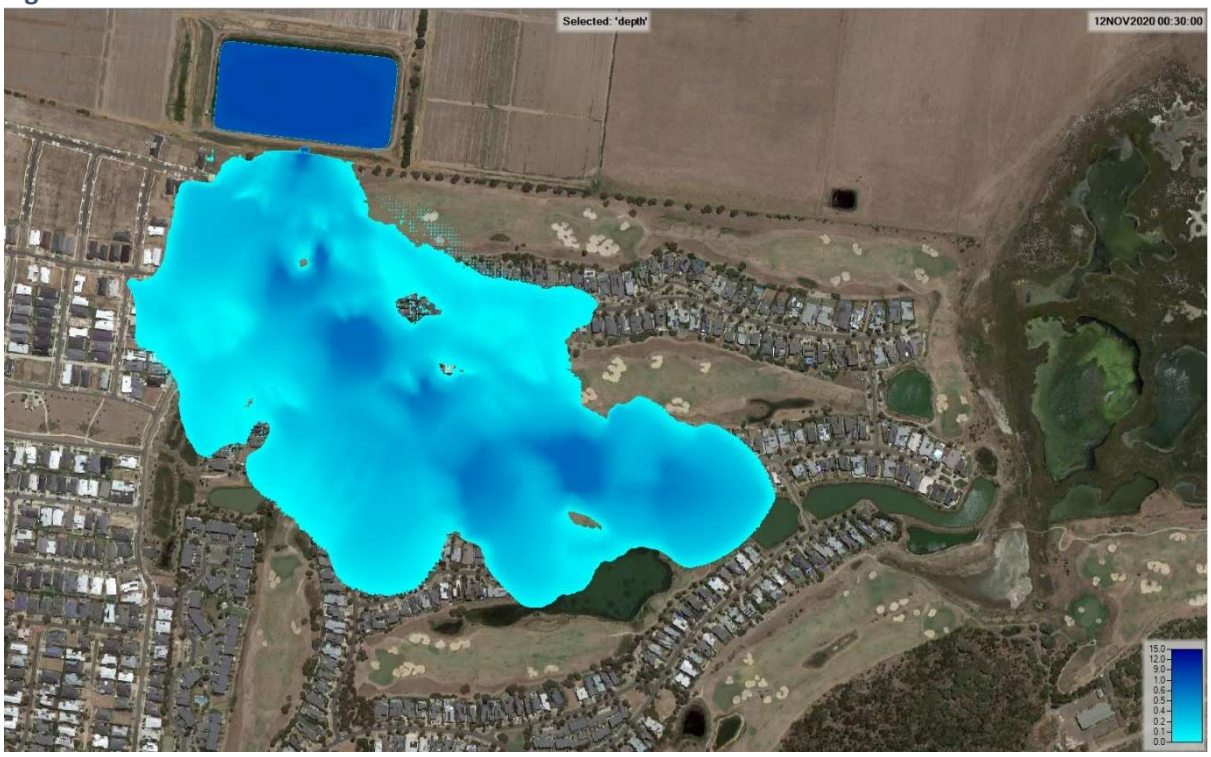


Figure 14 - 1 hours after dam break

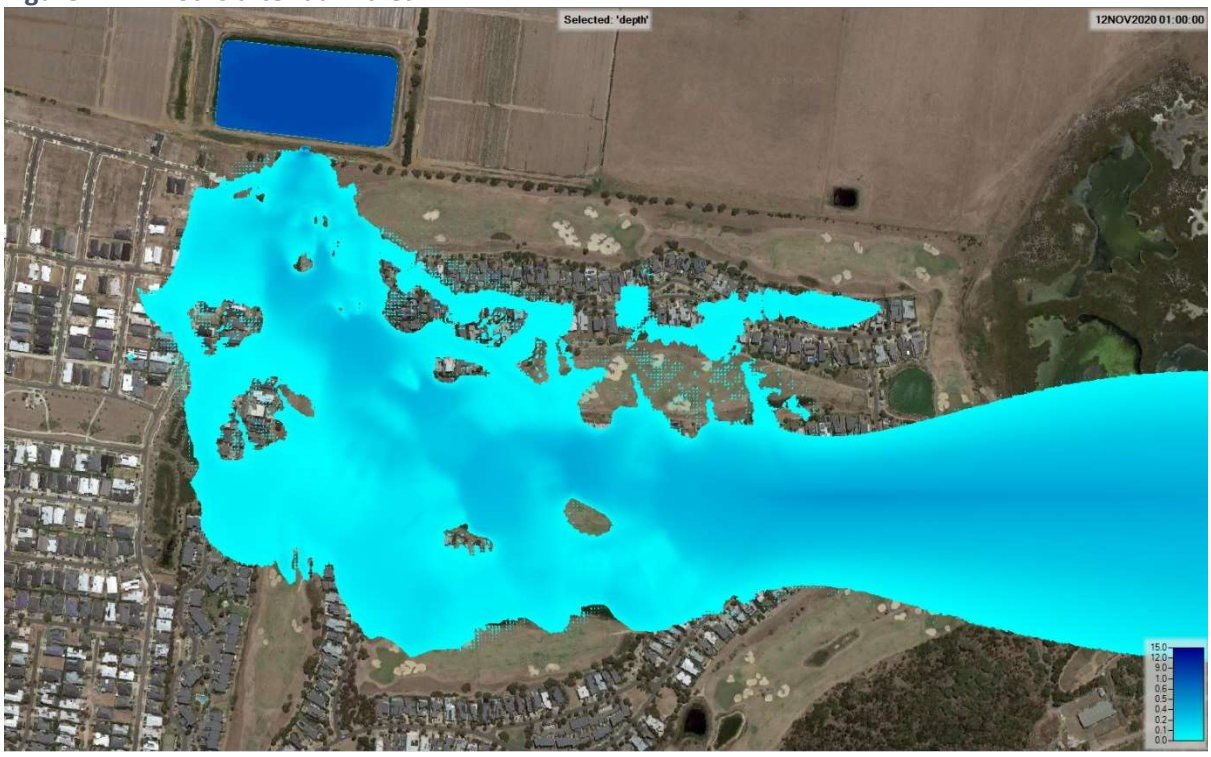


Figure 15 - 2 hours after dam break

Figure 16 - 3 hours after dam break

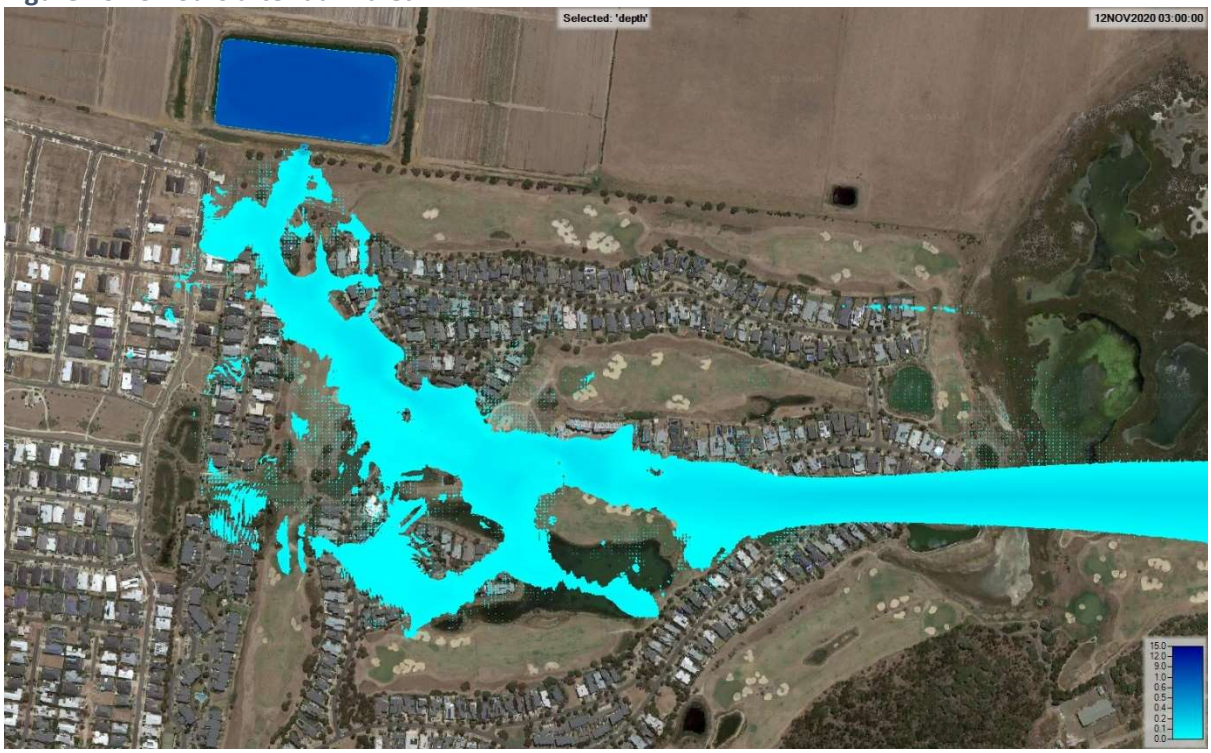
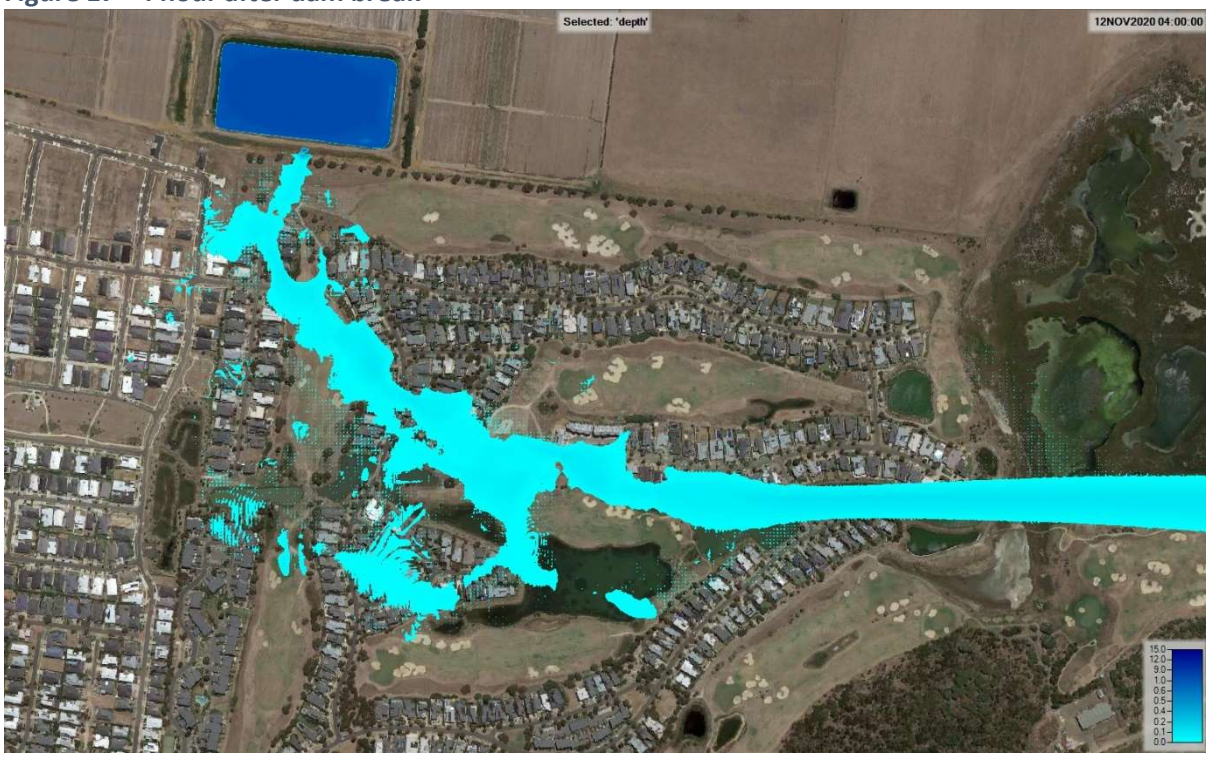


Figure 17 - 4 hour after dam break



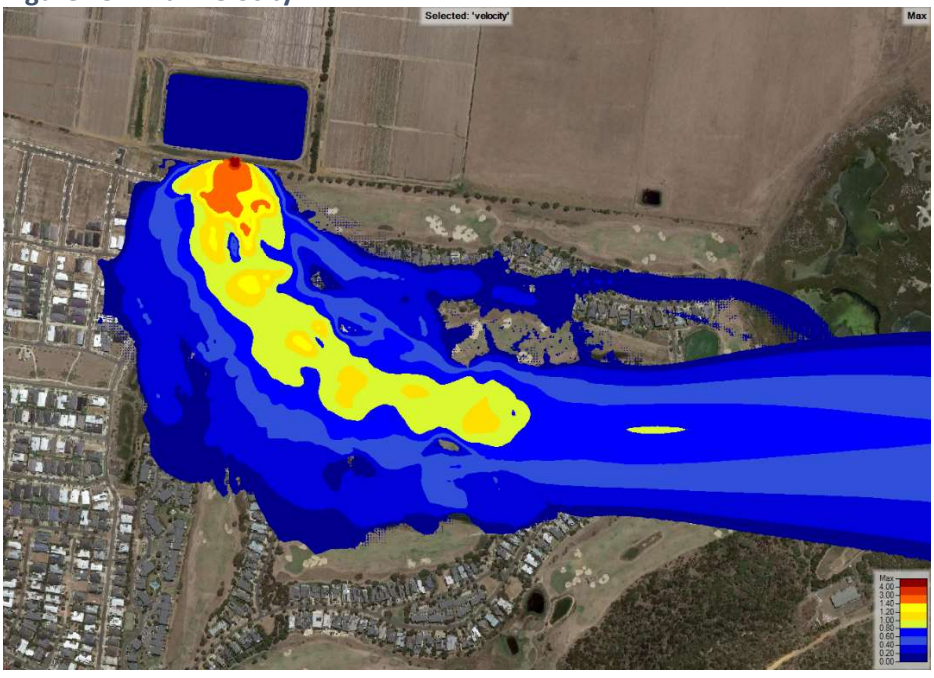
4.2 Maximum arrival time and velocity

The maximum arrival time is the time for water level to reach its maximum depth at each location as in Figure 18. Almost every potential location would reach its maximum depth within one hour.

Figure 18 - Maximum arrival time (hours)

Figure 19, shows the maximum velocity of flow after the dam break. The flood velocity at the dam break can reach up to 10-15 metre per second and as it spreads downstream it drops to 4-5 m/s and around 1 m/s at the closest residential properties to the dam. Flow velocities between 0.5-1 m/s can be seen within the centre of the flood plain towards the east.

Figure 19 - Max velocity



4.3 Inundation Area – Reservoir Level at RL12mAHD and Breach at South West Corner

Additional modelling was caried out where the breach location is on the southwest corner of the dam and the operating level is at RL12 mAHD.

Based on this modelling results, the maximum depth of flood in the nearby properties reaches 350mm.

5 References

- Froehlich, D. C. (2008). "Embankment Dam Breach Parameters and Their Uncertainties." Journal of Hydraulic Engineering **134**(12): 1708-1721.
- HEC-RAS "HEC RAS 2D modelling user manual - Version 5.0."

Disclaimer

The findings and conclusions contained in this Report are made based on site conditions that existed at the time this work was conducted. The conclusions presented in this report are relevant to the conditions of the site and the state of legislation currently enacted as at the date of this report.

Findings and conclusions are made assuming that the dam, water level, elevation maps, groundwater, geological and chemical conditions detailed within this report are accurate and remain applicable to the site at the time of writing. No other warranties are made or intended.

AGT has used a degree of skill and care ordinarily exercised by reputable members of our profession practicing in the same or similar locality.

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