Fingerboards Mineral Sands Project Inquiry and Advisory Committee Technical note

TN No: TN 031

Date: 15 June 2021

Subject: Response to the IAC's third request for information (10 May 2021, Tabled Document 294), questions 2-5 relating to dam construction

Questions and responses

Regarding the proposed water storage dams on the site, the IAC has the following questions: 2. Can the Proponent confirm that all water storage gully dams will be closed and removed as mining moves across the Project area?

Kalbar confirms that all the water storage dams will be removed from the Project area in a progressive manner. Each water storage dam will be removed once the rehabilitation of its upstream catchment has established to the point where the regulators (primarily Earth Resources Regulation) are satisfied that that the landforms are stable, and sediment runoff levels are commensurate with the pre-mining levels.

3. Chapter 3.7.3 of the EES describes that the freshwater storage dam and the runoff water storage dam spillways will be constructed in accordance with the ANCOLD Guidelines on the Consequence Categories for Dams (2012b). Can the Proponent confirm that the runoff water storage dams themselves will be constructed in accordance with the relevant ANCOLD guidelines?

Kalbar confirms that all runoff water storage dams will be designed and constructed in accordance with the requirements of all relevant guidelines developed by the Australian National Committee on Large Dams (**ANCOLD**[1]), including the ANCOLD *Guidelines on the Consequence Categories for Dams* (2012).

In saying this, not all of the runoff water storage dams meet the definition of a 'large dam' as set out in the ANCOLD Guidelines. Nonetheless, those Guidelines recognise that the standards they set may be useful for the design of all dams, regardless of whether they are formally 'large dams'.

4. The IAC notes that the given the nature of the soils in the Project Area and anecdotal evidence of dam construction issues for landholders, what type of consideration has been given to gully dam construction materials including: i. Has onsite testing been undertaken to confirm suitability? ii. Is it envisaged that materials to construct the dams will be imported onto the site or will onsite material be used? iii. What are the dam construction requirements?

[1] ANCOLD was formed in 1937 as the Australian committee of the International Commission on Large Dams (**ICOLD**), a non-government organisation established in 1928 that includes 100 member countries.

iv. Who will be undertaking construction monitoring and testing to ensure structural integrity?

i. Geotechnical investigation undertaken by GHD (2015) and MiningOne (2018) indicate that there are sufficient clay-rich materials available at the Fingerboards site that can potentially be used for construction of dam embankments and compacted clay liners, and that the Haunted Hills Formation gravels can be used in the construction of the catchment dam embankments. The testing undertaken showed that clayey subsoil material has Emmerson Class numbers of 1 and 2, indicating dispersive soils. However, see (iii) below for further information about the suitability of dispersive soils for dam construction.

ii. It is proposed to use on-site materials for the construction of the catchment dams to the maximum extent possible. The in-situ material will be stabilised to mitigate dispersive characteristics in accordance with further detailed geotechnical investigations and industry accepted dam engineering practices (see aspects of these at iii. below). Geotechnical investigations have shown that sufficient quantities of suitable material could be obtained on site, and it is not envisaged that materials will need to be sourced off-site.

In the unlikely event that materials need to be sourced off-site, they will be from known nearby sources that have been used for irrigation dams in the area. As the dams will be progressively constructed, it should also be noted that raw embankment materials (including the clay liner) can be selectively won from overburden mining operations and stockpiled in advance, which ensures that full material quality assurance and quality control can be undertaken prior to the need to commence dam construction.

iii. As indicated in ICOLD (1990), safe dams can be constructed with dispersive materials provided that the following precautions are taken:

- Materials compaction and density should be controlled - preferably to a density ratio of 98% (standard compaction) or greater, and water content at optimum moisture content plus 2%.
- Proper design and construction of pipes through the embankment (i.e. providing cut-off collars).
- Most dispersive soils can be rendered non-dispersive by adding 2% to 3% lime, and it should be mixed into the soil with equipment that can break the soil lumps so that 80% to 90% of the particles are less than 25 mm in diameter.
- Provide properly designed and constructed filters in the dam embankments.

Kalbar will incorporate these precautions when constructing the water storage dams at Fingerboards. Kalbar's dam embankment design is based on general site geotechnical information and preliminary material properties of site sourced materials that were derived from the geotechnical investigation. This preliminary information will be confirmed during the detailed design stage when detailed and location specific geotechnical investigations are undertaken.

The general design features provided for the embankment are summarised below:

- 450mm thick rock rip-rip erosion protection to upstream face;
- Liners to the upstream face of the embankment;
- Geomembrane liner on upstream face of the embankment;
- 900 mm thick compacted clay layer on the upstream face of the embankment, stabilised with 3% lime;

- Homogeneous earthfill embankment from local borrow with curtain and blanket drains for seepage control; and
- Concrete spillway with energy dissipation control and rock gabion scour control on downstream face and valley floor.

Due to the dispersive nature of the onsite soils, embankment curtain drains and liners on the upstream slope is proposed for seepage control and embankment stability.

The embankment slopes have been conservatively designed at this stage and stability assessment and seepage assessment will be undertaken during the detailed design, based on material parameters from geotechnical testing.

The following future work is recommended to be undertaken during the detailed design phase:

- Further dispersion testing to be conducted during the detailed design stage of the Project (i.e. Soil Conservation Service Test, Pinhole Dispersion Classification, etc.);
- Testing to confirm stabilisation of dispersive soils with lime, including compaction and permeability; and
- CPTu and shallow test pits will be undertaken in the valley/gully lines in areas where dams are proposed to be constructed and sand tailings materials are to be stacked.

iv. Kalbar will appoint engineers to supervise the construction of the dams and certify that they have been constructed to the standards required under the work plan. The engineers will be responsible for the quality assurance of the dam construction works, and will rely on geotechnical testing of proposed construction material undertaken at a NATA certified soil laboratory.

5. Whilst it may be a low likelihood, to what extent has Project risk planning considered the consequence of a catastrophic dam wall failure?

Preliminary 2-D modelling has been undertaken for the water storage dam as part of an analysis of the consequences of the failure of the Tailings Storage Facility (**TSF**). This modelling indicates that during a catastrophic dam failure, water would discharge initially to the north and then east, crossing the Bairnsdale-Dargo Road and Fernbank-Glenaladale Road, before discharging into the Mitchell River. Modelling of other water dams across the site would be undertaken to inform the detailed design of the dams. The relevant part of the TSF dam break analysis is attached, noting that Kalbar no longer intends to construct the TSF.

Dam break analysis has not been undertaken for the catchment storage dams. All of the water management dams are sized to capture the runoff from the 1:100-year ARI, 72-hour rainfall event, and water from the dams will be transferred to the process water dam as soon as practically possible. Emergency spillways for all the water management dams will be designed in accordance with the ANCOLD *Guidelines on the Consequence Categories for Dams* (2012).

8 QUANTITATIVE DAM BREAK MODEL RESULTS

8.1 Scenario A – Water Storage Dam Breach to North

8.1.1 Scenario A - Capacity and Failure Scenario

The water storage dam (WSD) is located near the crest of the plateau and is surrounded by deep incised valleys as illustrated in **Figure 14** and **Figure 15** has been designed as a cut to fill, side valley dam, with crest embankment level of 125 mRL, with a storage capacity of 2.2 Mm^3, of which 0.6 Mm^3 is located below the lowest point on the internal natural ground surface at 108 mRL, allowing for only 1.6 Mm^3 of water to be potentially realised from storage during a dam break scenario with up to 0.6 Mm^3 of embankment material. As the intent of the dam is a water storage dam, a spillway is not included within the design, with water levels in the dam controlled by pumping to the dam, with adequate operational allowance for incipient rainfall storage from a storm event up to an including the PMP. Thus whilst unlikely during operation, failure due to overtopping is modelled in this dambreak scenario. The maximum height of the dam is 22.5m relative to the downstream toe of the embankment, and 17m relative to the natural surface under the embankment.

Due to the topography and location the most likely location for embankment breach is to the north. Whilst a breach the to the south east is plausible, the location of the adjacent TSF will prevent this mode of failure propagating. Due to the topography, failure to the east and west will result in any failed material reporting to the same location (Long Marsh Gully).

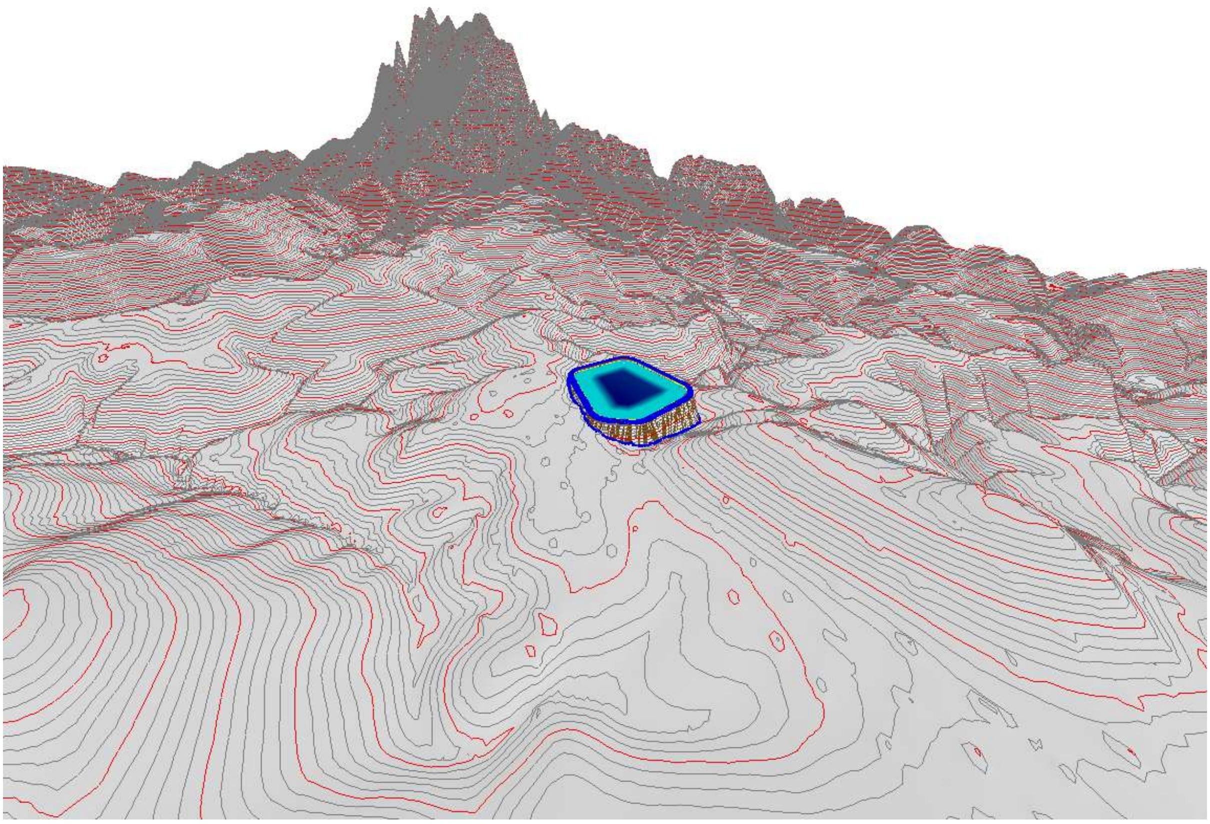

Figure 14 – 3d View of WSD from the East

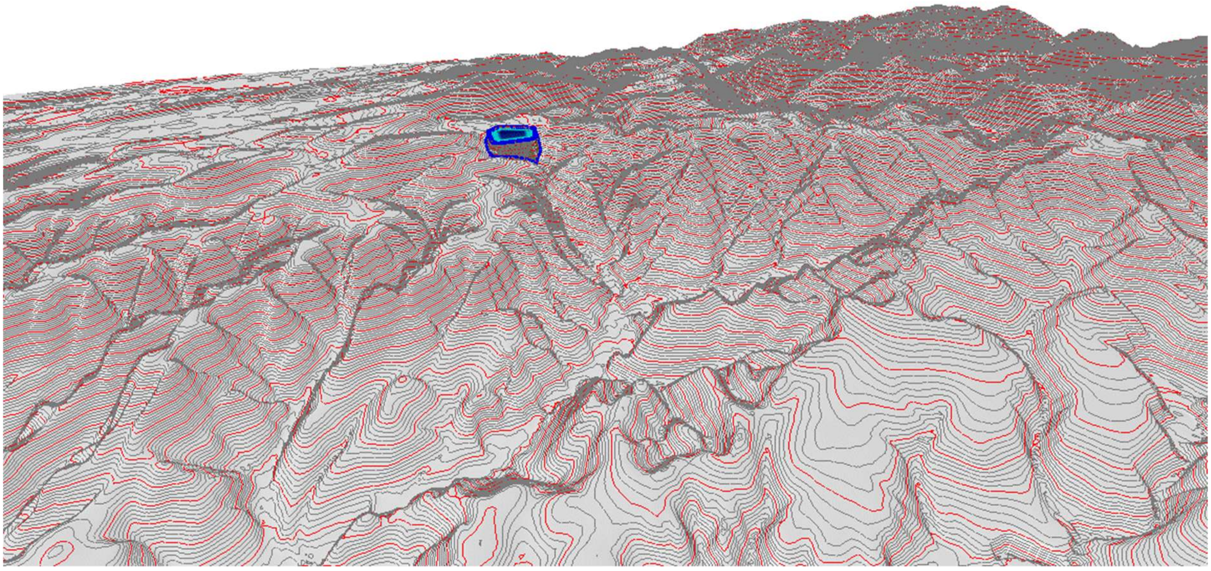

Figure 15 – 3d View of WSD from the North East

8.1.2 Scenario A – Model Layout

The WSD model layout in XPStorm is shown in **Figure 16**. The initial dam level is modelled as 125 mRL with the floor level modelled at 93mRL to reflect the average level of the dam base. The northern embankment is assumed to be completely breached with failure assumed to occur instantaneously resulting in the immediately release of all water and tailings from the facility.

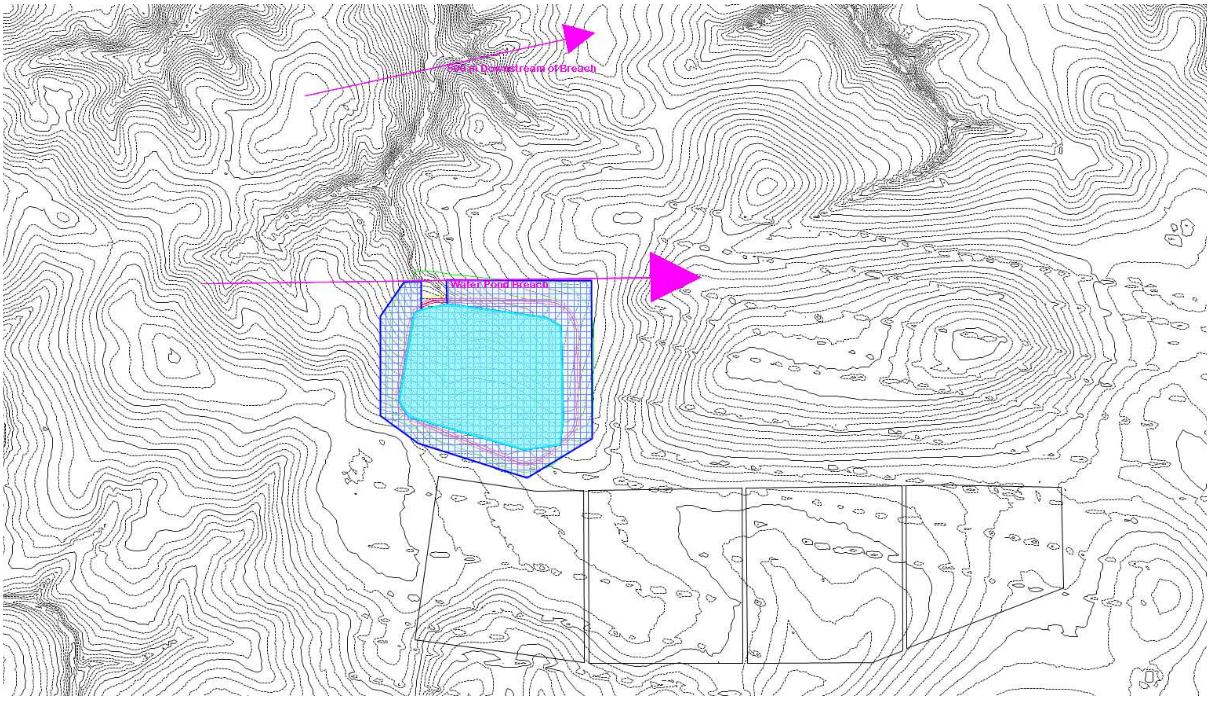

Figure 16 – Scenario A – XPStorm WSD Dam Break Model Layout

In addition to the flow cross section at the dam breach, flow sections have been evaluated at

- 500m downstream of the breach.
- Bairnsdale-Dargo Road
- Fernbank-Glenaladale Road, and
- at the Mitchell River at the eastern extent of the model

as shown in **Figure 17**.

8.1.3 Scenario A -Dam Break Run Out Impact Area

The area of influence from the dam break is shown in **Figure 18**. The maximum depth of water as the peak flow passes through the area is also colour contoured as shown in the legend for **Figure 18**. The reference grid shown on the figure is 1km x 1km.

From the 2D model it can be ascertained that the potential dam break would reach the Mitchell River and extend beyond the surveyed area without any additional assistance from water flowing along Long Marsh Gully or the Mitchell River.

The calculated run out distance for the initial flood wave from the 2d model exceeds 13km before reaching the limits of the survey file provided. Due to the limits of the model, this run out distance is less than the range predicted using empirical methods, but it is expected that the run out distance from the WSD breach would extend substantially further along the Mitchell River under all potential scenario's.

8.1.4 Scenario A - Dam Break Flow Rate, Release Volume, and Height

The flow rate, flow volume and height of water released from the WSD is measured in the flowing past the sections is indicated **Figure 19 to Figure 21**.

The breach size in the model has been sized to reach a peak flow rate of approximately 8000 m^3/s at the breach as per the empirical predictions in **Table 1**. The predicted flow rate below the breach quickly attenuates downstream of the failure as shown in **Table 3**. The time until the first flow is intercepted, and the time until peak flow rate occurs at each section is also shown in **Table 3**. The predicted maximum depth of flow at each of the sections and the cumulative flow in the 12 hours after the modelled breach event is also shown in **Table 3**. The cumulative release of 1.8 Mm^3 is approximately 10% greater than initially empirically estimated, however it is concurrent with the estimated water released in the initial flood the likely amount of embankment volume lost in the initial release. Any further embankment loss is expected to occur in the second phase of release and the impact will occur closer to the WSD.

Table 3 - Scenario A - Peak and Cumulative Flow Rates, and Maximum Depth

Reference Section	Peak Flow Rate (m^3/s)	Time to First Flow Intercepted (minutes)	Time to Peak Flow rate (minutes)	Peak Flow Depth (m)	Cumulative Flow (Mm^3)
Dam Breach	7,911	0.25	0.5	13.5	1.804
500m Downstream from Dam Breach	2,837	1.9	5.0	10.51	1.757
Bairnsdale-Dargo Road	1,124	22.2	27.6	2.3	1.671
Fernbank-Glenaladale Road	754	38.8	45.2	3.6	1.590
Eastern Extent of Model on Mitchell River	127	146.8	170.4	2.2	1.139

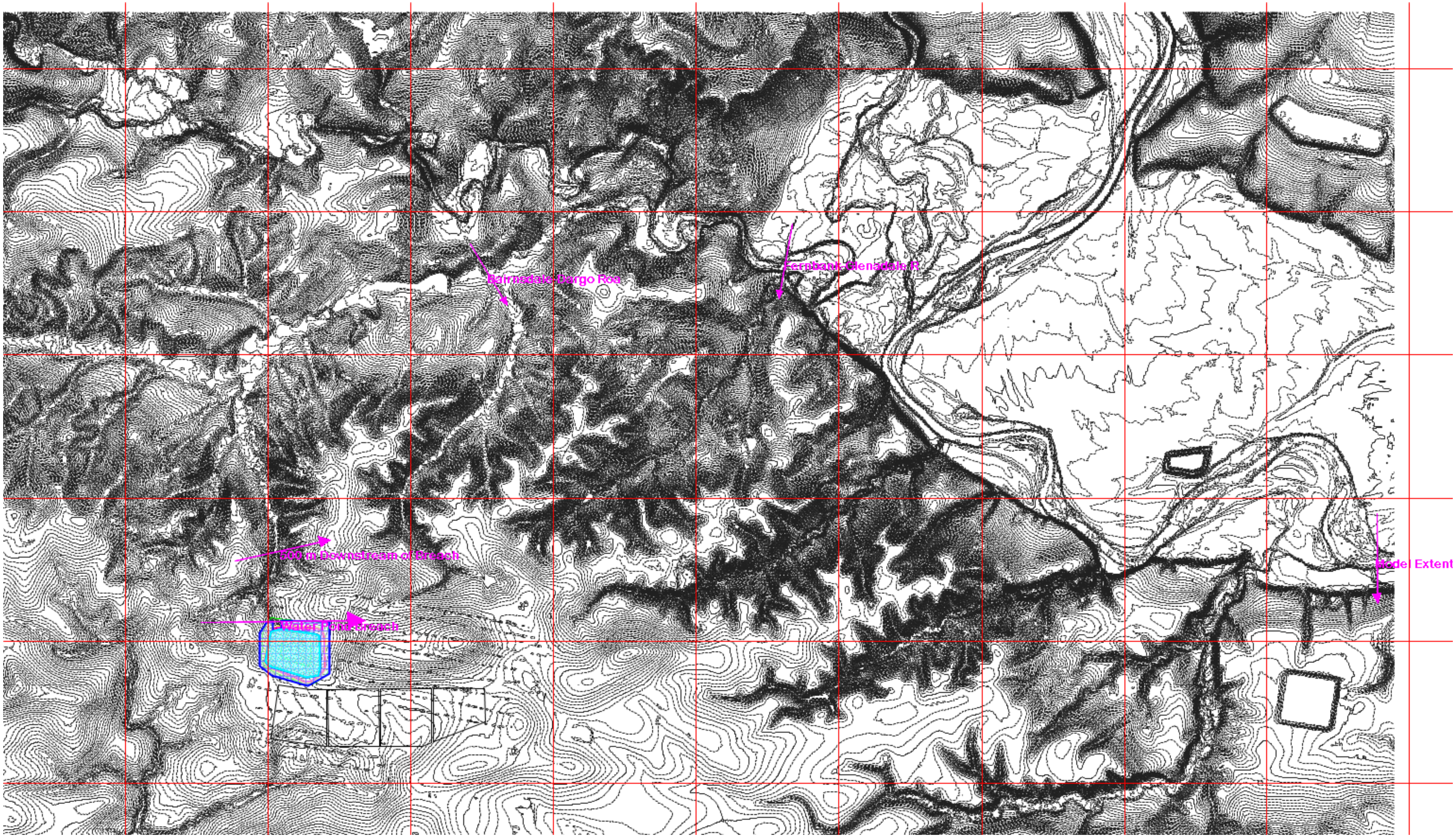

Figure 17 – Scenario A - Location of Modelled Flow Cross sections (in Pink)

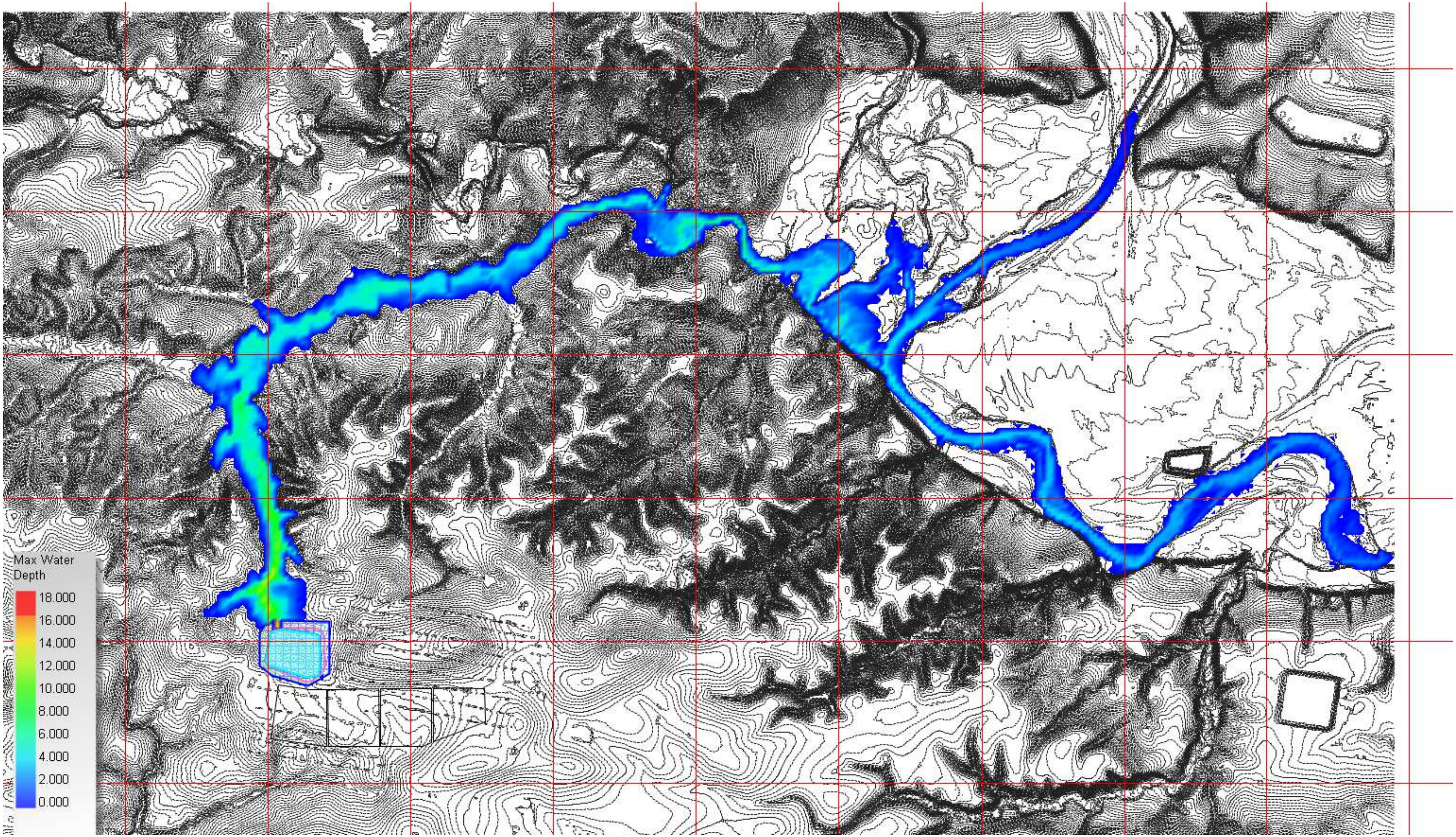

Figure 188 – Scenario A – Predicted Run-Out Impact Area

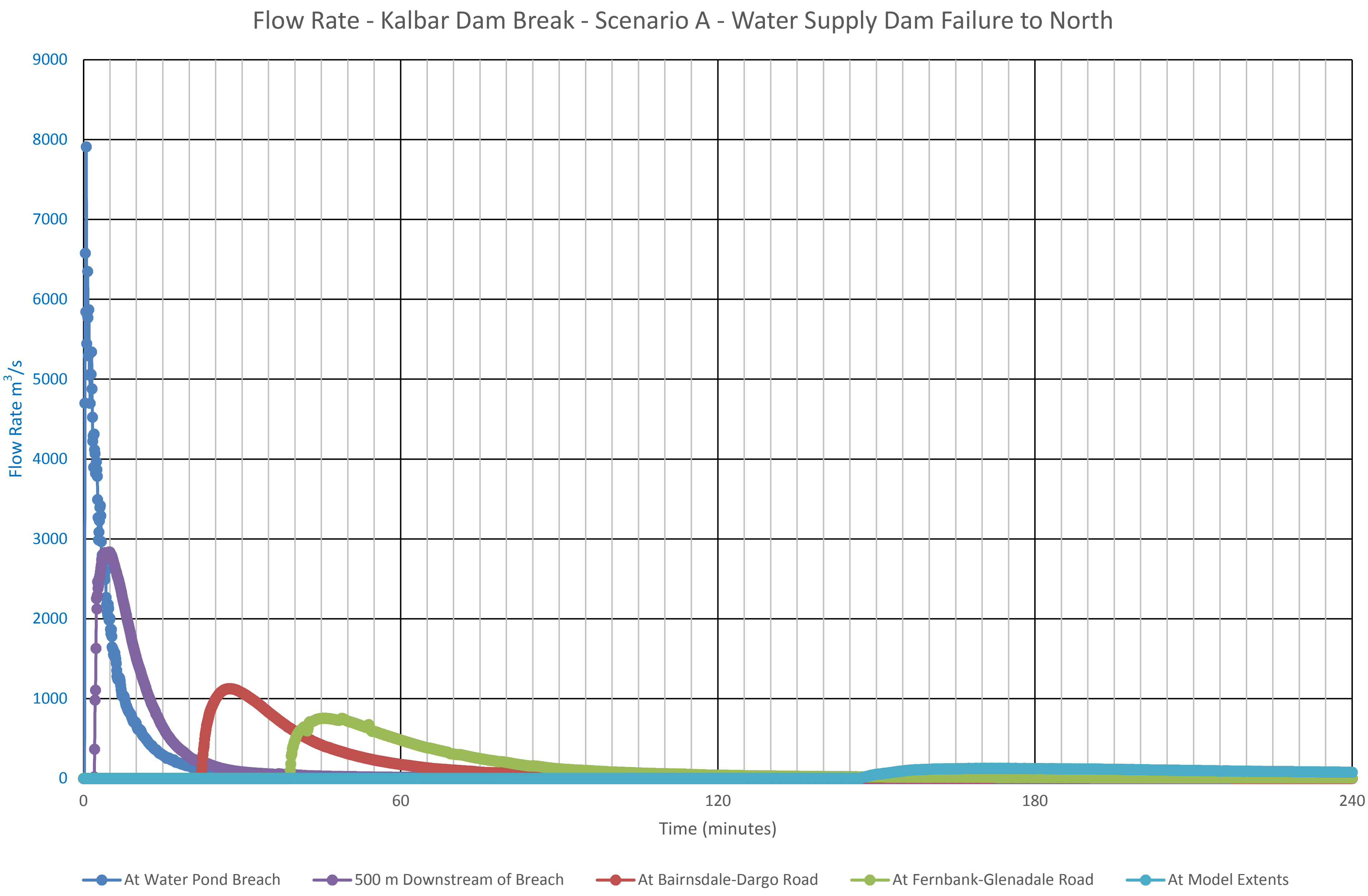

Figure 19 - Scenario A - Flow rate at reference locations

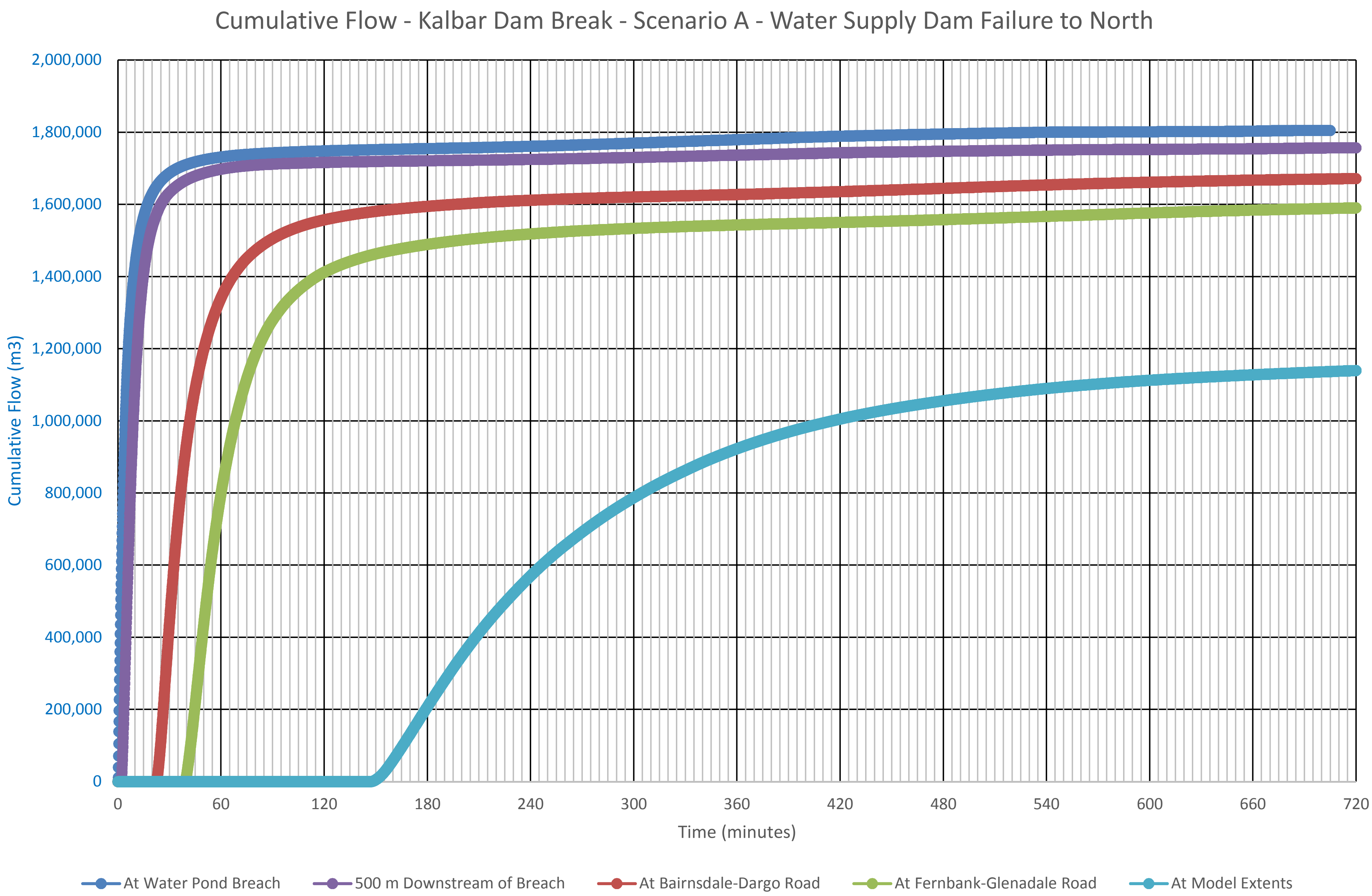

Figure 20 - Scenario A - Cumulative Flow at reference locations

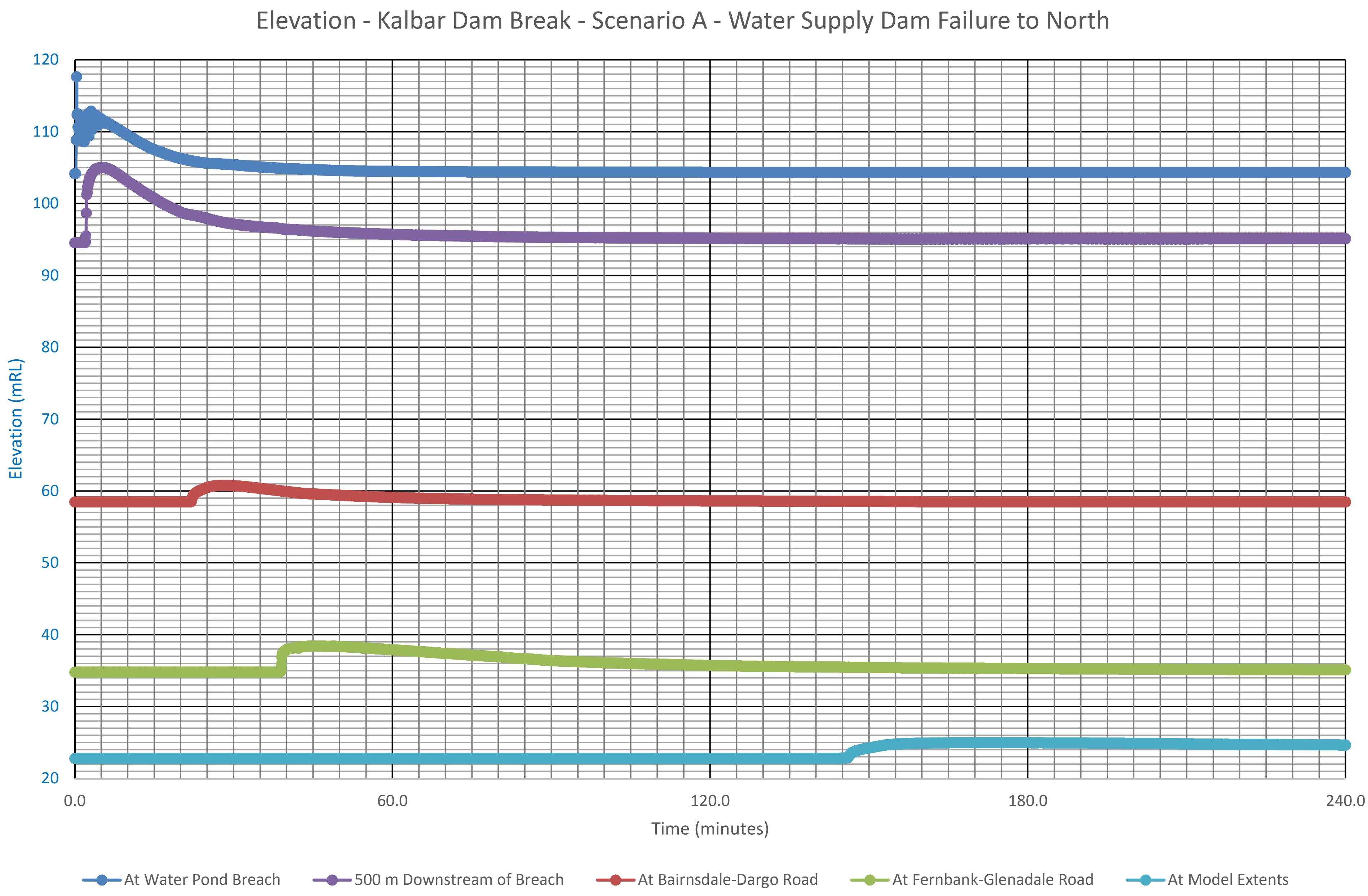

Figure 201 - Scenario A - Flow Elevation at reference locations