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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Modelling the Brumadinho tailings dam failure, the subsequent loss of life and how it could have been reduced" *by* Darren Lumbroso et al.

Darren Lumbroso et al.

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Comment: This chart seems to show the 9.7M cu.m volume, not the +35% volume of 13M cu.m

Reply: Yes that is correct. Robertson et al., 2019 estimated that approximately 9.7 million m3 of material was released, approximately 75% of the stored tailings (Robertson et al., 2019). This is stated in the paper.

Comment: In fact, general models such as DSO-99 or RCEM could be seen for use as screening models, as discussed in Reclamation's Dam Safety Public Protection Guide-

lines. It should be argued that more robust methods should be used for emergency planning.

Reply: The revised paper has been updated to reflect the fact that the as DSO-99 or RCEM methods are suitable for risk screening and that more robust methods are required for emergency planning.

Comment: Some source material should be provided to give justification to the PAR #'s used later in the report there is mention of anecdotal evidence for #'s in the canteen. Can this reference be provided? Why weren't PAR attributed to the 3 locomotives & 130 wagons mentioned? How were the houses identified? From aerial photograph, or other map methods?

Reply: There was only anecdotal evidence of the number of people in the canteen. It was assumed that there were no drivers in the locomotives because at the time of the failure they were not operational and, even if there had been, this would only have increased the numbers of people at risk by +3 because the wagons are used to carry ore not passengers.

The number and location of the houses in the LSM were identified from high resolution remote sensing data. The paper has been revised to reflect this. Comment: The document should remind us that the work is not meant to create a 100% accurate recreation of the life loss from this event. The note could reference the Discussion section where the rationale for this fact is explained further.

Reply: The paper has been revised to reflect this point.

Comment: Do we have any understanding on what people did to evacuate? Did they run to high locations, or just "away" from the mud slide in a downstream direction (which only prolongs the inevitable)?

Reply: There is not a clear understanding of exactly what happened because the failure happened so quickly. There is some video footage of one or two people getting into

vehicles to escape. However, it is our understanding that because the failure happened very suddenly and quickly at around lunchtime and that most of the workers were in the canteen and did not have a chance to evacuate.

Comment: Should stress that a person in an "injured" state is immobile. In fact, people who are "evacuating" can become injured and start moving more slowly than at the start of the simulation.

Reply: The paper has been revised to reflect this.

Comment: Can we also show the final model outcome with full flood extent & location of deceased? It is valuable to show where the fatalities occur for further discussion?

Reply: A figure showing this has been added to the revised paper.

Comment: The power of the agent based model is knowing locations are at high risk for fatality. No surprise that the mining site had high fatality rates. But which villages? This kind of information can also be used to develop the emergency plans. This richness in data output should be presented and discussed.

Reply: We have added a table to the revised paper showing which villages are affected together with an updated Figure, (Figure 7) showing where these villages are.

Comment: 1 minute reaction for trained workers at the mine could be accurate, but less so for downstream the general population downstream. With some reference to some of the USACE work on evacuation by Mileti and Sorenson, you could suggest this work may be optimistic for the effectiveness of warning. Sensitivity tests with delayed response should be performed to see the impact on fatality. Such tests are valuable in showing dam owners the impact in their delayed response to providing warning.

Reply: We have updated the paper to include a table showing the sensitivity of the number of fatalities in the different at risk areas to a range of response times ranging from immediately leaving a building to a 75 minute delay in departure. We have also included a discussion related to these points.

Comment: Proper hydraulic analysis is the most expensive part of emergency planning. If this work is already done (and SHOULD be done for moderate to high risk facilities), the expensive data collection portion of an agent based modeling has already been performed.

Reply: Yes we agree with this to a certain degree although in the case of tailings dams many facilities have not carried out mudflow modelling as part of their emergency planning. In addition, there are many thousands of tailings dams worldwide which have been abandoned. However, much of the data required for the LSM modelling can be gathered from aerial photographs and/or remote sensing data relatively inexpensively as was the case in this work.

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