Note:

This document is a combined Final Author's Response comprised of the two responses in the interactive public discussion. All changes indicated in this have been made.

Responses to comments of Reviewer #1:

We thank the reviewer, Raphael Paris, for the very thorough review and generous comments on the work under review. We are pleased to have found their suggestions exceptionally insightful, and our responses are as follows (in bold black), in order of the written comments (in blue):

The use of the Volcanic Explosivity Index VEI (e.g. at lines 8-9, 264, 266, 320-324, 371) is not fully appropriate here, because it is based only on the total erupted volume. Here you are dealing with short discrete explosions. You can keep the VEI values in Table 1, for information. However I would recommend referring to the energy or mass eruption rates in the text.

- Thank you for this point, we shall either replace instances with energy/rate or remove reference where this is not necessary.

I suggest adding a sentence on the tectonic setting, which is too briefly mentioned at line 24: "The 350 km-long TVZ forms the southern part of a back-arc basin behind the Tonga-Kermadec subduction zone. Most of the eruptive centres are aligned along the intra-arc Taupo rift."

- Thank you, we accept this and will insert as-is at sentence end on L25.

The TVZ cannot be considered as a purely silicic magmatic system, because the magmas erupted range from andesites to rhyolites.

- We agree; this may have persisted from when actually discussing the local reservoir beneath Lake Taupo, rather than the TVZ as a whole. "silicic" will be removed from L24.

At line 169 you state that "the water and explosion depths are equivalent." This is valid only in the case of a new vent formed on flat lake bottom. If the explosion comes from a pre-existing submarine cone, then explosion depth and water depth are not equivalents. This statement should therefore be qualified.

- The "water depth" of these explosions is limited to the immediate surrounding directly underneath the explosion. As these parameters were designed for explosives which could be held midway through the water column or near the surface, these were designed to help determine the shallowness of an explosion and account for the effect of the bed directly under any explosion (Méhauté & Wang, 1996). A volcanic explosion is inherently from the surface beneath the water, so therefore the water depth at the explosion must always be the same as the explosion depth, even with a shallow change in the surrounding due to a volcanic cone.

- In any case, while this may pose an interesting investigation possibility with a particularly steep cone, the scenario locations in this study are not placed in locations of steep bathymetry. To clarify these points within this work, an additional clause will be inserted at L169 to reflect the above point.

I suggest slightly reorganizing the paper as follows:

3. Results

3.1. Tsunami propagation and wave heights at the coast

3.2. Tsunami inundation and potential impact on infratructures

- We accept this good suggestion for structure with thanks. Sections 3 and 4 will be made into the suggested two sub-sections as-is without additional text.

In the discussion, we lack a short discussion (at line 324?) on the probabilities mentioned on Table 1, in the light of the new results obtained here.

- Thank you for this point; given this verges towards a full probabilistic assessment, we instead suggest a short inclusion at this point to note the relevant uncertainties and how a more formal study may be undertaken with the information from this study.

The scenario presented at lines 330-334 is very pragmatic and relevant. Indeed in the case of such an eruption, all people would be probably evacuated before a tsunami could impact them. Could you add a short sentence of the consequences in terms of evacuation policies?

- At this point we shall add that any evacuation routes that require transportation links adjacent to the lake shore should be assessed for potential compromise from any such tsunami.

In the conclusion, maybe you could formulate some recommendations for a local tsunami warning system in Lake Taupo?

- The relevant timeframes involved in this hazard are likely too short to recommend any kind of reactive warning system. Instead it may be best to rely on education, awareness and preparedness. We will ensure this point is raised in the conclusion.

Line-by-line corrections/suggestions:

line 7: "This minimum size corresponds to..."

9: "slope" rather than "run-up"?

37: "(HTHH, January 2022)"

- We agree with these corrections/suggestions.

37: You could cite other references on the HTHH tsunami (e.g. Carvajal et al., 2002; Omira et al., 2022).

- Agree - this manuscript was originally submitted prior to most of the recent work developing from that event.

41: cite also Maeno & Imamura (2011) for the 1883 Krakatau tsunami debate.

56: "and in the present work it is..."

- We agree.

59-63: this sentence is perhaps too long.

- We agree; this is adjusted as also asked by Reviewer 2 (see other response for detail).

92: refined against what?

- Clarify to:

"...for instance, in tsunami models it is the free-surface elevation field that is typically used for refinement criteria."

127: 7% of what?

- Clarify as "...maximum 7% of recorded tsunami sources as determined by..."

128-129: not sure if these lines are really useful here.

- These couple of lines related to an earlier comment about the importance of awareness and preparedness rather than reliance to on warning systems.

194: "'We selected the five..."

- We agree.

230-232: again, this sentence is a little bit long.

- Will change to (removing last part of sentence):

"Fig. 6 compares the crest amplitude and velocity data between the different simulations. This shows that a positive relationship exists between both crest heights and horizontal wave velocities at the shore and the explosion energy (and, therefore, also ejecta volume and MER)."

248: refer to Fig 6 (c-d).

- We agree.

257: 1 m instead of 1 cm?

- 1 cm is correct as the plots show the extent of inundation which exceeded 1 cm depth.

340: "asteroid-ocean impact, megatsunami from ocean-island flank collapse, and the recent tsunami..."

- Agree to change, excluding "megatsunami from".

345: "over half a decade old " -> a reference is needed here.

- Will reference the past technical reports and associated work documented and reviewed in Méhauté & Wang (1996)

350-352: I was quite surprised that you don't cite here the work of Shen et al. (2021a, 2021b).

- Many thanks for this, we will include.

367: "of what any tsunami hazard"

- We agree.

384: What is the address of the website where Basilisk can be found?

- EGU formatting requires it to be contained in references.

Suggestions on figures:

change the colour of the eruption sites on figure 2 (white or yellow?).

- We shall adjust the colour of the markers to make them darker yellow or orange, dependent on visual accessibility.

Fig 4: add source location (eruption sites) on the maps (same for fig 5).

On the left side of fig 4, could you please mention the location number (1 to 5) as in Table 2, for more clarity (same for fig 5).

Fig 6: add a dotted line to indicate the 1 m threshold value?

Fig 6 c) d): in the caption, indicate that the first numbers refer to the scenarios and the name to the source locations 1 to 5.

Fig. 8: Indicate to which closest source it corresponds on the different maps (same for fig 9).

- We agree with these suggestions. Many thanks for identifying these oversights and potentials for improvement.

References:

Le Méhauté, B. and Wang, S., 1996. Water waves generated by underwater explosion (Vol. 10). World Scientific.

Responses to comments of Reviewer #2:

We thank the anonymous reviewer for their helpful and insightful review and the effort taken over the comments. We address the points raised (in blue) in order that they are raised. Our responses are in black with any suggested text revisions in red.

First, what is the motivation of using MLSW for this case?

Authors used multi-layer SWE for numerical simulations, and showed that the computational efficiency of the MLSW solver is poor. Recent studies on HTHH (Pakoksun et al. 2022) showed that numerical simulations with NLSW or Boussinesq-type equations are in good agreement with the near-field observation. It would be desirable for the authors to perform numerical simulations with NLSW and Boussinesq eqs, and compare the maximum inundation heights and computational efficiency.

Authors may argue that the waves generated by the volcanic eruption are very dispersive. However, I am not sure that Lake Taupo is large enough for the waves to develop dispersive characteristics since the waves reach the shore in 12 minutes or less.

- We thank the reviewer for raising this question. The motivation for use of a multilayer non-hydrostatic type model is established in Hayward (2022a), where the scheme was compared against NLSW and Boussinesq-type equations implemented within the same numerical framework for waves generated by initial displacements and explosions.

- It is well evidenced from previous field tests and experiments that explosively generated waves can exhibit significant dispersive characteristics (Le Méhauté & Wang, 1996). Prior investigation of this phenomena with the multitude of simulation equations can demonstrate strong differences, especially in the form of the resulting wavefield (Hayward 2022b). In these previous comparisons, it is not seen that the size of the lake prevents dispersive wave characteristics developing when utilising a scheme capable of resolving them.

Second, it is unclear how the authors handled the bottom friction. One of the important factors for predicting current speed and Inundation height is the bottom friction coefficient. In the study of inundation by storm surges, Madli and Dawson (2014) claimed that variable friction can be important to take into account in storm surge simulations, and numerical models apply complex bottom friction fields. I would like to know how authors considered the bottom friction, and wet/dry interface for simulations.

- Thank you for this important point. For the simulations run in this study, bottom friction is implemented in the similar way as is done in Hayward (2022a) by adding a quadratic bottom friction term which is applied across all cells at each timestep, and described further by Popinet (2011, 2015) and Beetham (2015). A short description and reference will be added to address this within the manuscript at the end of Section 2.1.

- The wet/dry interface problem is addressed by Popinet (2020) and is unaltered in its implementation in this model.

L59-63 unclear

- Will simplify and rephrase to:

"The aims of this work are to present a detailed case study of volcanic wave hazard from idealised explosive subaqueous sources. By utilising an appropriate numerical scheme for the types of generated waves and with high resolution digital terrain models (DTM), this work will provide a basis on which future probabilistic hazard and risk assessments can be developed to take into account this potential volcanic hazard source."

L77 "have been attempted using" -> used

- We accept this succinct change.

Section 2.1 & 2.2 are similar to Hayward et al. 2022b. Authors may shorten these parts.

- We note that it is essential to maintain the independence of individual works, and we feel that these sections are necessary to keep paper standalone and are already kept towards a minimum.

Inconsistent in the simulated time. Which is correct? L204 "All runs were executed for 24 minutes of simulated time" L219 "All scenarios were computed until a simulated time of 1400 s"

- Thank you for noticing this oversight; the simulations were originally planned for 24 minutes but were actually computed for a slightly shortened completion time of 1400 seconds. We will correct this at L204.

L211 “The number of these placed along a section is set to match the maximum horizontal grid resolution.” unclear

- Will rephrase to:

"The resolution of numerical gauges across each section is set to match the maximum horizontal grid resolution of the simulation."

L240 “leading to a longer duration from the first arrival to the maximum amplitude wave at greater distances from the source” unclear

- Will rephrase to:

"...across most of the lake. This leads to a longer duration between the arrival of the first wave and the arrival of the wave with the largest crest amplitude as the distance from the source increased.”

L309 “For these sources, this does not happen and therefore the reflection, and the incidence of troughs between wave peaks at the inlet, produces negative (or reverse) discharges from the inlet towards the lake.” unclear

- Will rephrase to:

"For these sources, the gate is not overtopped. The flux down this channel is therefore reflected back down producing a trough that is equivalent to a negative (or reverse) discharge from the inlet back towards the lake."

L312 72% of something?

- Will rephrase this part of the sentence as:

"...this reduces the peak discharge by 72% when the wave travels..."

Figure 4 & 5 The information on the wave height is hard to discern from the figures. It would be better to plot the maximum wave height along the perimeter of the lake (in 2-D)

- We understand the issue of accurately reading the data in these figures. However, this proposal would not resolve the issue as it would result in 40 small graphs which would struggle to be any more discernible than these two figures to convey the same information. In addition, this would mask details of the spatial comparison.

- Reviewer 1 suggested alterations to the two current figures which will be implemented, please see the response to this reviewer. Additionally, the data used for these figures, including the Python code used to generate them, are accessible from permanent links within the work.

References:

Beetham, E., Kench, P.S., O'Callaghan, J. and Popinet, S., 2016. Wave transformation and shoreline water level on Funafuti A toll, Tuvalu. Journal of Geophysical Research: Oceans, 121(1), pp.311-326.

Hayward, M.W., Whittaker, C.N., Lane, E.M., Power, W.L., Popinet, S. and White, J.D., 2022a. Multilayer modelling of waves generated by explosive subaqueous volcanism. Natural Hazards and Earth System Sciences, 22(2), pp.617-637.

Hayward, M.W., Whittaker, C., Lane, E., Power, W. and Nukurangi, N.T., 2022b, April. Submarine explosive volcanism–numerical modelling of tsunami propagation and run-up. In Australasian Coasts & Ports 2021 Conference.

Le Méhauté, B. and Wang, S., 1996. Water waves generated by underwater explosion (Vol. 10). World Scientific.

Popinet, S., 2020. A vertically-Lagrangian, non-hydrostatic, multilayer model for multiscale free-surface flows. Journal of Computational Physics, 418, p.109609.

Popinet, S., 2015. A quadtree-adaptive multigrid solver for the Serre–Green–Naghdi equations. Journal of Computational Physics, 302, pp.336-358.

Popinet, S., 2011. Quadtree-adaptive tsunami modelling. Ocean Dynamics, 61(9), pp.1261-1285.