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Memorandum

TO: The Honorable County Council
Jack Louws, County Executive

FROM: Cliff Strong, Senior Planner

THROUGH: Mark Personius, Asst. Director

DATE: February 8, 2017

SUBJECT: 2016 Critical Areas Ordinance Update
County Council Review, Workshop 5, 21 February 2017

On February 21st the Council will continue its review of the 2016 Critical Areas Ordinance Update. Topics to be covered include:

Review of Certain Proposed Amendments to:

- Article 3 – Geologic Hazards (including lahars)

To prepare for this meeting, please review Article 3 of the draft code, the Best Available Science Addendum regarding that section (in your previous meeting packet materials), in which I point out the more substantive recommended amendments, and this memo, in which we describe how we got to this point and the options Council has.

Lahars in Whatcom County

Contents

Why Staff is Presenting So Much Information, as Well as Other Options?

At the Council's first public hearing on the Critical Areas Ordinance (CAO) the majority of the public testimony (22 of 28 people) was geared toward swaying the Council not to amend the lahar regulations, or more precisely to not have such regulations. Council made a motion for staff to develop lahar regulations based on our tsunami regulations. Staff has done this (see "Option 1: A Lahar Code Based on the Tsunami Code," page 7). However, staff doesn't believe that Council has had the opportunity to fully understand the context of geologic hazards at Mt. Baker or the risks posed to Whatcom County residents. While Council does have the authority to adopt whatever rules they want, it is only after having such a public discussion (see "What Tahoma Audubon Society v. Pierce County Tells Us," page 12). Thus, staff feels it incumbent to first present what is known about lahars prior to Council making such a decision.

It should also be noted that public testimony concerning the perception of risk posed by lahars appears to be based on *individually* held beliefs of risk tolerance. Emerging risk assessment methodologies are available that quantify both *community* and *individual* risk posed by geologic hazards. Proposed development is commonly evaluated according to *community* risk tolerances, which are commonly treated more conservatively, whereas *individual* risk tolerance is more typically employed in scenarios such as home expansions where the increased risk exposure is assumed by the individual and not society. In considering revised regulations Council should consider the potential increase to community risk posed by the adoption of revised volcanic hazard regulations. Toward this end staff is prepared to update Council on to strides made toward improved geologic hazard characterization since the 2014 Natural Resources Committee briefing, as well as provide recommendations for future improvements; some of which would have the added benefit of informing the revision of volcanic hazard area regulations.

History (How We Got to Where We Are on the Draft Code)

Staff had not planned on updating the volcanic hazard area code when we first started the CAO update as it hadn't been identified as a problem, nor had the CAC or the TAC identified any egregious issues requiring revision. However, after we had finished reviewing the code with the TAC and CAC, a handful of prospective applicants for marijuana processing facilities made inquiries about properties they had identified as potentially suitable locations. Staff identified that the properties fell within a lahar hazard areas and that the use wouldn't be allowed based on staff's interpretation of the code, which states that only single-family residences and duplexes are allowed in lahar hazard zones (see "Existing CAO Language," page 14). Potential applicants then went to the BIAWC for help, who stepped in to lobby for a change in the code.

Most existing larger scale or more intensive development in the LHZ's appear to have been in existence prior to adoption of the original CAO and are therefore considered nonconforming uses to the CAO. Staff was also aware that USGS-published maps depicting areas of potential lahar inundation—which had previously been adopted as best available science— were not prepared at a scale appropriate for parcel-level analysis and could only be considered approximate. Staff therefore reached out to the

USGS, who acknowledged that an updated hazard map and publication was needed for Mt. Baker and that this work is currently under production.

Based on these considerations staff was of the opinion that adoption of significantly revised volcanic hazard area standards—especially when updated hazard mapping was forthcoming—was not advisable. As a result, staff prepared amended volcanic hazard code language that allowed all uses per the underlying zoning, but with occupancy limits comparable to single-family residential uses as in the current code. The rationale of this approach was to accommodate additional uses in these areas but preclude sensitive uses or high concentrations of people until such time that updated hazard mapping and risk assessment could be used to propose more scientifically sound volcanic hazard area regulations, as explained below.

Development of the Proposed Lahar Hazard Zones

In response to the Planning Commission's request for an amended volcanic hazard area code that would be less restrictive to uses in lahar hazard areas, staff was tasked with researching lahar regulations in other Washington State counties. Of counties potentially impacted by lahar hazards, Pierce County was found to have the most evolved, defensible ordinance.

The Pierce County ordinance is built around empirically-derived lahar travel-time estimates after the work of Pierson (1998)[1]. Regulations are established according to *travel time zones* based on increasing lahar arrival times with distance from Mt. Rainier. Additional use restrictions are then applied for designated *volcanic hazard areas,* which correlate to three distinct lahar designations of increasing hazard severity as well as pyroclastic flow hazard areas, each of which are interpreted by the USGS to have impacted, or to have the potential to impact areas within the respective *travel time zones* in the future.

Paramount to the Pierce County approach is the availability of accurate models published by the USGS of lahar inundation and pyroclastic hazard areas, which were used to delineate the respective *volcanic hazard areas.* In addition*,* Pierce County's regulatory framework is benefited by the presence of a robust seismic network at Mt. Rainier that allows for early detection of increased magmatic activity, which may presage volcanic or lahar activity, as well as a lahar alert system triggered by acoustical flow monitors. The combination of monitoring, detection, and lahar alert justifies the establishment of Pierce County's *travel time zones.*

In an attempt to devise regulations similar to Pierce County, staff generated travel-time estimates for potential lahar paths traveling down the Middle and North Fork Nooksack River valleys, respectively. A lahar traveling down the Middle Fork will arrive at the confluence of the Middle and the North Fork Valley sooner and arrival times downstream of the confluence are based on a Middle Fork lahar. Travel times were estimated by two methods. The first used commonly observed lahar velocities, which are noted to decrease from high velocity in confined, steep-gradient valleys near the volcanic source to lower velocity as the lahar reaches the lowlands and the river becomes unconfined and gradient

[1] Pierson, T.C., 1998. *An Empirical Method for Estimating Travel Times for Wet Volcanic Mass Flows*. Bulletin of Volcanology, v. 60, p. 98-109.

decreases. Lahar velocities of 50, 25, and 15 miles per hour were used for this effort. In addition, staff reached out to Dr. Tom Pierson, Cascade Volcano Observatory Research Scientist and author of the above-referenced paper, and requested assistance applying his methodology to a lahar at Mt. Baker. Dr. Pierson graciously provided staff with estimated arrival times at specific locations such as Glacier, Deming, and other key geophysical locations along the respective, potential lahar paths. These data were used to validate the arrival times determined by the former methodology, which were found to correspond well.[2]

In the North Fork Valley the town of Glacier lies well within Lahar Zone A, if delineated correlative to lahar zonation established in the Middle Fork Valley, where Lahar Zone A extends to the Mosquito Lake Bridge at the approximate 15 minute lahar arrival time. At the direction of the Planning Commission staff extended Lahar Zone B to the town of Glacier to allow for more uses within the established LAMIRD community and in recognition of the existing Resort-Commercial and Small Town Commercial zoning. This decision should be considered non-conservative, especially when compared to Pierce County regulations. In Pierce County the most proximal hazard zone extends to the 30 minute lahar arrival time in the Puyallup and Carbon River systems and the 60 minute lahar arrival time in the Nisqually and White River systems. Adoption of lahar hazard zonation as conservative as the Pierce County approach would extend the more restrictive regulations (Lahar Zone A) to Deming, or beyond.

In summary, it is Staff's opinion that a number of key components are lacking in Whatcom County that make adoption of lahar regulations that mimic Pierce County's currently inadvisable. While County Staff helped develop the Planning Commission's proposed Volcanic Hazard code revision, staff is of the opinion that such an approach is problematic based on the following reasons:

a. <u>Absence of a lahar warning system or a reliable seismic network at Mt. Baker</u>
   In Pierce County and the Planning Commission's proposed code revision, lahar regulations are applied with decreasing use restrictions according to increased lahar travel time. In the absence of detection and alert it *cannot* be assumed that evacuation will function as an effective means of hazard mitigation. This issue is further confounded by the need for a reliable seismic network that could offer early warning and allow for evacuation prior to initiation of a lahar.

b. <u>Non-conservative Lahar Hazard Zone Delineation</u>
   Were Whatcom County to adopt lahar hazard zones correlative to Pierce County the highest hazard zone (Lahar Hazard Zone A) should extend to Deming at the ~1 hour lahar arrival time. As proposed by the Planning Commission, Glacier is included in Lahar Hazard Zone B to allow for increased uses in an established community. This is highly non-conservative due to the very short lahar arrival time (<15 minutes) and the resulting inability to rely on evacuation as a form of mitigation, as well as the potential for smaller-volume, but higher frequency lahars impacts.

[2] It should be noted that Dr. Pierson's travel times may be conservative as they are based on empirically-derived travel times for lahars averaging 10^7 million cubic meters in volume, which would be considered a very large, low recurrence event. Despite this conservative interpretation, Dr. Pierson urged caution with regard to the regulatory application of travel time zones in the absence of a lahar detection and alert system.

c. Modeling and delineation of lahar hazards at Mt. Baker is currently outdated and generalized
Pierce County regulations are benefited with accurate models of potential lahar inundation areas. In addition, lahar inundation models are available for lahars of varying magnitude and frequency, allowing further refinement of land use regulations. Such models for Mt. Baker are presently in production at the USGS and estimated to be available by 2019.

d. Emergency preparedness and response plans rely on a robust Lahar Detection and Alert System
Emergency planning, which could be considered a form of hazard mitigation, is severely hindered in the absence of the above-described lahar detection and alert system. While emergency plans are continually being updated and improved, until a detection and alert system is in place at Mt. Baker response plans are effectively reactive measures. Furthermore, a lahar detection and alert system would likely only be effective in areas such as Deming, and downstream, where sufficient time (~1 hour) would be available to use evacuation routes.

Due to the non-conservative nature of the lahar hazard zones and the absence of a monitoring and alert system, staff recommended to the Planning Commission that any regulations based on *lahar hazard zones* maintain very low occupancy limits for any new permitted uses along the North and Middle Forks of the Nooksack River (Lahar Zones A and B). Once updated lahar mapping and risk assessment is completed more tenable occupancy limits could be considered. Despite staff's recommendation, and following much debate, the Planning Commission ultimately elected to support the Piece County-based volcanic hazard code language, yet with significantly increased occupancy limits and fewer restrictions on sensitive uses. It should also be pointed out that the occupancy limits recommended by the Planning Commission are such that, with the exception of Lahar Hazard Zone A, uses within the established communities would likely be more limited by other zoning regulations, such as the floor/area ratios of the LAMIRDS, than the proposed volcanic hazard area regulations.

What Do We Know About Lahars in Whatcom County?

Cynthia Gardner and Seth Moran with the USGS-Cascade Volcano Observatory (CVO) have graciously offered to attend the February 21 COTW workshop and present the geologic history and potential hazards at Mt. Baker. They will also review monitoring efforts currently being undertaken at other volcanic centers, both in the USA and abroad, and discuss paths forward at Mt. Baker for improved monitoring and hazard awareness. The CVO maintains on-line information about hazards at Mt. Baker, which can be found at the following url: https://pubs.usgs.gov/fs/2000/fs059-00/ .

What State and/or Federal Emergency Response and Preparedness Efforts are Going On?

Dr. Gardner and Mr. Moran will present this information at the February 21 COTW workshop.

Local Emergency Response and Preparedness Measures

Please see John Gargett's "A Risk Based Planning Approach for Lahar and Volcanic Hazards in Whatcom County," page 14.

Legal Requirements

Before we explore Council's options, the legal requirements of WAC 365-190, Geologically hazardous areas, should be reviewed. Following are the pertinent sections; the entire text is found under "WAC 365-190-120 Geologically hazardous areas" on page 26.

(1) Geologically hazardous areas. Geologically hazardous areas include areas susceptible to erosion, sliding, earthquake, or other geological events. They pose a threat to the health and safety of citizens when incompatible commercial, residential, or industrial development is sited in areas of significant hazard.

Section (1) basically says that geohazards pose a threat when "incompatible" development is sited in areas of "significant" hazard. However, neither of these terms is defined. Is incompatible development that which puts someone in harm's way, or that which worsens a risk, to either an individual property owner or to the larger community? And does Council consider lahars a significant risk? Or does Council find them an insignificant risk due to their low probability? Or are they significant due to the large consequences should one occur? Remember, lahar risk should be viewed on the basis of annual probability not an annual return period. The difference is that while they are infrequent events, the chances of one happening in any one year may be relatively small, but don't change year to year.

Staff suggests that if Council wants to adopt minimal regulations, it would behoove you to find that lahars aren't a significant hazard.

(2) Some geological hazards can be reduced or mitigated by engineering, design, or modified construction or mining practices so that risks to public health and safety are minimized. When technology cannot reduce risks to acceptable levels, building in geologically hazardous areas must be avoided. The distinction between avoidance and compensatory mitigation should be considered by counties and cities that do not currently classify geological hazards, as they develop their classification scheme.

Section (2) basically says that we must avoid development in geohazard areas if the risk can't be mitigated. *Staff suggests that if Council wants to adopt minimal regulations, it may be prudent to find that an early warning and evacuation plan is adequate mitigation.* Of course, this presupposes that we have such a system in place, which may not be feasible for areas proximal to Mt. Baker such as Glacier.

(10)Other geological hazard areas:

(a) Volcanic hazard areas must include areas subject to pyroclastic flows, lava flows, debris avalanche, or inundation by debris flows, lahars, mudflows, or related flooding resulting from volcanic activity.

From section (10), it is clear that lahar hazard areas must be declared a volcanic hazard area, which the proposed code does. How we respond to that is up to Council.

Options for Council

Council has a variety of options, ranging from the least restrictive (allowing *all* new uses in Lahar Hazard Zones that could be permitted in accordance with the underlying zoning regulations) to the most

restrictive (restricting all new development except SFR). Something in between might be to allow *most* lower occupancy uses allowed by the zoning code, but regulate essential facilities, hazardous facilities, and higher occupancy uses, including special occupancies, and/or covered assemblies to some degree.

Staff has identified three options for Council to consider. Whichever option is chosen, Council would have to find that the risk posed to communities and future generations is acceptable in consideration of the potential hazards. Furthermore, a warning system, signed evacuation routes, and education could be added to any of these options, though would need to be funded.

As mentioned, pursuant to *Tahoma Audubon Society v. Pierce County* (page 12) Council has the sole authority to choose the level of risk our citizens are willing to accept, though it needs to be on the record as having had a thorough discussion and understanding of the potential risks of their decision.

Option 1: A Lahar Code Based on the Tsunami Code (as per Council motion)

At the public hearing, a motion was approved to "Request staff to bring forward a proposal to remove lahar language and insert language that says lahars will be treated like tsunami zones, with the same level of evacuation route planning and education."

Thus, Council has asked for lahar regulations that mimic our tsunami regulations. In actuality, the existing tsunami hazard regulations direct the technical administrator to the volcanic hazard regulations. Adopting lahar regulations that mimic the tsunami regulations would just create a logic loop in the code. However, for this discussion, staff assumed the Council intended to let people build all allowed uses, and rely on emergency warning systems, emergency preparedness, and education, but with no other mitigation (e.g., building structures to withstand a lahar, which is considered unfeasible in areas subject to high velocity lahar flows as might be experienced as far down valley as Deming).

First there are a couple of differences between these types of hazards that we'd like to point out.

(1) Geologic inference suggests that tsunamis have the potential to occur more frequently than lahars.
(2) Tsunamis generated by large, Cascadia Subduction Zone earthquake would trigger early detection and alert systems currently in place.
(3) A lahar warning system has not been established in Whatcom County.
(4) We have signed evacuation routes for tsunamis but not for lahars.
(5) Most development in tsunami hazard areas is single-family residential, which is allowed by current CAO geohazard regulations. Commercial or other uses would not be allowed without mitigation capable of reducing the risk posed to the proposed development.
(6) We can mitigate for tsunamis. In tsunami hazard areas, we require that structures be built so that habitable spaces are above the expected height of the tsunami/flooding, that floodwater can pass through crawl spaces without significant structural damage, and that the foundation is designed to withstand the interpreted hydraulic and impact forces. No types of structural improvements are capable of mitigating or withstanding lahar impacts for much of the proximal lahar hazard area.
(7) In the tsunami hazard areas land is available for development (i.e., located outside of tsunami hazard areas) within close proximity, allowing development to proceed largely unhindered by

using avoidance as required by WCC 16.16.320(A). This is generally not the case for lahar hazard areas, especially in the foothills region where lahar hazards are interpreted to extend across the valley floor.

(8) And lastly, there is evidence that we may expect to experience an increased frequency of debris flows (sometimes used interchangeably for lahar) at Mt. Baker related to glacial retreat, as similar effects have been noted at Mt. Rainier, Mt. Hood, and other glaciated mountain ranges. While these events may not be as large as lahars, there is the potential for them to impact development relatively near the mountain, and with increased frequency and no warning. If a warning system were developed, ideally it would encompass this hazard also.

It should also be pointed out that the existing tsunami alert system (warning system, evacuation signage, and education) is not a CAO regulation, but something inherited by our Emergency Management Division of the Sherriff's Office, who is developing a comprehensive AHABR system. Thus, if this is an approach the Council wants to implement (and planning staff supports installation of such a system, especially if the Council chooses not to limit development by regulatory means), then funds would need to be appropriated and the system would need to be set up.

Council should also consider whether they want to regulate *any* sort of sensitive land uses, such as emergency services, hospitals, schools, hazardous facilities, etc., in the lahar hazard zones. Assuming not (for the purposes of this memo), then below is the tsunami code, followed by a lahar regulation that mimics it, as Council has requested.

Tsunami Code

16.16.365 Tsunami Hazard Areas –Standards.

The standards of WCC 16.16.320 ~~and 16.16.350~~ shall apply. For development within tsunami hazard areas the proposed development shall be designed to provide protection for the tsunami hazard that meets the projected hazard on the Department of Natural Resources Tsunami Inundation Maps. For other low lying coastal areas not included on the Inundation maps, development shall be designed to provide protection for debris impact and an inundation as determined by current Department of Natural Resource modeling unless other measures can be shown to provide equal or greater protection.

Lahar Code Based on Tsunami Code

16.16.350 Standards – Volcanic hazard areas.

The standards of WCC 16.16.320 shall apply.

(The rest of the tsunami code (above in underline) couldn't apply, as it has to do with building above the predicted flood height, which wouldn't apply to lahars.)

In a nutshell, WCC 16.16.320, states (the complete text is found in the Draft Code):

- That new development should to be located, engineered, and constructed to as to reduce risks and not increase hazard potential;
- That impacts should be avoided;
- That new development must be directed toward portions of a parcel that are not subject to, or at risk from, geological hazards;

- That critical facilities shouldn't be constructed or located in geologically hazardous areas if there's a feasible alternative location outside geologically hazardous areas that would serve the intended service population;
- That a qualified professional must review development proposals that occur in potentially geologically hazardous areas to determine the potential risk;
- That proposed development should be sited far enough from erosion and landslide hazard areas to ensure at least 100 years of useful life;
- That agricultural activities are be allowed within geologically hazardous areas, and,
- That subdivisions aren't allowed in most geohazard areas.

Option 2: Planning Commission Recommendation

As mentioned above (Development of the Proposed Lahar Hazard Zones, page 2), staff had recommended a simpler set of regulations to the Planning Commission, but with the caveat that we revisit this section after we have the newer USGS data. However, they were interested in looking at other options so staff helped developed the current proposal. One of the benefits of this scheme is that it sets up 4 different Lahar Hazard Zones based on estimated travel time of a lahar, allowing us to tailor regulations in each of those zones based on potential risk (see Table 1). In essence, it sets up a regulatory system similar to Piece County's, though without the detailed data.

However, as you well know, a number of people testified against this language at your first public hearing. The heart of the public opposition had to do with the proposed occupancy limits (shown in Table 1), and a perception that certain businesses wouldn't be able to expand. However, we don't believe those testifying saw, or understood, footnote 2 of that table, which states, "Maximum occupancies listed here may be increased per WCC 16.16.350(D)."

Table 1. Volcanic Hazard Zone Standards

Facility/Occupancy List[1]	Use Allowances and Maximum Occupancies[2]			
	Lahar Hazard Zone			
	A	B	C	D
Essential Facilities	Prohibited	Prohibited	Allowed, subject to underlying zoning, but shall meet the requirements of 16.16.260 and 265.	Allowed, subject to underlying zoning
Hazardous Facilities	Prohibited	Prohibited	Allowed, subject to underlying zoning, but shall meet the requirements of 16.16.260 and 265.	Allowed, subject to underlying zoning
Special Occupancies	Prohibited	Allowed, subject to underlying zoning, with a maximum occupancy of 100.	Allowed, subject to underlying zoning, but shall meet the requirements of 16.16.260 and 265.	Allowed, subject to underlying zoning
Covered Assemblies	Prohibited	Allowed, subject to underlying zoning, with a maximum occupancy of 100.	Allowed, subject to underlying zoning, but shall meet the requirements of 16.16.260 and 265.	Allowed, subject to underlying zoning
All other uses allowed by Title 20, Zoning	• *Within the Glacier LAMIRD* – All other uses allowed by Title 20, with a maximum occupancy of 25. • *Outside the Glacier LAMIRD* – Limited to single-family residences and their accessory structures	All other uses allowed by Title 20, with a maximum occupancy of 100.	Allowed, subject to underlying zoning, but shall meet the requirements of 16.16.260 and 265.	Allowed, subject to underlying zoning

1 See Article 9 for definitions of these facilities.
2 Maximum occupancies listed here may be increased per WCC 16.16.350(D).

> **16.16.350(D) Technical Assessment and Review.** In zones A & B[3], any project proposing a maximum occupant load greater than 25 shall be required to have a volcanic hazards assessment prepared by a qualified professional that includes recommendations for siting of improvements intending to avoid volcanic hazards and a volcanic hazard management and evacuation plan. In addition, the technical administrator shall have the authority to require such assessment for any project deemed subject to an elevated risk from volcanic hazards.

This section basically says that any of the occupancy limits may be raised if the applicant has a report done by a "qualified professional that includes recommendations for siting of improvements intending to avoid volcanic hazards and a volcanic hazard management and evacuation plan." It appears that the public testimony given against the Planning Commission's proposal was based on misinterpretation, as the proposed language would generally allow all development per the underlying zoning. Thus, contrary

[3] C & D not listed since occupancy limits aren't listed for those LIZs.

to their testimony, any of those business, schools, fire stations, etc. could expand as long as they put together an evacuation plan to get people out of harm's way were a lahar to occur (and meet the other parts of the zoning code).

In summary, staff believes that the Planning Commission's recommended language would work as a framework for future regulations, once better data is available, but doesn't believe that it works with the occupant loads proposed, especially without a warning system in place. Staff's original recommendation using the Piece County model would have maintained the existing lahar hazard area limits on occupancy and/or congregations of large numbers of people until the forthcoming USGS data could be used to adapt the proposed zonation based on a more accurate assessment of risk.

Option 3: A Lahar Code Based on the Existing Lahar Code, with Some Modifications

Given Council's intent and staff's concerns with Options 1 and 2, we have prepared a third alternative for consideration. The below language is based on our existing lahar code, but modified for clarity and brevity, to eliminate the concept of lahar hazard zones and occupancy limits, and to acknowledge existing, legal nonconforming uses, essential facilities, and cellular communication facilities. As you can see, it, too, would allow most uses but would require any land use of greater intensity or density than single-family residence and accessory structures to develop an emergency management and evacuation plan for their site, and for some uses to propose hazard mitigation measures.

16.16.350 Standards – Volcanic hazard areas.

A. The following uses may be allowed in volcanic hazard areas subject to WCC 16.16.320(A, B, and C) and the provisions below:
   1. Single-family residences and duplexes.
   2. Accessory structures not involving human occupancy.
   3. Sewer collection facilities, communication facilities, and other utilities that are not likely to cause harm to people or the environment if inundated by a lahar. Underground utilities such as pipelines shall be allowed if demonstrated through a Volcanic Hazard Assessment to not likely be damaged by scour caused by a lahar.
   4. Expansion of legal nonconforming uses meeting criteria of WCC 16.16.270 and WCC 20.83, and subject to the submittal and approval of a Volcanic Hazard Assessment meeting the requirements of subsection B(1-3).
   5. Essential facilities, subject to the submittal and approval of a Volcanic Hazard Assessment meeting the requirements of subsection B(1-3).
   6. All other uses allowed per the property's zoning district, subject to the submittal and approval of a Volcanic Hazard Assessment meeting the requirements of subsection B(1-4)

B. Volcanic Hazard Assessment Requirements. Where required by subsection A, a Volcanic Hazard Assessment shall be submitted for approval. Said assessment shall be prepared by a qualified professional or pertinent local, state, or federal agency and include the following elements:
   1. A travel time analysis that determines the amount of time anticipated for a lahar to reach the proposed project site.

2. If available, a description of existing or proposed detection and notification systems installed and maintained by a public entity. Until detection and notification systems are available, provide information on available resources for volcanic hazard monitoring and emergency preparedness.
3. An emergency management plan for the facility that:
    a. Is consistent with and integrated into a community emergency plan maintained by the Sheriff's Office of Emergency Management.
    b. Includes an emergency evacuation plan showing that the proposed project is that is within walking distance to a legally accessible area outside of the lahar inundation zone in an amount of time less than the anticipated time that it takes a lahar to reach the site, ideally after the triggering of a lahar warning system.
    c. Is required to be updated and exercised every three years.
4. Hazard mitigation measures deemed capable of withstanding lahar impacts and ensure life safety.

Summary

- Staff does not believe adopting regulations similar to the tsunami regulations is appropriate as it fails to provide sufficient mitigation for the interpreted hazards and would pose increased risk to our mountain communities. However, if after having this public discussion of risk Council wants to adopt regulations that allows higher occupancies and/or congregations of large numbers of people, staff suggests it would be prudent to find:
    - that lahars are not a significant hazard,
    - that an early warning and evacuation plan is adequate mitigation; and,
    - that the risk is acceptable.
- Though the Planning Commission's recommended language provides a good framework for the future, once better data is available, staff does not believe that it works with respect to occupant loads proposed. Staff's original recommendation using the Piece County model would have maintained the current limits on occupancy and/or congregations of large numbers of people until the forthcoming USGS data could be used to adapt the proposed zonation based on an accurate assessment of risk.
- Staff believes the 3rd option, a modified version of our current regulations, is the best interim approach to protecting people and property from potential volcanic hazards until a volcanic hazard monitoring system and emergency management plan is implemented and forthcoming hazard mapping can be included.
- Staff believes a robust volcanic hazard monitoring system and emergency management plan is warranted.
- Staff believes that the regulations should be revisited after we've received and analyzed the new lahar modeling data and volcanic hazard report we expect from the USGS within the next couple of years.

What Tahoma Audubon Society v. Pierce County Tells Us

(CPSGMHB Consolidated Case No. 05-3-0004c)

(The below text is verbatim from the decision.)

Tahoma Audubon Society challenged the provisions of Ordinance 2004-57s (Pierce County's CAO) concerning "covered assemblies" in certain volcanic hazard zones. Park Junction Partners intervened on behalf of the County. Petitioner Tahoma Audubon argued that Pierce County failed to use the best available science in allowing 400-person occupancy in a lahar inundation zone that would be inundated within one hour of a lahar event, in a valley where no early warning system was feasible. Pierce County responded that risk assessment is a public policy choice which must be left to elected officials. Park Junction Partners asserted that Mount Rainier visitors "voluntarily choose to assume volcano-related risks" and that Pierce County was entitled to weigh the lahar risk against the economic goals of the County in encouraging tourism.

The Board found that the County had used best available science in mapping the lahar inundation zones and in calculating the time for lahars to reach locations within the inundation zones. The Board found that the GMA mandate to use best available science to protect the "functions and values" of critical areas – RCW 36.70A.172 – has no apparent application to volcanic hazard areas and that no other GMA provision appears to require the County to make human life and safety its paramount concern when adopting critical areas regulations. The Board determined that Petitioner Tahoma Audubon did not carry its burden of proving Pierce County's action was non-compliant with the GMA. The Board agreed with the County that life-safety risk assessment is a public policy determination that rests with the moral conscience of elected officials, not with the Board. The Tahoma Audubon petition was dismissed.

This Board held that the state's "minimum guidelines" (365-190 WAC) are not mandatory, only advisory. However, the Board also concluded, "If the county does not use [the minimum guidelines] … it must explicitly identify those indicators it does use to satisfy the statutory analysis requirements."

Pierce County's regulations for volcanic hazard areas establish three sets of Lahar Inundation Zones based on the size of lahars as determined by the USGS – Case I, largest and least frequent, Case II, and Case III, most frequent but less destructive. Lahar travel times zones A, B, C, and D5 are based on the *estimated time for a lahar flow to reach a specific area*, adjusted for the availability of warning systems in the Puyallup River and Carbon River basins. No warning systems are practicable in the Upper Nisqually Valley because the likely source of lahars is too close to the population.

The County prohibits bonus densities in any of the volcano hazard areas. "Essential facilities"[4] and "hazardous facilities"[5] are also prohibited. ("Special Occupancy Structures" include schools, day care centers, nursing homes.)

[4] "Essential facilities" are necessary to maintain life and safety functions, such as police and fire stations, emergency medical facilities.

[5] "Hazardous facilities" house or support toxic or explosive chemicals.

In a Case II Lahar Inundation Zone, Travel Time Zone A, the occupancy of a "covered assembly" is limited to 100 persons unless the project proponent satisfies certain requirements, in which case the occupancy may be increased to 400. The special conditions involve providing for evacuation of all occupants to a safe height out of the lahar inundation zone in the time appropriate to the lahar travel time zone.

Tahoma Audubon claims that the County's "covered assembly" occupancy allowance in Lahar Inundation Zones violates RCW 36.70A.010 because the "safety" of the state's residents is not protected. However, the Board must look to sections of the statute that impose specific requirements because the Board's jurisdiction is limited to "the requirements of this chapter…."The Board concurs with the County. RCW 36.70A.010 – Legislative findings – indicates general legislative intent but does not create specific duties enforceable by this Board.

The Board is persuaded that Pierce County used best available science to designate its volcanic hazard areas. The County also incorporated best scientific analysis in its regulations by differentiating land use allowances based on current mapping of lahar inundation zones and, in particular, the lahar travel times from likely sources high on the flanks of Mount Rainier to populated areas in the lowlands. In addition, new lahar early warning systems were designed and installed in two drainages – Puyallup River and Carbon River – through close collaboration between Pierce County staff and USGS volcanologists.

The Board finds no direct requirement in the GMA that would allow it to substitute its judgment for that of the Pierce County elected officials on this matter. The GMA defines geologically hazardous areas as areas that "are not suited to siting of… development consistent with public health or safety concerns," [RCW 36.70A.030(9)], but there is no affirmative mandate associated with this definition except "protect the functions and values." Petitioners have not persuaded the Board that the requirement to protect the functions and values of critical areas has any meaning with respect to volcanic hazard areas or that the GMA contains any independent life-safety mandate.

The Board agrees with Pierce County that land use policy and responsibility with respect to Mount Rainier Case II lahars – "low probability, high consequence" events – is within the discretion of the elected officials; they bear the burden of deciding "How many people is it okay to sacrifice?"

A Risk Based Planning Approach for Lahar and Volcanic Hazards in Whatcom County

John Gargett, Deputy Director, Division of Emergency Management, Whatcom County Sheriff's Office

Whatcom County faces the potential for a variety of risk, safety and security, and emergency/crisis events from its coastal waters on the Salish Sea to its eastern border in the North Cascades. The risks and threats have been well documented in the 2016 Whatcom County Natural Hazard Mitigation Plan. The Mitigation Plan is used to help guide both land use and emergency planning efforts. The 2016 Whatcom County Comprehensive Emergency Management Plan addresses how Whatcom County will respond to a catastrophic event that affects the entire county.

While many of the natural hazard risks have been known and existed for years, the density of population in these risk areas has grown, the nature of the responsibility of Whatcom County government to provide a response has grown, and residents and users of these areas are expecting more of government.

The Federal Emergency Management Agency has been conducting an update to the risk map (RiskMap) for Whatcom County since 2011. The primary goal of the Federal Emergency Management Agency RiskMap program is to reduce the loss of life and property through an integrated community approach of Risk Based Emergency Planning. The preliminary results of this work were presented in January 2017 and the information is a valuable tool in helping Whatcom County develop a resilience strategy to the risks facing Whatcom County.

Figure 1 - FEMA RiskMap Life Cycle

One of the rationales for Risk Based Emergency Planning in Whatcom County is that we are a diverse geological environment that has continued, and will continue, to change over time. Landslides, volcanic eruptions, lahars, mud flows, floods, earthquakes, tsunamis, wild fires, wind storms and severe weather are part of living in Whatcom County. The Whatcom County Natural Hazard Mitigation Plan is a living and active document that addresses many of these hazards from a comprehensive planning perspective, the results of should be incorporated into land use regulations. Mitigation efforts and land use regulations do have a positive impact on the effects of many of these hazards but they do not eliminate the hazard and are only a part of Risk Based Planning.

The Whatcom County Sheriff's Office Division of Emergency Management is responsible for the Whatcom County Natural Hazard Mitigation Plan and Comprehensive Emergency Management Plan. The Whatcom County Sheriff's Office Division of Emergency Management recognizes that there also must be site, hazard, and threat specific planning that builds beyond the base provided by the Natural Hazard Mitigation Plan and Comprehensive Emergency Management Plan. You cannot eliminate all risk through land use planning and you cannot have comprehensive planning apply to every risk. We must live in harmony with our natural environment and build a resilient community that ensures that

property rights, environmental protection, economic development, land use planning, and emergency management are balanced, and that the risks are understood, reasonable strategies employed, and communities protected.

Risk Based Emergency Planning recognizes that some areas in Whatcom County have unique risks that may require this balanced approach, and that it is not possible to mitigate all effects of a hazardous event. Risk Based Emergency Planning views the sub segments of a community as an ecosystem comprised of the natural environment, existing and proposed land use policies, emergency detection, warning and action plans. (See Figure 1)

Figure 1 - Risk Based Planning Methodology

Case 1: Risk Based Emergency Planning Applied to the Tsunami Threat in Coastal Whatcom County

Tsunamis are a potential threat for our coastal communities here in Whatcom County, although arguably one of the lower threats. Winter Storms, Erosion, Severe Winds, and Tidal Overflow all occur regularly, have significant impact, and regularly cause damage to our coastal areas.

Beyond the Washington State Department of Natural Resources and National Oceanic and Atmospheric Administration Tsunami Hazard Map of the Bellingham Area[6], there has been no published scientific

[6] Walsh, T.J., V.V. Titov, A.J. Venturato, H.O. Mofjeld, and F.I. Gonzalez (2004b): *Tsunami hazard map of the Bellingham area, Washington: Modeled tsunami inundation from a Cascadia subduction zone earthquake*.

information on the tsunami threat to Whatcom County. Even in the study one of the limitations is, "*while the modeling can be a useful tool to guide evacuation planning, it is not of sufficient resolution to be useful for land-use planning*"

Tsunamis are unquestionably a potential risk that must be planned for the coastal areas of Whatcom County. While there may be scientific debate about frequency, size, type, and other details related to the specific impacts, the Washington State Department of Natural Resources and National Oceanic and Atmospheric Administration Tsunami Hazard Map does suggest that the coastal areas of Whatcom County should plan for surge inundations of between three and five meters. There has been some additional modeling expected to be published in 2017 that suggests the planning for a surge in Whatcom County could be between five and seven meters. The Risk Based Emergency Planning approach is shown in Figure 2.

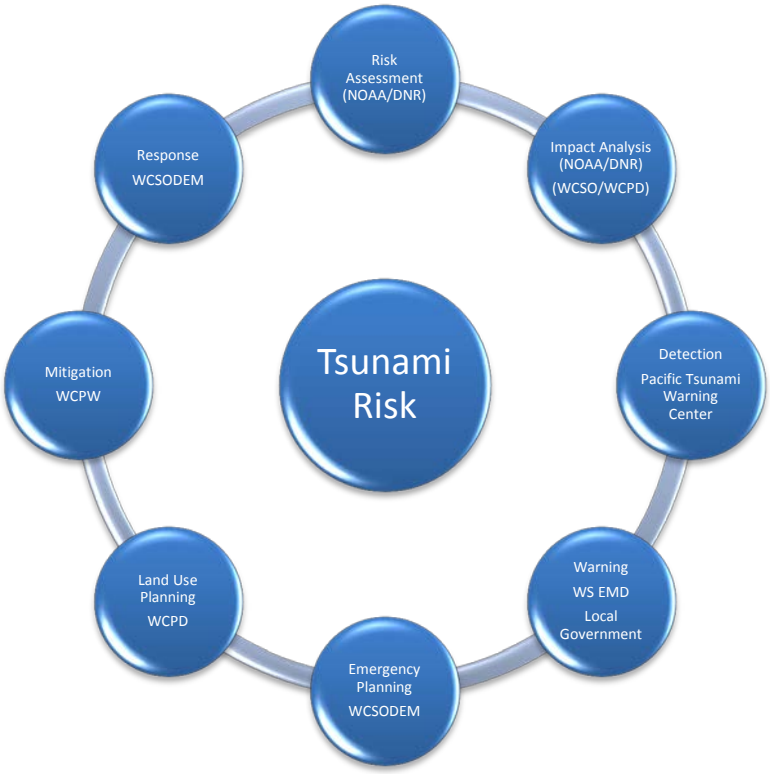

Figure 2 - Risk Based Planning for Tsunami's In Whatcom County

What we do know about tsunamis in Whatcom County is that:

- The risk of a tsunami is real based on the best available science;
- There is a potentially significant impact on our coastal communities;
- There is an international warning system for regional or distant tsunamis;

Washington Division of Geology and Earth Resources Open File Report 2004-15, 40 × 36 in. color sheet, scale 1:50,000.

- The building code requires mitigation for structures built in tsunami threatened Coastal Communities;

When the risk of tsunamis is considered against what Whatcom County has done, the results are generally that Whatcom County is not prepared for a tsunami because it has:

- No comprehensive coastal warning system;
- No Coastal Community specific emergency response plans;
- Never exercised its Whatcom County Comprehensive Emergency Management Plan for a tsunami;
- Held minimal, if any, training with Whatcom County departments, local fire districts, or regional partners on a tsunami response in the Coastal Communities of Whatcom County.

If a formal audit were conducted on the state of readiness of Whatcom County following a tsunami today, the summary would probably say that while Whatcom County was aware of the risk and did undertake some building standards, but it did not have a comprehensive warning system, had not done Coastal Community Emergency Planning, and was generally unprepared as shown in Figure 3.

Figure 3 – Possible Audit Outcome on Whatcom County Tsunami Preparedness

The fact that the Whatcom County Sheriff's Office Division of Emergency Management has begun Risk Based Emergency Planning specifically for Tsunamis in 2017 would perhaps mitigate these short-comings and be a positive factor in the final report since the work was underway.

Case 2: Jones Creek Landslide – A Risk Based Emergency Planning Success

Whatcom County has one of the largest landslide risk profiles in Washington State. The Jones Creek alluvial fan and associated deep-seated landslide in Acme is an example of effective Risk Based Emergency Planning. The 27-acre slide area in Jones Creek that is currently moving is not new or unique in the drainage. The town of Acme is built on the alluvial fan of Jones Creek, created by the outflow of previous slides over thousands of years. The Acme Elementary School is in the outflow area, as are most of the buildings (both commercial and residential) in the town of Acme. Jones Creek has had debris flows for thousands of years and will continue to experience them.

Because of the 2009 debris flow, as well as the work of Kerr Wood Leidal in 2003 on the slide, the community of Acme, along with Whatcom County, began a comprehensive look at how to live with the identified hazard. Whatcom County Public Works has engineered mitigation that should redirect potential flows away from Acme and is currently seeking funding to undertake additional work. Whatcom County Planning has incorporated the hazards into the process for new building permits. The Whatcom County Sheriff's Office Division of Emergency Management has developed a response strategy in concert with Whatcom County Fire District #16, Whatcom County Public Works, Mt. Baker School District, and the Washington State Department of Natural Resources. The United States Geological Survey has placed a gauge on Jones Creek as a detection measure with funding from Whatcom County Public Works. Whatcom County Fire District #16 is responsible for early warning. The Whatcom County Sheriff's Office Division of Emergency Management leads the ongoing review, update, exercising, and implementation of the emergency plan.

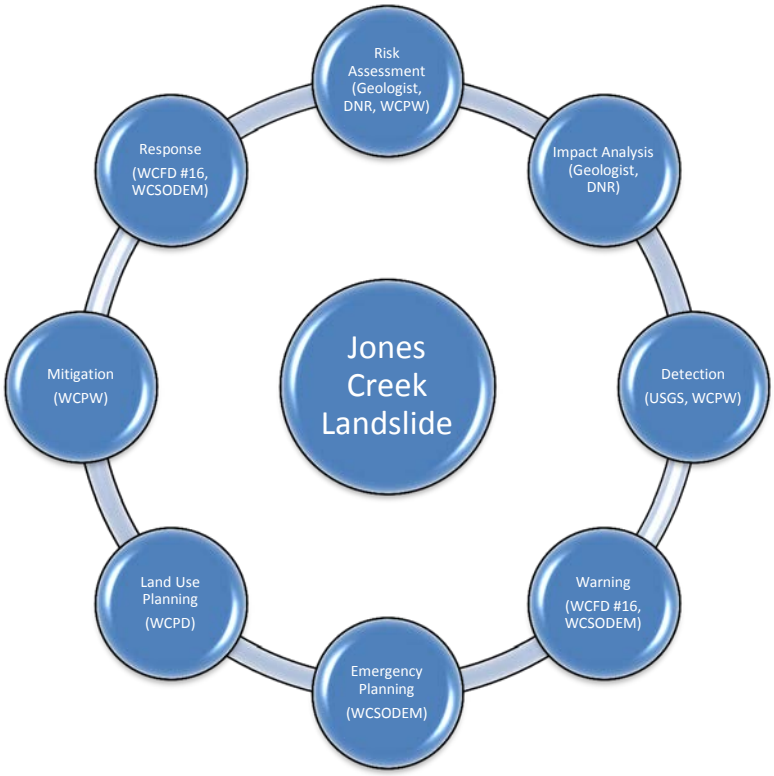

Figure 4 -Jones Creek Risk Based Planning

The Whatcom County Sheriff's Office Division of Emergency Management has applied Risk Based Emergency Planning to Jones Creek; thus, Whatcom County is aware of the hazard and is addressing the hazard from all possible perspectives.

If a formal audit were conducted on the state of readiness of Whatcom County following a landslide at Jones Creek today, the summary would probably say that Whatcom County was aware of the hazard, had undertaken Risk Based Emergency Planning, incorporated the hazards into its land use planning, had a detection and warning system in place, had planned its response, and was undertaking mitigation activities. (See Figure 5.)

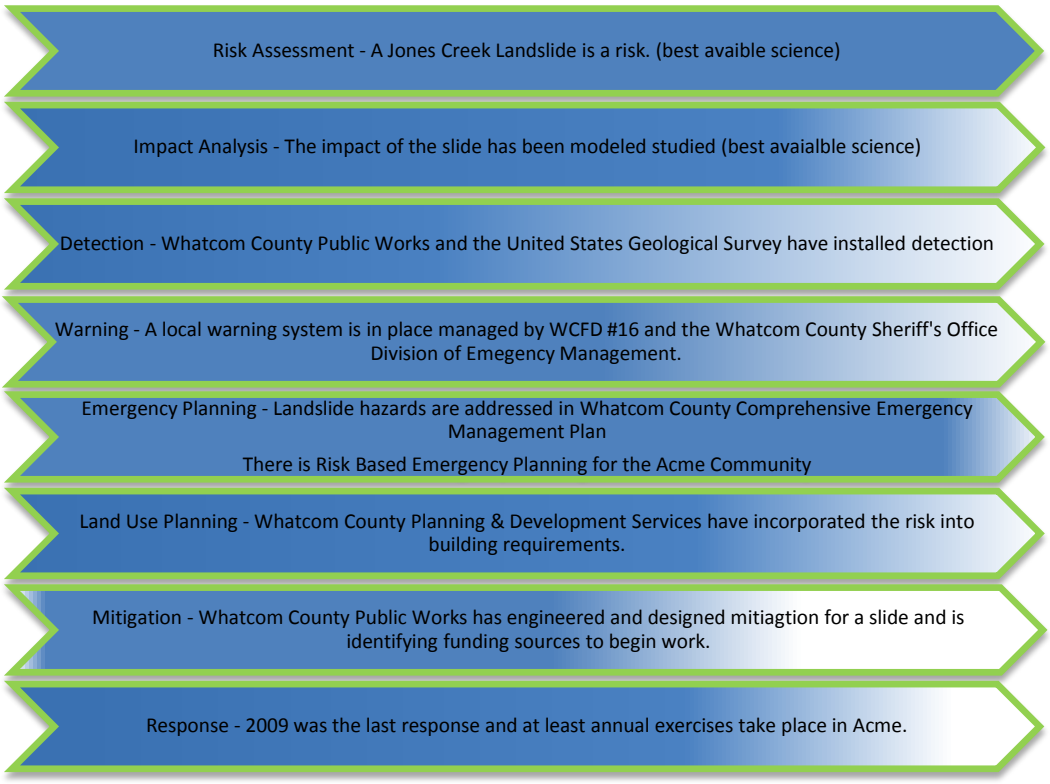

Figure 5 – Possible Outcome on Whatcom Counties Preparedness for a Jones Creek Landslide

Case 3: Risk Based Emergency Planning Applied to the Volcanic and Lahar Threat in Whatcom County

Mt. Baker is an active volcano and a threat for communities in Whatcom County, although, as with tsunamis, arguably one of the lower threats. Based on the Federal Emergency Management Agency RiskMap report, lahars are a clear risk in Whatcom County, "*A lahar is a mudflow or debris flow from the slope of a volcano that originates from melted snow and ice. An eruption from Mount Baker could cause a lahar to follow the Nooksack River drainage and through portions of Ferndale. Mount Baker has erupted in the past and will erupt again. While the probability of an eruption is low, volcanic activity will cause massive destruction of property and probable loss of life. Volcanic activity that results in a debris flow could also cause flooding along the Nooksack River. There may be little warning for nearby populations to evacuate in the event of a lahar. An eruption could also trigger earthquakes and landslides (Whatcom County 2015).*"

The United States Geological Survey, through the David A. Johnston Cascades Volcano Observatory, has studied and documented the potential hazards of Mt. Baker. These include Lava Flows, Pyroclastic Flows, Tephra, and Lahars. While all are potential threats to the general population of Whatcom County, Lahars present the largest threat to the Nooksack River communities, as shown in Figure 6.

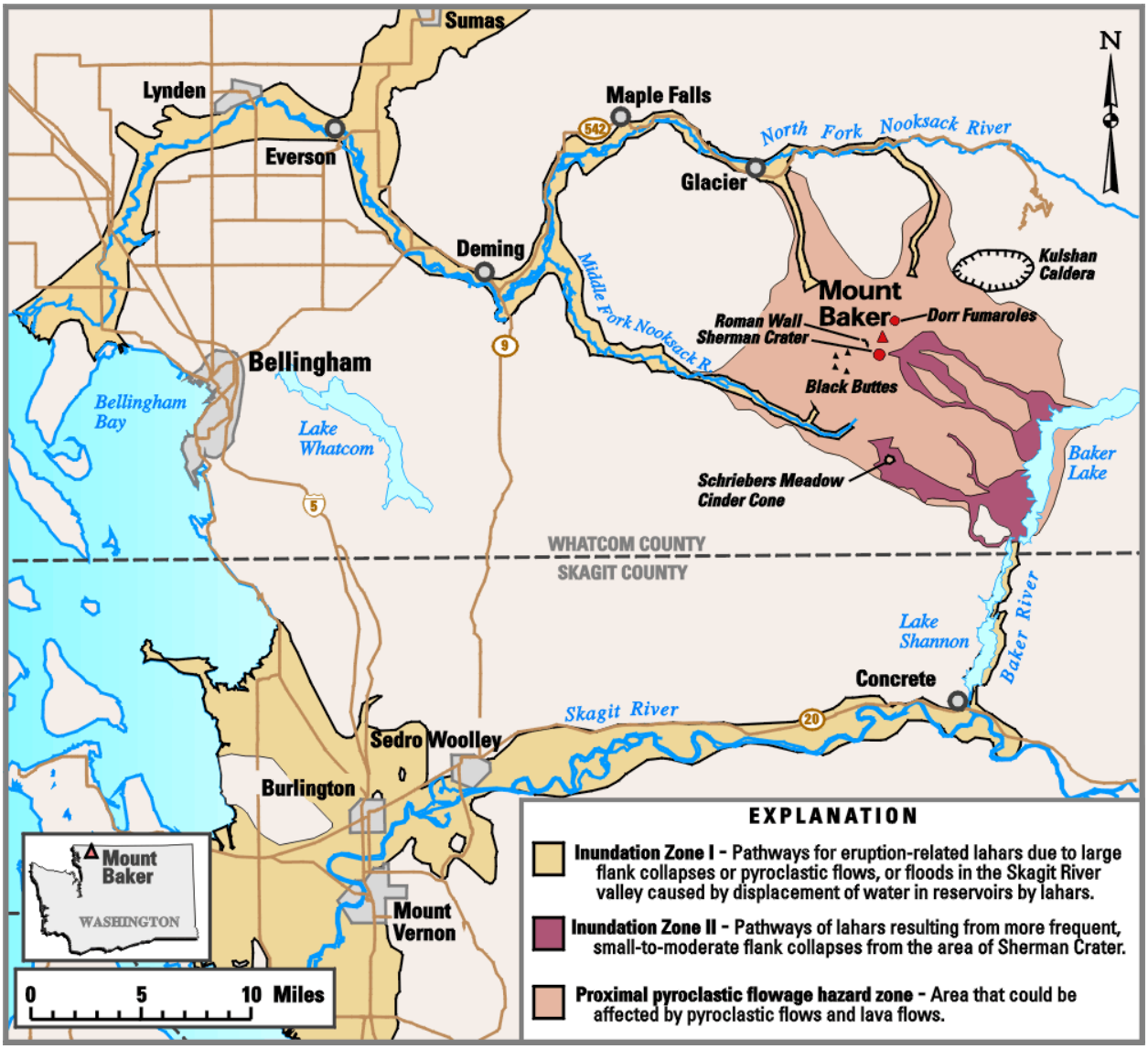

Figure 6 - Lahar Hazard to Whatcom County[7]

Lahars are a known documented hazard in Whatcom County and directly threaten communities along the Middle and North Forks of the Nooksack River, including the towns of Glacier, Maple Falls, and Deming. Lahars also could cause damage in the towns of Everson, Sumas, Lynden, and Ferndale. In the 2017 Federal Emergency Management Agency RiskMap Report, over 600 buildings in Ferndale are identified that may be at risk from Mt. Baker Lahars. According to the United States Geological Survey,

[7] *Potential volcanic hazards from future activity of Mount Baker, Washington*, Open-File Report 95-498, By: Cynthia A. Gardner, K.M. Scott, C.D. Miller, B.M. Myers, Wes Hildreth, and P.T. Pringle

6800 years ago there was a lahar (not caused by a volcanic eruption but rather a landslide) that is described where: "*deposits in the Middle Fork indicate that the debris flow was at least 100 m (325 ft) deep as it moved downvalley. Deposits from this event can be traced from the Middle Fork to the main Nooksack River and as far downstream as Deming. Beyond Deming, these deposits are buried by river sediments; however, on the basis of the behavior of similarly sized cohesive debris flows at Mount Rainier and Mount St. Helens, it is likely that this debris flow continued downstream to Puget Sound.*"

The lahar that occurred about 6800 years ago is not unique in the documented history of events from Mt. Baker. To ensure that the information on the hazards of Mt. Baker is well understood, the United States Geological Survey is in the process of updating the models for the potential effects of lahars from Mt. Baker. Other scientists have expressed their belief that the effects of lahars may be overstated, however, all agree that the threat does exist at least as far downstream as Deming.

Lahars are unquestionably a potential hazard with associated risks that must be planned for the Middle and North Fork of the Nooksack River drainages of Whatcom County. While there may be scientific debate about frequency, size, type, and other details related to the specific impacts, the United States Geological Survey, Washington State Department of Natural Resources, and both Whatcom County and Private Geologists do agree that Whatcom County should plan for lahars. In terms of the Risk Based Emergency Planning approach, this is shown in Figure 7.

Figure 7 - Risk Based Planning for Lahar's In Whatcom County

What we do know in Whatcom County about Lahars is that:

- The hazards and risk of lahars is real based on the best available science;
- There is a potentially significant impact on our riverine and mountain communities;

When the risk of lahars is considered against what Whatcom County has done, the results are that Whatcom County is not prepared for a Lahar because it has:

- Very limited detection;
- No Warning System
- No Mountain or Riverine community specific emergency response plans;
- Never exercised its Whatcom County Comprehensive Emergency Management Plan for a lahar or eruption of Mt. Baker;
- Held minimal, if any, training with Whatcom County departments, local fire districts, or regional partners on a lahar response in Whatcom County.

If a formal audit were conducted on the state of readiness of Whatcom County following a lahar today, the summary would probably say that Whatcom County was aware of the hazards and potential risks, but due to a lack of detection equipment, warning systems, Risk Based Emergency Planning, clear land use requirements, and limited mitigation efforts, was woefully unprepared (Figure 8).

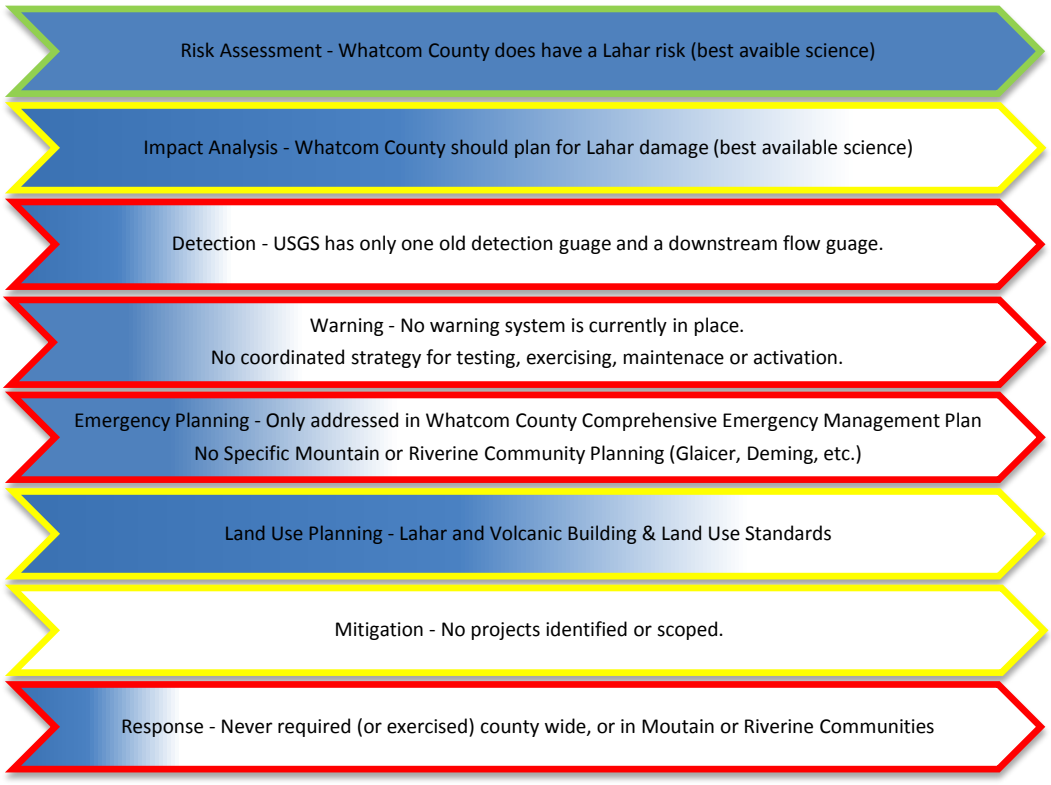

Figure 8 – Possible Audit Outcome on Whatcom County Lahar and Volcanic Preparedness

The fact that the Whatcom County Planning and Development Services has undertaken community based land use planning since at least 2005 and the Whatcom County Sheriff's Office Division of

Emergency Management has begun planning for a 2018, lahar-based volcanic hazard full-scale exercise would perhaps mitigate for these short-comings and be a positive factor in the final report since the work was underway. It is critical for Whatcom County to demonstrate that it is aware of its hazards and potential risks and is addressing those risks from all possible perspectives.

Conclusion

Whatcom County needs to undertake Risk Based Emergency Planning for it volcanic and lahar hazards and associated risks as the density of population in these risk areas has grown, the nature of the responsibility of Whatcom County government to provide a response has grown, and the expectations of the residents and users of these areas are expecting more of government. Landslides, volcanic eruptions, lahars, and mud flows are realities of living in Whatcom County. You cannot eliminate all risk through land use planning alone and you cannot have comprehensive emergency planning that applies to every risk. We must live in harmony with our natural environment and build a resilient community that ensures that property rights, environmental protection, economic development, land use planning, and emergency management are balanced, that the risks are understood, reasonable strategies are employed, and communities are protected through Risk Based Emergency Planning.

Existing CAO Language

Article 3. Geologically Hazardous Areas

16.16.310 Designation, mapping and classification.

C. For purposes of this chapter, geologically hazardous areas shall include all of the following:
   4. Volcanic Hazard Areas. Volcanic hazard areas shall include areas subject to lava flows, pyroclastic flows, pyroclastic surges, mud flows, lahars, debris flows, debris avalanche, ash (tephra) clouds or ash (tephra) fall, lateral blast, ballistic debris, or flooding resulting from volcanic activity.

16.16.350 Standards – Volcanic hazard areas.

Development may be allowed in volcanic hazard areas; provided, that all reasonable measures have been taken to minimize risks and other adverse effects associated with volcanic hazards, and when the amount and degree of the alteration are limited to the minimum needed to accomplish the project purpose. For lahar inundation zones, the following activities shall be allowed as specified:

A. Developments that meet the reasonable use or variance standards and procedures as set forth in WCC 16.16.270.
B. Sewer collection facilities and other utilities that are located underground and not likely to cause harm to people or the environment if inundated by a lahar.
C. Critical facilities, as defined in subsection 1 of "critical facilities," Article 8 of this chapter, of 50 or more persons may be permitted within lahar inundation zones subject to the conditional use permit requirements of Chapter 20.84 WCC; provided, that the following criteria are also met:
   1. The applicant demonstrates through submittal of a travel time analysis prepared by a qualified professional or local, state, or federal agency the amount of time that is anticipated for a lahar to reach the proposed project and evacuation route, together with a description of existing or proposed detection and notification systems to be installed and maintained by a public entity.
   2. The applicant has provided an emergency evacuation plan prepared by a qualified professional or local, state, or federal agency showing that the proposed project is located directly adjacent to a safety zone that is within walking distance in an amount of time less than the anticipated time that it takes a lahar to reach the site after the triggering of an alarm and notification.
D. Accessory structures not involving human occupancy shall be allowed.
E. Single-family developments and duplexes may be permitted in lahar hazard areas subject to WCC 16.16.320(A).

16.16.320 Geologically hazardous areas – General standards.

The following requirements shall apply to all activities in geologically hazardous areas:

A. Alterations shall be directed toward portions of parcels or parcels under contiguous ownership that are not subject to, or at risk from, geologic hazards and/or are outside any associated buffer established by this article.

16.16.800 Definitions.

"Critical facilities (essential facilities)" means buildings and other structures that are intended to remain operational in the event of extreme environmental loading from flood, wind, snow or earthquakes pursuant to the International Building Code (IBC), 2003 Edition. These include, but are not limited to:

1. Buildings and other structures that represent a substantial hazard to human life in the event of failure including, but not limited to:
    a. Buildings and other structures where more than 300 people congregate in one area;
    b. Buildings and other structures with elementary school, secondary school or day care facilities with an occupant load greater than 250;
    c. Buildings and other structures with an occupant load greater than 500 for colleges or adult education facilities;
    d. Health care facilities with an occupant load of 50 or more resident patients but not having surgery or emergency treatment facilities;
    e. Jails and detention facilities;
    f. Any other occupancy with an occupant load greater than 5,000;
    g. Power-generating stations, water treatment for potable water, wastewater treatment facilities and other public utility facilities not included in subsection 2 of this definition;
    h. Buildings and structures not included in subsection 2 of this definition containing sufficient quantities of toxic or explosive substances to be dangerous to the public if released.
2. Buildings and other structures designed as essential facilities including, but not limited to:
    a. Hospitals and other health care facilities having surgery or emergency treatment facilities;
    b. Fire, rescue, and police stations and emergency vehicle garages;
    c. Designated earthquake, hurricane or other emergency shelters;
    d. Designated emergency preparedness, communication, and operation centers and other facilities required for emergency response;
    e. Structures containing highly toxic materials as defined by IBC Section 307 where the quantity of the material exceeds the maximum allow-able quantities of IBC Table 307.7(2);
    f. Aviation control towers, air traffic control centers and emergency air-craft hangars;
    g. Buildings and other structures having critical national defense functions;
    h. Water treatment facilities required to maintain water pressure for fire suppression;
    i. Power-generating stations and other public utility facilities required as emergency backup facilities for structures listed above.

Chapter 365-190 WAC Minimum Guidelines to Classify Agriculture, Forest, Mineral Lands, and Critical Areas

WAC 365-190-120 Geologically hazardous areas

(11) Geologically hazardous areas. Geologically hazardous areas include areas susceptible to erosion, sliding, earthquake, or other geological events. They pose a threat to the health and safety of citizens when incompatible commercial, residential, or industrial development is sited in areas of significant hazard.

(12) Some geological hazards can be reduced or mitigated by engineering, design, or modified construction or mining practices so that risks to public health and safety are minimized. When technology cannot reduce risks to acceptable levels, building in geologically hazardous areas must be avoided. The distinction between avoidance and compensatory mitigation should be considered by counties and cities that do not currently classify geological hazards, as they develop their classification scheme.

(13) Areas that are susceptible to one or more of the following types of hazards shall be classified as a geologically hazardous area:

- (a) Erosion hazard;
- (b) Landslide hazard;
- (c) Seismic hazard; or
- (d) Areas subject to other geological events such as coal mine hazards and volcanic hazards including: Mass wasting, debris flows, rock falls, and differential settlement.

(14) Counties and cities should assess the risks and classify geologically hazardous areas as either:

- (a) Known or suspected risk;
- (b) No known risk; or
- (c) Risk unknown – data are not available to determine the presence or absence of risk.

(15) Erosion hazard areas include areas likely to become unstable, such as bluffs, steep slopes, and areas with unconsolidated soils. Erosion hazard areas may also include coastal erosion areas: This information can be found in the Washington state coastal atlas available from the department of ecology. Counties and cities may consult with the United States Department of Agriculture Natural Resources Conservation Service for data to help identify erosion hazard areas.

(16) Landslide hazard areas include areas subject to landslides based on a combination of geologic, topographic, and hydrologic factors. They include any areas susceptible to landslide because of any combination of bedrock, soil, slope (gradient), slope aspect, structure, hydrology, or other factors, and include, at a minimum, the following:

- (a) Areas of historic failures, such as:
  - (i) Those areas delineated by the United States Department of Agriculture Natural Resources Conservation Service as having a significant limitation for building site development;
  - (ii) Those coastal areas mapped as class u (unstable), uos (unstable old slides), and urs (unstable recent slides) in the department of ecology Washington coastal atlas; or

(iii) Areas designated as quaternary slumps, earthflows, mudflows, lahars, or landslides on maps published by the United States Geological Survey or Washington department of natural resources.

(b) Areas with all three of the following characteristics:
  (i) Slopes steeper than fifteen percent;
  (ii) Hillsides intersecting geologic contacts with a relatively permeable sediment overlying a relatively impermeable sediment or bedrock; and
  (iii) Springs or groundwater seepage.

(c) Areas that have shown movement during the Holocene epoch (from ten thousand years ago to the present) or which are underlain or covered by mass wastage debris of this epoch;

(d) Slopes that are parallel or subparallel to planes of weakness (such as bedding planes, joint systems, and fault planes) in subsurface materials;

(e) Slopes having gradients steeper than eighty percent subject to rockfall during seismic shaking;

(f) Areas potentially unstable as a result of rapid stream incision, stream bank erosion, and undercutting by wave action, including stream channel migration zones;

(g) Areas that show evidence of, or are at risk from snow avalanches;

(h) Areas located in a canyon or on an active alluvial fan, presently or potentially subject to inundation by debris flows or catastrophic flooding; and

(i) Any area with a slope of forty percent or steeper and with a vertical relief of ten or more feet except areas composed of bedrock. A slope is delineated by establishing its toe and top and measured by averaging the inclination over at least ten feet of vertical relief.

(17) Seismic hazard areas must include areas subject to severe risk of damage as a result of earthquake induced ground shaking, slope failure, settlement or subsidence, soil liquefaction, surface faulting, or tsunamis. Settlement and soil liquefaction conditions occur in areas underlain by cohesionless soils of low density, typically in association with a shallow groundwater table. One indicator of potential for future earthquake damage is a record of earthquake damage in the past. Ground shaking is the primary cause of earthquake damage in Washington, and ground settlement may occur with shaking. The strength of ground shaking is primarily affected by:

(a) The magnitude of an earthquake;

(b) The distance from the source of an earthquake;

(c) The type or thickness of geologic materials at the surface; and

(d) The type of subsurface geologic structure.

(18) Other geological hazard areas:

(b) Volcanic hazard areas must include areas subject to pyroclastic flows, lava flows, debris avalanche, or inundation by debris flows, lahars, mudflows, or related flooding resulting from volcanic activity.

(c) Mine hazard areas are those areas underlain by, adjacent to, or affected by mine workings such as adits, gangways, tunnels, drifts, or air shafts. Factors which should be considered include: Proximity to development, depth from ground surface to the mine working, and geologic material.