

**Final Report**

**NSHM Product Usability Testing - Public Map and Web Content**

Contract # G15PC00059

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### **Acknowledgements**

We gratefully acknowledge all of the individuals who participated in this project. Participants were enthusiastic, engaged, focused, reflective and honestly responded with their judgments and ideas about the maps and communicating earthquake hazard. We thank them for their time and important contributions.

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## I. OVERVIEW

U.S. Geological Survey National Seismic Hazard Model (USGS NSHM) maps are a highly technical product with a strong presence in the informational culture of our non-technical society. NSHM maps reach well into the public's eye through the media and third party resources, especially on-line.

Patterns of information seeking are well studied in public health and the social sciences more broadly [1-5]. When people want to understand technical information such as earthquake hazard, they often start with reputable authorities such as the USGS, but if they don't understand the authoritative information, they will keep looking for information they can understand, and too often end up with inaccurate interpretations or pseudo-science. It can be very difficult to change such initial impressions (confirmation bias) [6-8]. Thus recent NSHM efforts to improve the understanding of their products by non-technical audiences are well founded.

Many professionals who are important actors in hazard preparedness are highly educated but have limited technical expertise. This group includes emergency managers (EMs) and state and local officials. It is important to note that EMs in particular play an important role in communication and decision making around hazard planning and mitigation, not just in response.

When experts make products for the "general public", such products can miss their mark because the general public is not homogeneous. Instead, it is composed of many different audiences with different needs. Thus this study targeted a particular subset of the "general public", EMs and associated state and local officials. The selection of this audience was driven by these factors:

- that is the make-up of members of the North Texas Earthquake Working Group who have expressed urgent need to understand NSHM products, especially the upcoming 1-year map;
- at the 2014 workshop "New Audiences, New Products for the NSHM", participants recommended that NSHM products focus on local officials, the general public, and "go-between" experts who interpret NSHM for others;
- several colleagues in EM have made repeated requests to Sue Perry for certain changes to the NSHM public map; and
- it is reasonable to assume that results with this audience could also apply to other highly educated non-technical audiences.

In 2014, social scientists and readability experts at How to Health Literacy (H2HL) conducted a small pilot study of the NSHM 2008 public map. It found that a small sample of highly educated but non-technical test users had difficulty interpreting the map and associated web pages. Users misunderstood fundamental map messages and concepts. This led to the larger study conducted in fall 2015 by H2HL.

The main objective of this study was to identify what revisions and enhancements of the USGS NSHM map would improve its usability among Emergency Managers (EMs) and closely affiliated Emergency Management personnel.

To accomplish these objectives, we used a user-centered design approach to evaluate conceptual, linguistic and design elements of existing USGS maps and new map elements inserted as potential aiding tools.

This study was conducted in two phases: 1) initial introduction and exploratory interviews and 2) subsequent usability testing sessions. Study interviews and usability sessions were conducted from September 2015-December 2015. A total of eight non-federal individuals and four federal employees participated in the study.

Through the usability testing, we identified and explored all users' responses to: three existing NSHM maps (Figs. 1-3): NSHM 2014 map, 2% in 50 years, PGA, with induced seismicity polygons ("Map %g"); 2) Map that shows number of damaging earthquakes, at MMVI or greater, in 10,000 years ("Map #/VI"); 3) Map that interprets %g in terms of MMI ("MMI Map") *We will refer to these maps respectively as "Map %g", "Map #/VI, and "Map MMI" going forward.* Also tested were variations to the color, legend and descriptive text of Map #/VI.

For a subset of users in areas experiencing suspected non-tectonic earthquakes, we also gathered user response to (Fig.4), the Ground Shaking Hazard from Natural and Induced Earthquakes (Figure 13-B from USGS Open-File Report 2015-1070 about the fall 2014 Oklahoma workshop). The final version of the 1-year map was being developed while this usability study occurred.

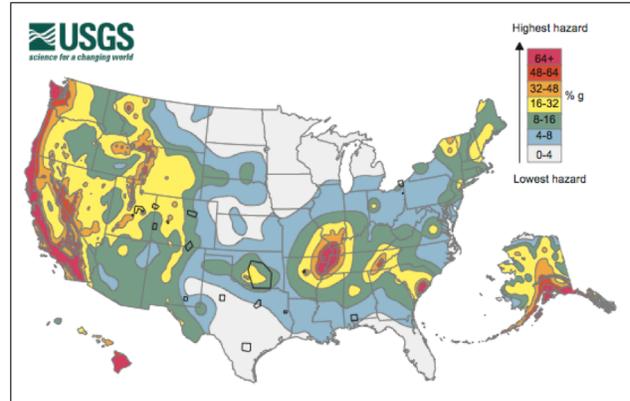
Finally, we tested users' reactions to selections of web content developed for a non-technical audience.

## Findings

- All study participants found it necessary to provide information about earthquake hazard to a wide range of interested parties, such as the public at large, public officials (both at local and state levels), community partners, and the media, as well as individuals directly involved in emergency planning and management.
- Unanimously study participants want an earthquake map to function in two ways:
  - to provide clear, not overly technical information on earthquake hazards to assist them in their mitigation planning;
  - to provide usable tools to present and explain earthquake hazard to various constituents, including local officials, the general public, and other audiences

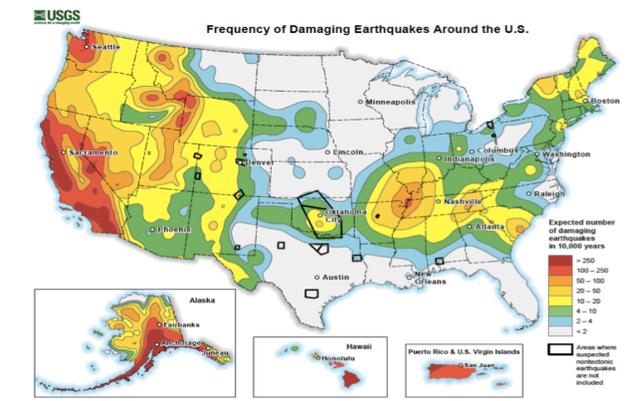
### Figure 1: Map %g

**Description:** NSHM 2014 map, 2% in 50 years, PGA, with induced seismicity polygons



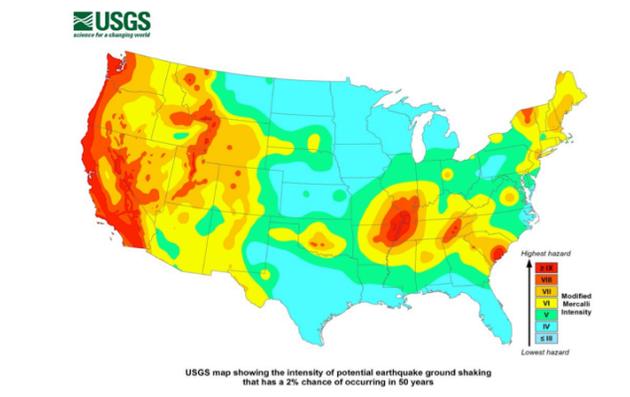
### Figure 2: Map #/VI

**Description:** Map that shows number of damaging earthquakes, at MMVI or greater, in 10,000 years. Adapted from a map that USGS made for the FEMA Preparationthon  
<http://community.fema.gov/hazard/earthquake/be-smart>



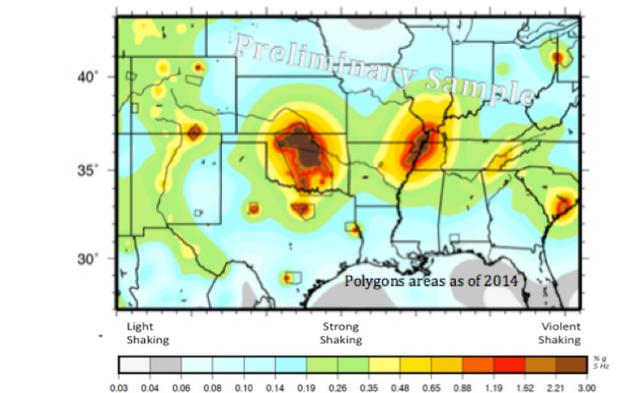
### Figure 3: MMI Map

**Description:** Map that interprets %g in terms of MMI, as used in Jaiswal et al, 2015



### Figure 4: Natural and Induced Map

**Description:** Ground Shaking Hazard from Natural and Induced Earthquakes. Figure 13-B from USGS Open-File Report 2015-1070



- Corroborating NSHM experience with users of Map %g, our study participants said that metric (%g) used in the map was difficult to use and even more difficult to explain to an audience. Even participants who regularly use this map and were facile with the concept of %g did not believe %g was the most effective way to communicate earthquake hazard to non-technical users.
- As opposed to the %g map, users reacted positively to Map #/VI and the MMI Map. These maps presented information of interest to them and held out the promise of interpretability. However, users identified specifics about what made the maps easier and harder to interpret and use.
- Hazard map colors served both functional and aesthetic roles for the study participants. While some participants *preferred* a “classic” as opposed to a “warm” colored hazard map, all participants *interpreted* the colors similarly; with the “warm” colors conveying greater hazard than greens, blues, and whites/greys.
- Participants suggested a specific section on the NSHM website with accessible, understandable information to help explain earthquake hazard maps. Topics such as ‘*How to read this map*’, ‘*How to use this map*’ were seen as particularly useful.
- Participants were divided in their opinions as to the language level needed on the website. Most felt offering the ability to drill down from more simple information (seen as useful for town council members or local officials) to more detailed information would be help to address this issue.
- Users encountered barriers and difficulties in various conceptual, linguistic, and design elements of the maps.
  - Conceptual barriers to accurate interpretation of the map included not understanding technical terms and concepts (e.g. %g, probabilities, ‘geologic time’); understanding how probabilistic maps work; interpretation of hazard vs risk.
  - Linguistic/literacy barriers included confusion in interpreting terms such as “frequency” and “damaging”, specific math literacy difficulties regarding understanding the computation involved with %g.
  - Design barriers included misinterpretation of the legend; decoding color schemes accurately; as well as decoding symbols currently used for nontectonic earthquake hazard areas.

## Recommendations

The following recommendations are divided into those related to the maps themselves and then those related to any accompanying web-based or print materials:

### ➤ Recommendations for the Maps

- Revise and produce Map #/VI as the primary map. Map#/VI should be used for printing on postcard and should appear in primary position as first map in the new web content. MMI Map as 2nd and Map %g as 3rd map. Most users felt that maps worked best in conjunction, each telling an important piece of the story.
- Make all three maps easily accessible on the website.
- Follow good principles of map design. In particular: map hierarchy, title, legend, lines, explanatory text/notes and color.

- Include a written as well as a numeric label for each category of the legend. Consider limiting the legend categories to 5.
- Use a warm color pallet if the intention is to show that earthquake hazard exists everywhere.
- For the areas with "nontectonic" earthquakes, use new graphic elements with rounded and thinner lines as the present angular lines are too distinctive relative to the curves of the hazard levels. Because of their visual prominence they disrupt the hierarchy of the map information.
- Use accompanying written materials to address common misunderstandings and misinterpretations about the NSHM map. Importantly address:
  - confusion about probabilistic vs. scenario maps
  - confusion about forecasts vs. predictions
  - uncertainty doesn't mean the science is wrong
  - what intensity means and how each intensity relates to damage
  - the 10,000 year time frame on the #/VI map
  - what it means (and doesn't mean) when two different areas are the same color on the map
  - why induced earthquakes are excluded from some NSHM maps
- Expand efforts to produce maps and associated information that match user expectations – such as interactive maps, hyperlinks in narrative text, and easy navigation akin to GoogleMaps.
- **Recommendations for associated web-based and print information:**
- Materials created to accompany NSHM maps should make it clear what readers can and cannot find in the maps and how they can be used.
- Use universally accepted clear language principles. These include:
  - Target vocabulary and sentences to approximately 8-10th grade language level;
  - Keep sentence length to approximately 15 words. Vary sentence style and clauses—many people erroneously use only simple declarative sentences but in fact this reduces clarity;
  - Use good cohesion and logic between sentences and paragraphs—limit the number of ideas in a single sentence or paragraph; repeating terms and concepts can help;
  - Don't try to explain everything in one piece—select the most important scientific / technical terms and concepts and provide clear language definitions; for those few important terms, don't use synonyms;
  - Keep in mind that terms which are common-to-earthquake experts - 'frequency', 'tectonic', 'scenario', 'hazard and risk' - can have a different meaning for non-technically sophisticated readers.
  - Avoid all jargon – this is often is perceived as deceptive or exclusionary. Eg. The current language on the #/VI map legend about nontectonic earthquakes.
  - Illustration - Use photos and other illustrations to specify degree of damage. If possible, on the web these images would be interactive – reader could

scroll over-mouse-over and click on them. All participants wanted help understanding what different levels of damage would be like.

- Include a Q & A format as an effective way to tackle perennial questions; people are comfortable with the "Frequently Asked Questions" format.

In conclusion, **NSHM staff should work to incorporate a user-centered design approach with new audiences.** This will result in maps and accompanying materials that are best matched to the needs and interpretive skills of various target audiences.

The traditional wisdom has been that NSHM maps are not particularly relevant to EMS because EMS focus on disaster response. Participants in this study contradicted this view, and indicated that for mitigation, planning, education, and discussions with a wide range of constituents, they could make repeated use of NSHM maps, provided they had a map and accompanying materials that they could understand.

## II. METHODS

The following describes the methods undertaken for this project during September to December 2015.

### ➤ **Literature Review**

H2HL conducted a review of the existing literature to provide a knowledge base about perception, use, and understanding of maps and natural hazard information to create recommendations grounded in evidence. Content in online databases, research journals and publications, and grey literature were searched and represent a cross-disciplinary selection of topics, e.g. health literacy, psychology, disaster management. Literature is cited, as appropriate, throughout the report.

### ➤ **Participants**

This study was conducted in two phases: 1) initial introduction and exploratory interviews and 2) subsequent usability testing sessions. The total study sample consisted of eight non-federal individuals and four federal employees (see Table 1) following Office of Management and Budget / Paperwork Reduction Act (OMB/PRA) requirements. Participants were recruited as described below.

**Recruitment of Participants:** A list of possible individuals to comprise the study sample was compiled by Sue Perry of the USGS Science Application for Risk Reduction (SAFRR) project and members of the NSHM, Rob Williams of the USGS Central and Eastern US Earthquake Program, and through participation in the North Texas Earthquake Working Group (NTEWG) as well as a workshop about incorporating induced seismicity, held by NSHM team in Oklahoma in fall, 2014. Sue Perry sent letters of introduction to approximately twenty EMs, local officials, state geologists, and members of the NTEWG who had previously volunteered to work with the USGS to improve products. The purpose of the study was briefly explained and individuals were asked to respond if they were available during the study period, interested, and willing to take part in an initial phone call/in-person meeting and perhaps a subsequent online usability session with the two project investigators, Christina Zarcadoolas and Wendy Vaughn. Research staff contacted individuals and scheduled initial calls for exploratory interviews.

### ➤ **Phase 1: Exploratory Interviews**

Initial exploratory interviews of 45 minutes with study participants were conducted September to November 2015 (see Table 1 for a description of each of the participants). The table does not include names because anonymity supports more honest user responses [9].

**Table 1: Study Participants**

#	Role	Purview	Level of Participation
1	Risk Manager for large private company	National/International	Exploratory (a)
2	Executive Director, Emergency preparedness non-profit agency	Northeast regional	Exploratory/Usability
3	State EM	California	Exploratory/Usability
4	State EM	Pacific Northwest	Exploratory/Usability
5	City EM	Local-level/Texas	Exploratory/Usability
6	State EM	Texas	Exploratory (b)
7	Assistant Professor, Geotechnical Engineering	Texas	Exploratory (b)
8	City official	Local-level/Texas	Exploratory/Usability
9	Associate Professor, Geophysics	Texas	Usability**
A*	Geophysicist, USGS	Southwest	Exploratory/Usability
B*	Geotechnical Engineer, Army Corps of Engineers	Southern regional	Exploratory/Usability
C*	FEMA official	Regional (Region IV)	Exploratory (a)
D*	Research Geophysicist, USGS	Pacific Northwest	Exploratory (c)

\* Federal employee operating in official capacity (not subject to PRA limits of 9 or fewer persons)

\*\* Not available for initial exploratory interview

(a) Does not use NSHM products directly, so usability tests N/A

(b) Unavailable for usability during study period

(c) Provided background information on potential users

The purpose of the initial exploratory interviews was to:

- Introduce the goals of the project.
- Better understand the role/s these individuals had in their job and locale
- Determine if they used or were using USGS Earthquake hazard maps and in what types of situations had they used the maps
- The strengths and limitations of the earthquake map/s used
- If a respondent hadn't used USGS earthquake map, why?
- What information would they like a map to provide

The interviews were not recorded digitally. Notes were taken during the sessions and field notes were prepared for each interview within 24 hours. At the conclusion of the interview, most participants were invited to take part in a subsequent web session in which they would be looking at maps and revised text elements and asked their opinions.

### ➤ **Phase 2: Usability Testing Sessions**

During December 2015, usability sessions of approximately 1 hour was conducted virtually, by webinar, with eight participants to evaluate the conceptual, linguistic and design elements of the existing NSHM maps and accompanying materials, proposed new map elements. The usability session was conceived and designed using standard user-centered design principles.

A user-centered design (UCD) approach is characterized by iterative user/consumer input throughout the design process [10-12] and is in some fields called a participatory process (e.g. Creighton, 2005 [13]). There are many variations of the UCD approach. When users are involved throughout the process investigators have access to an accumulation of information that drives and refines the ultimate product/tool. Usability testing reduces the number of errors users have with a tool while increasing the ease of use of the tool.

Ideally a UCD approach is used iteratively as a product is being developed. This allows the team to try out a number of design alternatives as more is learned about the users. UCD can also be used, as we did in this NSHM study, to identify aspects of the user experience and to make recommendations for a modified tool. The assumption in this situation is that the usability testing is likely to yield questions as well as design solutions. UCD is not generally used to test long pieces of text. This is better served through cognitive interviews and focus groups.

We used a form of UCD that involves initially conducting a task analysis to identify the information and elements a user most likely needs to recognize and comprehend in order to use a product - in this case, a map or accompanying, explanatory text. The task was the basis for designing a usability protocol – the actual questions, tasks or scenarios you present to the user in a session [12]. For the web content we presented a list of topics that would appear on the website as well as a representative passage from the web content. We asked users to read and respond to these two items.

A usability session can be of any length but needs to factor in user fatigue. In a session the researcher works with an individual study participant (user) in real time (either virtually or live) and interacts strategically as the user views and interacts with the product or text. The researcher poses tasks to the user and employs an ongoing “think-aloud” method that encourages the user to talk freely about what they are doing or thinking as they view the materials.

In terms of total number of usability tests considered adequate for any given tool/product, typically, a range from as few as five to ten participants is used in each round of usability testing [14]. When the sample population shares relevant core characteristics (in this case experience in EM or communications), 5-10 participants is usually sufficient. The researcher proceeds to conduct usability sessions until “saturation” is achieved [15]. In this context, saturation means that results are similar from one participant to another. As a form of qualitative research there is a point of diminishing returns where collecting more data does not necessarily yield new information or insights [15, 16]. Additionally the scope of the study and the nature of the topic as well as the study design are factors that may also influence saturation.

Through this process researchers can learn:

- What does the user expect from the text/tool?
- Is the hierarchy of information on the (text) map clear and appropriate?
- What elements are high-barrier (difficult to read and understand)?
- What elements pose no barrier (not difficult to read and interpret)?
- What is the overall information load – too much information, the right amount, not enough?
- Is there a match between the conceptual information in the map and the users grasp of these concepts?
- Is information missing from the map that the user needs/wants?
- What ideas and suggestions does the user have for improving the map or the elaborating map materials (web content, fact sheets)?

The snapshot in Figure 5 gives an example of questions used during this usability study.

**Figure 5**

**Example of Usability Session Questions**

1. Let’s take a look at this map. Judging from the title what type of information do you think you’ll likely find on this map?
2. When you compare XX area to YY area what would you say the earthquake hazard is in XX area?
3. (probe) How did you determine that?
4. Do you think most people would understand that?
5. According to this legend, what how many damaging earthquakes are forecasted to occur in X region in the next 10,000 years?
6. If you were using explaining EQ hazard to the town council meeting you mentioned early, would this map be useful or not?

### III. FINDINGS

The objective of this study was to identify what revisions and enhancements of the USGS NSHM public map would improve its understanding and use among Emergency Managers (EMs) and affiliated local officials.

Note about the participant statements as they appear in this report: We did not audio record sessions. Notes were taken. Two coders independently reviewed all statements to insure accurate interpretation. In most cases participants' statements are close paraphrases of what was said. These paraphrases are presented in quotes. Verbatim (word-for-word) remarks are italicized. In any bulleted list of participant remarks each bullet represents an individual speaker.

#### A. Participants' Experience with the USGS and Maps

**Previous experience with use of the NSHM and other USGS products:** Most participants had seen/were familiar with USGS products. About half were familiar with the 2014 NSHM map. A few (non-USGS) participants were very familiar with a wide range of USGS products, tools and resources available on the USGS website, including the NSHM maps.

**Working with local USGS offices:** Some participants reported close relationships with local USGS offices or personnel, who assisted them in obtaining needed information.

**Emergency Managers have & need varying degrees of technical/science knowledge:** The EMs we spoke with were not a homogeneous group in terms of science backgrounds and expertise with earthquakes specifically. Participants freely offered up their familiarity and facility with specific earthquake knowledge, terms and information. For example, some EMs could explain %g while others had never heard of it. The same was true for the Modified Mercalli Scale. Some were very facile with understanding a probability.

Participants said maps should be created with these variations in technical/science knowledge kept in mind – a basic level for those less familiar with these concepts and at the same time providing a way to access more detailed (scientific) information for those who want it. Throughout our interviews, participants referred to 3 key elements in thinking about hazard maps:

1. EMs from different regions have different hazards and different levels of these hazards in their regions which drive their needs for information;
2. EMs have different technical skill and knowledge;
3. EM capabilities and infrastructure differ across the country and these influence what hazards are prioritized.

#### PUBLIC VS. PRIVATE EMERGENCY MANAGEMENT PROFESSIONALS

In addition to participants from public agencies, we also spoke with one private-sector risk manager for a large, international corporation. For this participant, USGS data was extremely valuable, however, the challenge of using the NSHM is that the USGS does "not want to take opinions to end users ... [USGS] do not give guidance – [they] make users interpret and make decisions with limited knowledge." Thus, for this company, information was not sufficient. They also wanted recommendations about how to use the information. According to this participant, third-party firms that aggregated USGS data and provided advice better met their needs. The respondent also stated that companies cannot rely on a staff member reading a website and/or map and trying to understand complicated information not in their field and then, on the basis of that limited information, make "multi-million dollar planning decisions". In addition, they need a product to "dig down", allow them to "get warned" if something was about to happen, and provide automated updates when there were changes to information. This respondent concluded "I would suggest just provide data to aggregators to translate information" for this audience. The NSHM and the USGS are important to this effort to ensure aggregators are drawing the correct interpretations from the data.

**What Participants Said They Need from a Map:** Emergency Managers described three main roles they played in their job – planning, mitigation, and response. Participants understood that the NSHM maps were not for response, but identified the potential contribution of the NSHM in both planning and mitigation roles; in planning, NSHM maps could be used in talking with the public or local officials; in mitigation, NSHM maps could be valuable in understanding risk in terms of hazard. To be useful, hazard maps must be clear, understandable and easy to explain, because:

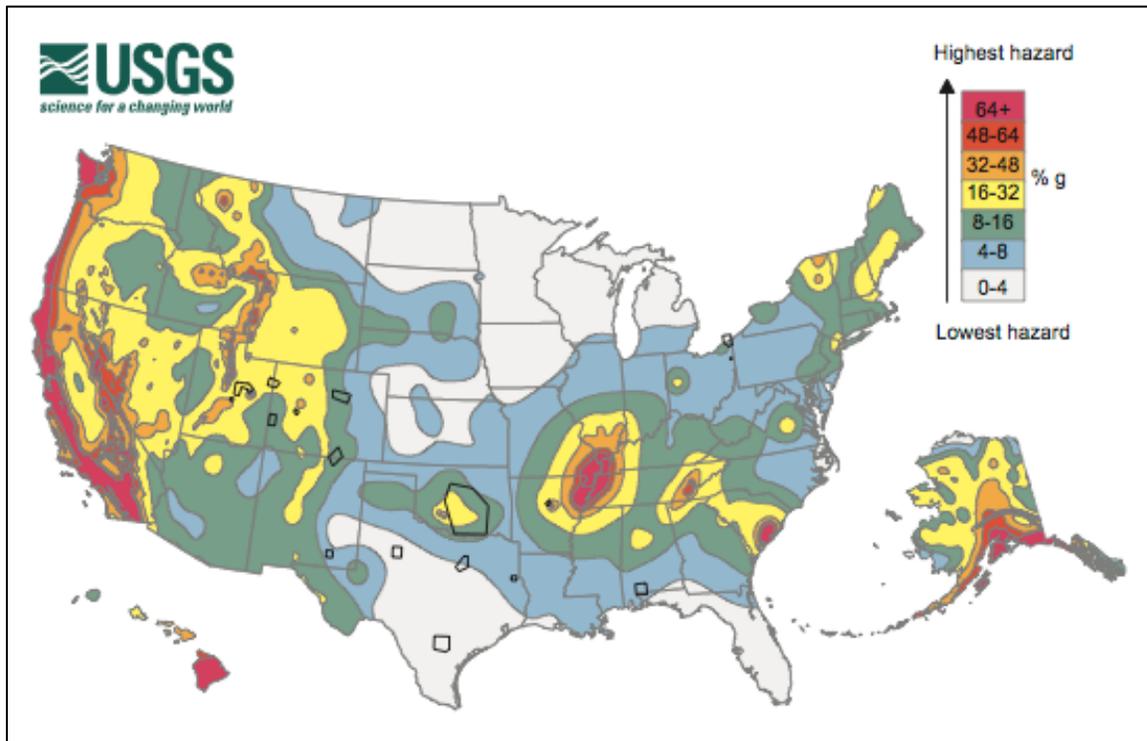
- “EMs at the local level need to be able to explain it to their bosses, officials, *“city mayor needs to know what it means” – they don’t need to know all the science behind it, just understand enough to be able to use the information to make planning decisions*”
- “If the info is not easy for us to understand, we’re going to skip over it. Or not be accurate. It’s not ok to say *“I don’t understand it.”*”

**Being a “translator” of information:** Regarding the EMs roles, as important as interacting and providing earthquake hazard information to colleagues directly involved in emergency planning and management, all EMs spoke of the need to provide earthquake hazard information to a range of non-technical audiences, such as local and state officials, community partners, the media and the public at large. They see themselves as a *“translators”* of information, thus they try to make the hazard maps more accessible to non-experts.

**Using Maps for Mitigation Plans:** According to the EMs we spoke with, one important component of their responsibilities is developing hazard mitigation plans that are routinely submitted to FEMA. They reported that mitigation plans are often created by emergency preparation and planning personnel with varied levels of experience and training. Study participants painted a picture of the local decision making process around prioritizing hazards as not always based on good use of evidence. Decisions may be based on the time frame of a particular group’s lived experience. For example; *“I don’t remember an earthquake. Our hazard is flood.”* Thus there is *“no science behind it, not standardized.”* Participants suggested that clear, not overly technical information on earthquake hazards would assist those in roles associated with disaster planning to help make more informed decisions.

## B. Testing the Maps

### ➤ Map %g

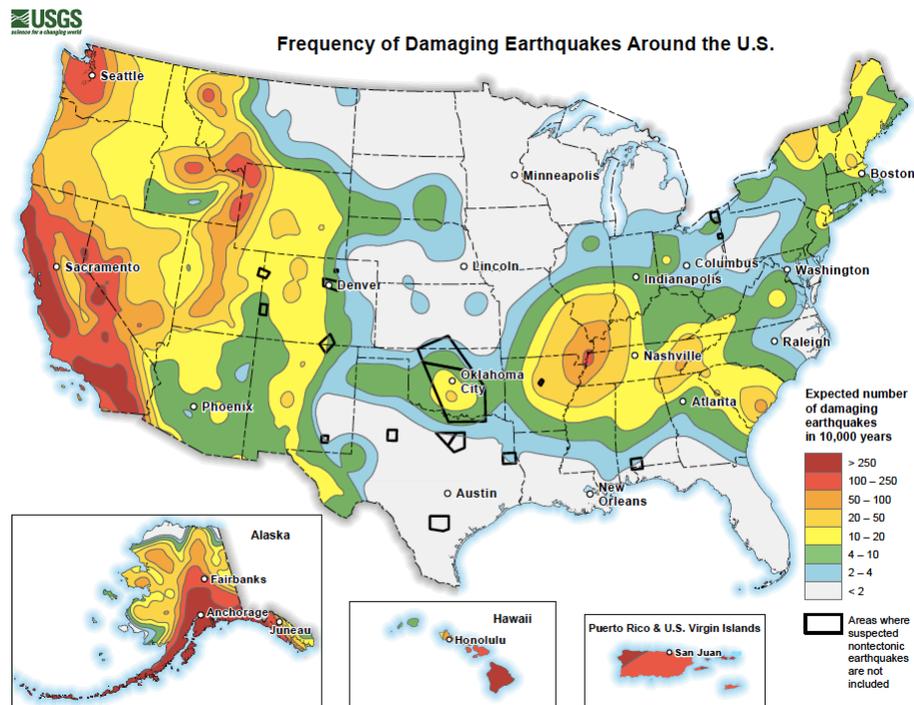


### Overall Reaction to Map %g

Corroborating prior feedback NSHM team has from nontechnical viewers of the %g map, study participants said that metric (%g) was difficult to apply and even more difficult to explain to their audiences (ranging from city and town council members, other fiscal managers and various lay publics). Even participants who regularly use this map and were facile with the concept of %g reported that they do not believe %g is the most effective way to communicate earthquake hazard to non-technical users.

- *"It's impossible to read this map. I use it exclusively to point to CA – it's bad here."*

➤ Map #/VI



**Title – “Frequency of Damaging Earthquakes Around the U.S.”**

The title of the map is easy to read and yet users’ expectations for what the map would be reporting were stymied because of the 10k year timeframe. As users got started reading and interpreting the content of the map they raised questions and problems:

- One user (high degree of science knowledge) questioned the use of the term “frequency.” What frequency? *“Frequency means other things in the EQ world”*
- A few users questioned, *“What is a damaging earthquake?”*

**Legend – “Expected number of damaging earthquakes in 10,000 years”**

Comments about the legend centered on the timeframe/low frequency of the events *“I know this is how USGS thinks”* but I’m on a 10 year scale, much less on a 10,000 year scale.”

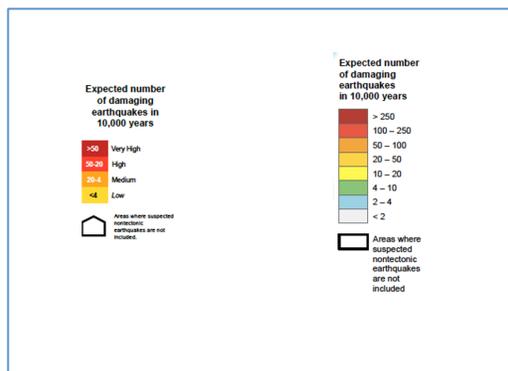
- *“People are going to see that 10,000. It requires a paragraph explaining why we are using this time frame.”*
- *“10,000 years is not a time scale most people are going to care about. People would want to reduce this to get in into a frame that makes sense to them. I’d divide by 1,000 so I’d get X number in 10 years.”* [But was unsure if this was valid.]
- *“High risk states – they need a shorter timeframe – 30 years”*
- *“Nobody is going to plan for a 10k yr event. I’m trying to sell people on being ready.”*
- *“Scientists not really thinking about the audience”* *“way too long”* – felt that if he said to his boss there might be 2 earthquakes in 10,000 years *“when we present ... we’re talking about 10,000 years ... people could laugh”* *“10,000 years? I think only in terms of months ... or 5-10 years”*

A few participants stated that “geologic” time is needed. *“I understand 10,000 is necessary ... if you don’t use 10,000 years, we’d all look the same.”* While users named this problem with the timeframe, some recognized that using a shorter timeframe may yield a map with little information. Users did not have a better solution other than to use 10k and have associated information (such as map caption, web material, and fact sheet) that further explained the issue of time frame.

### Modified Legend

Based on results of our exploratory interviews, we also tested a modified legend (Figure 6). [The map was not adjusted to match the categories in the modified legend.] In this modified legend we collapsed categories in the legend from 8 categories to 4 categories and each category was given a verbal descriptive label (very high...low). Participants were informed that this was a rough draft and to focus on the legend.

**Figure 6**



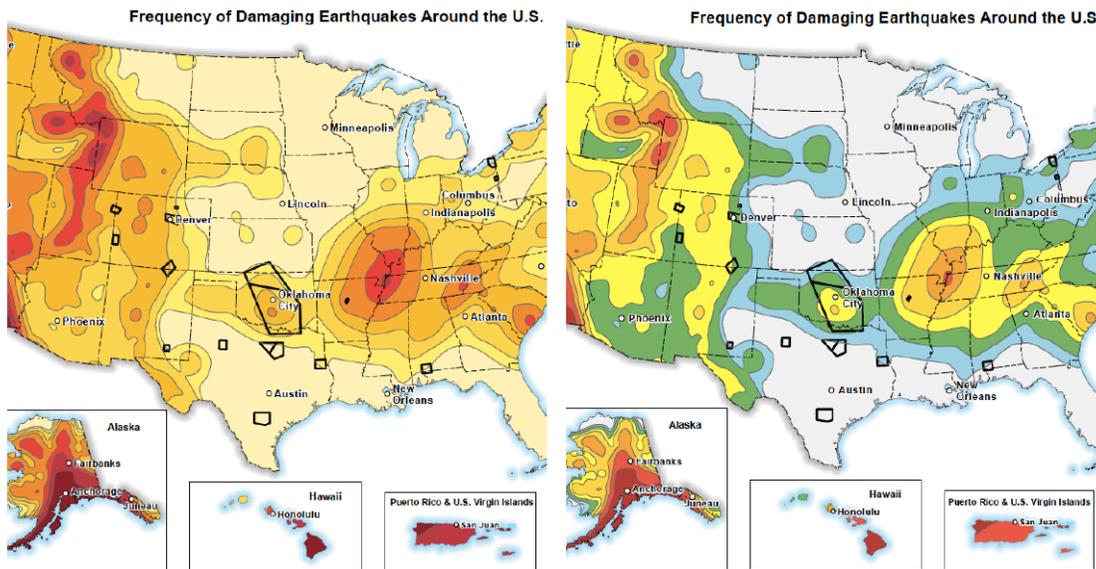
Most participants preferred the revision that added verbal labels to the categories. They said the colors, numbers and verbal together were more “compelling” and “clear.”

- *“Tells a better story.”*
- *“A number and a descriptive...that’s why I think this legend is very, very good.”*
- *“The legend with words is much more understandable by EM than the numbers on right.”*
- *“It’s good – it’s clear because of the words.”*
- *“I like the words and numbers in the boxes.”*
- *“I like the words. I like numbers instead of %”*

However, most participants did not want to have only 4 categories of hazard (*“doesn’t parse it nearly as fine”*). Participants wanted at least 5 categories.

- *Makes it hard to see some details. “Smooths over and takes out some of the complexity.”*
- *“4 categories is too few. At least 5, maybe a higher level. Medium should be in the middle.”*

➤ Map #/VI Color – “Classic” vs “Warm”



Color served both functional and aesthetic roles for the study participants. We asked them to first view the “classic” colored map and provide their reactions. We then showed participants the “classic” colored map next to the “warm colored” map. Aesthetically, several participants *preferred* the “classic” as opposed to the “warm” colored map. They described it as easier to look at, with good contrast. However when it came to what the colors “mean” all participants *interpreted* the colors similarly. When they could see the contrast in the two maps they concluded that the maps were “*dramatically different.*” They stated that they now realized that the maps could “convey a different message” just based on the colors.

- Everyone interpreted the hot colors as telling a story about more hazard everywhere.
- Cooler colors (such as blue and green) represented less concern than the oranges and yellows.
  - “You might see blue and green as areas of no concern.” “You would naturally interpret” that “green means go” “red = really bad – like a stop sign.”
  - “Green is less worrisome.”
  - “Cool colors could give someone who was not as familiar with what the map was communicating the wrong idea.”
  - “Blues and greens convey “calm”
  - “The blue and cooler colors ... Florida that’s white. I’m not concerned at all about that.”
- Compared to the light yellow, both white and grey colors were seen as representing areas of no hazard.
  - “Warm colors would be more appropriate for emergency managers and *more accurate ... there is no place in the US without some risk*”.

- Like that all of the US had some shading – *“there’s potential to have earthquakes...even though it may be incredibly low. Not white....”*
- *“White – it didn’t even ‘deserve’ a color.”*
- *“When I look at the greyed out areas, the white [grey] is inconsequential.”* The greyed area was compared to the greyed out boxes you see on your computer when you can’t click somewhere.
- *“The colors on the map tells me my area [in grey] -- “that’s the safest you can be.”*
- Likes the white for map on the left because it *“simplifies”*. You know where *“0% – no hazard”*

Several participants felt the color scheme should:

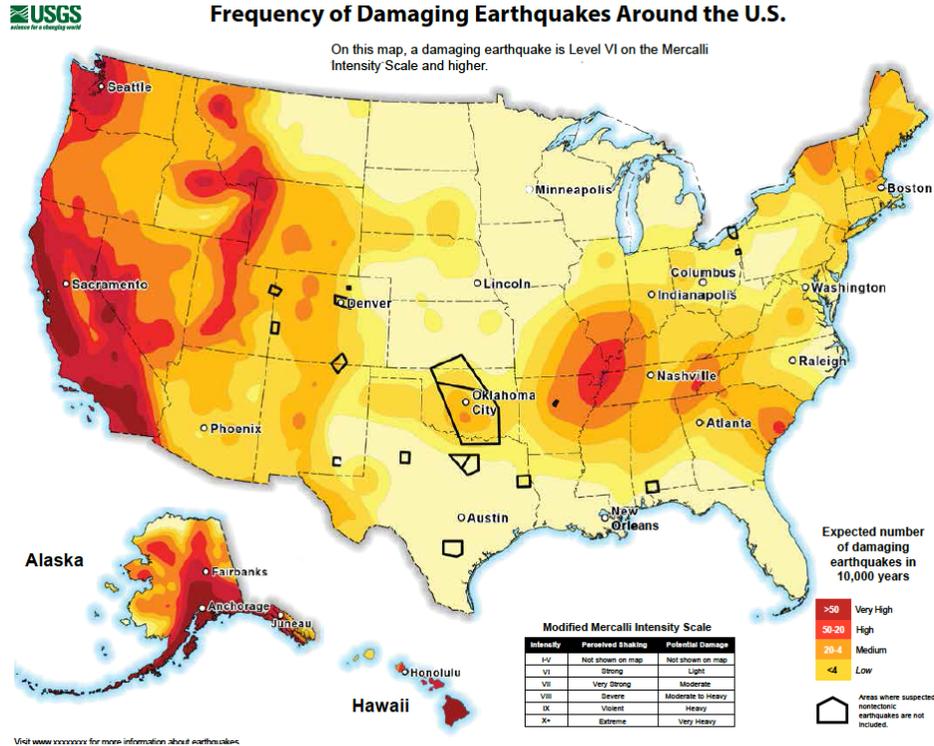
- *“depend on what story they [the NSHM team] want to tell.”* *“Is there hazard everywhere? Or are there areas with no/almost no hazard to worry about?”*
- *“If there are only 2-4 earthquake in 10K years – they can be blue. I would feel pretty safe. The people who might feel differently – my colleagues in moderate states who would like people to be aware of earthquake risks generally.”* The speaker went on to explain that people will look first at the colors- warm colors mean high risk and cool colors mean low risk.

Although most did not comment on this, two participants voiced concern about whether the map addressed issues of color blindness.

### **Icons to represent areas of nontectonic earthquakes**

The polygons were also the source of confusion for some -- *“boxes were throwing me off”*. Some of the lines used to draw the polygons did not seem to make sense (see OK with a line dividing the boxes). The fact that these boxes had sharp corners when the rest of the map was curves and rounded edges, caused confusion - some participants tried to assign meaning to the shape of each individual polygons. The weight of the lines also seemed heavily drawn to indicate a feature not being addressed on the map.

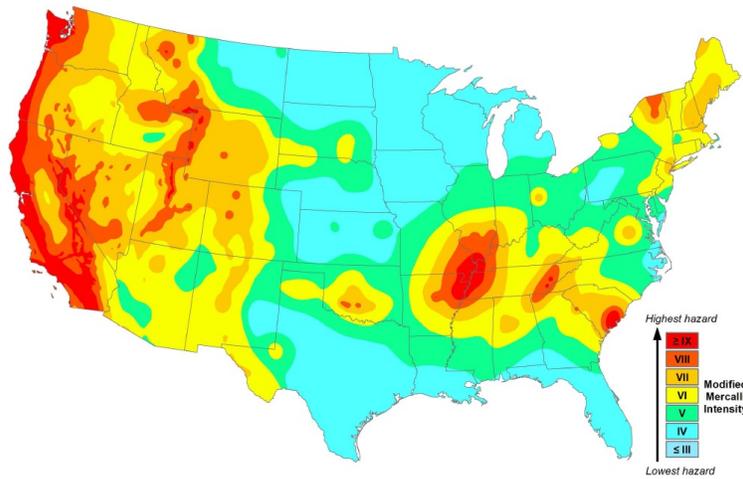
➤ Frequency at MMI VI and Higher



In the Phase 1 exploratory interviews several participants mentioned ‘intensity’ when discussing earthquake hazard. As the Map #/VI defines ‘damaging’ earthquakes as a function of intensity–MMI (Level VI and higher) we explored whether including some additional information about MMI would clarify and increase understanding of the map. However, all participants found this particular addition confusing and revealed misunderstandings about the meaning of MMI intensity that could be significant for other USGS products, not just NSHM maps.

- “MMI – it’s something totally different – mixing frequency and type of damage. I don’t know how this relates to the map.”
- “Too much information”
- “You don’t know how many of which intensity earthquake happened in an area.”
- “You can have an earthquake in SC with an MMI of 9 or 10 and you might think [why] I’m not in this darker redder color (but the colors are representing frequency).”
- Several thought there could be confusion between the rating on the intensity scale and magnitude. People might think a VI is an M6 which “seems like a pretty big EQ.”
- “Mercalli is not well understood and opens this map up to misinterpretation. Why am I seeing this? How does this connect to what I’m seeing on the map?”
- “Are all the earthquakes going to be a level 6? But they could be a much higher level. People don’t talk as much about intensity as they do in places like Italy.”

## ➤ MMI Map



USGS map showing the intensity of potential earthquake ground shaking that has a 2% chance of occurring in 50 years

**Overall Response to MMI Map:** When shown the MMI Map, participants responded favorably overall and they showed less confusion about this presentation of intensity. Some responses suggest they were confused about what the #/VI map showed, rather than about intensity.

- “Good map in the sense that there’s plenty of detail and you’re looking at intensity.”
- “It [Intensity] has more physical meaning than %g”
- “Intensity works and makes sense to people.” [Participant was referring to the fact that descriptions of shaking and damage make more sense to people.]
- “MMI is handy because you have a verbal description. Nice because you can provide a map, like 50 year time frame, where we have a 10% chance of having ground motion of intensity 7 here in our location – this is doable. Instead of showing in %g, then it has a physical (qualitative) meaning.”
- “Shaking and damage tells a better story”
- “For the average emergency manager – the difference between this map and [the frequency map] may not be much, but this does have a bit more information.”

**Barriers on MMI Map:** Problems and difficulties users had with the MMI map was as follows:

- “The problem I have here is that I have no idea ... what a MMI is.”
- Several participants “took issue” with the color scheme:
  - “The blue areas – I have an issue with them. It’s not necessarily accurate to say that there is no risk here (in the blue).”
  - Colors are “garish”
  - Colors “threw me”
- Mercalli “feels subjective”
- People might mistake MMI for Magnitude (several participants made a comment about this)

- [In the legend] *“Lowest hazard to highest hazard is not right for this map. You’re really talking about potential damage.”*
- This map should add: *“There is the potential of having a damaging earthquake anywhere.”*
- Participants were particularly concerned about the caption on the bottom of the map.
  - *“You can’t have it both ways. You can’t have this non-technical and technical.”*
  - Participant read out loud the sentence at the bottom – stopped and said *“2% - probability “no-no-no-no” ... %s and probability people won’t get.”*
- *“I do like a ground shaking map but 2% chance of occurring – “Makes my brain hurt.”*

Participants suggested modifications to color, legend, and the title/sentence to improve understanding of the map.

- *“I like this map. To improve it – along with MMI colors and number – [Add a description of] perceived shaking.”*
- One participant boiled it down for us:
- *“It’s about how people feel in an earthquakes and how buildings feel.”*
- *“Improve description of 2%”*

### Probability versus Worst Case Scenario

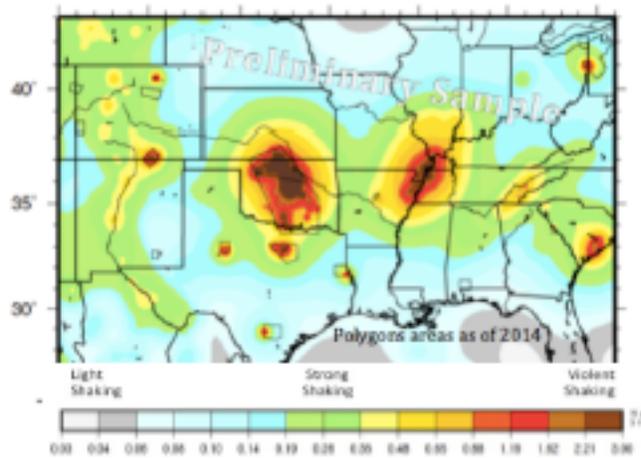
During the discussions of earth shaking and intensity, EMs repeatedly mentioned wanting the maps to show them a **“worst-case scenario.”** They want to make sure their planning and facilities are ready for what is going to be the worst effects of a possible, specific earthquake on a particular area.

While the NSHM are probabilistic and intended for long-term planning, user comments and requests for information on magnitude and **“worst-case scenario”** information, suggest there is not clear understanding of the distinction between **scenario and probabilistic maps**. Nor was there understanding of how a probabilistic map could be beneficial and provide a different view of longer-term earthquake hazard. *“Go with the worst-case scenario – better than the probabilistic model”*

None of the maps tested advised users of the differences between scenario and probabilistic maps.

## NON-TECTONIC EARTHQUAKES

The following findings are a result of discussions we had during the Exploratory Interviews only with participants who worked in areas with suspected nontectonic earthquakes. They were asked to respond to an early version of the 1-year map with induced/non-induced earthquakes from OFR 2015-1070.



According to participants, %g remains a high barrier concept "not understandable to non-technical users", even with the annotation of the legend ("Light Shaking, Strong Shaking, Violent Shaking"). Participants were concerned that their region had a high degree of hazard (indicated by brown on the map). These respondents found the map "alarming because it makes TX and OK look like California....As bad as it could get." This did not match their experience or expectations about earthquakes, to such an extent that it made them question the credibility of the science. Comments about this legend also revealed lack of understanding that NSHM maps do not provide information about individual earthquakes.

- "What is violent shaking?" "Violent shaking' needs to be defined." Participants associate violent shaking with larger events, such as those in CA.
- "I don't know what that means – What is violent shaking?" "What does that [violent] mean?" Easier to use "Richter scale". "[Richter scale is] easy and out there and I didn't know I needed anything other than that"
- [This map] "Makes TX look the worst on the scale." It seems like it [TX] is as "bad as CA". I didn't think that could be right.
- "This can't be right."

Participants were also interested in knowing if this was a "worst-case scenario":

- "Is this as bad as it will get" "People feel this is the foreshadowing of the big one." "Will something bad or worse will happen in the future?"

Participants who were in areas experiencing felt EQs on an almost daily basis were willing to accept that the hazard was increasing. In these areas, the map could be used as a "call to action" by showing how their area was in dark colors.

## C. Evaluating the Web Content

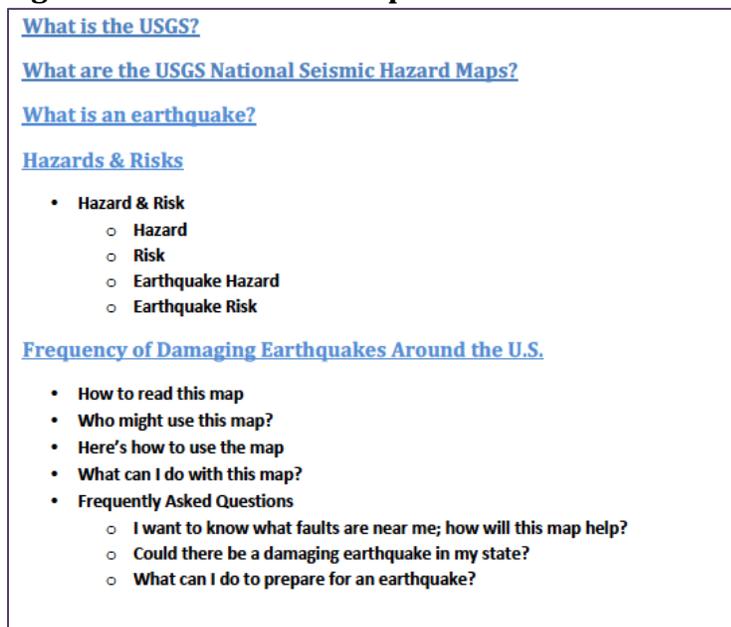
Participants said it would be good to have a separate section of the website devoted to content for non-technical audiences. They reflected on the constituents they speak to. Participants referred to this sort of content as a “Cliffs Notes” and even suggested naming the section “Plain Speaking” or “Educate Me”.

- *“It would be nice to have somewhere to send people (residents) who wanted more information especially when the jurisdiction “get[s] inundated with calls” after a felt earthquake.”*
- One participant described getting at least one call a week from someone/lay user who wants more information about earthquakes. *“But what’s the map for a non-technical group? Where would you send them? Too many choices. “You need a section [called] ‘Simple Stuff’ or ... someplace ... on the website where folks can go who just want to see ‘a map’ not hundreds.”*

Participants also liked the idea of having hyperlinks in/on the map and in the web content which would allow a user to click through for more information, such as data sources, “How to use/read the map”, “More information”. Participants reviewed an outline of topics in the new web content as well as two representative paragraphs (See Figs 7-9).

### ➤ Web Content Topics

**Figure 7 – Web Content Topics**



All participants felt the topics in Fig. 7 was mostly complete. *“Those hit a lot of the questions.”* A few suggested that the topics could be refined and personalized even further, E.g. ‘What is risk? What is hazard? What does it mean [for] me?’ If the web content were to be linked directly to the map, another participant suggested minimizing information such as ‘What is USGS? What’s their role/mission’ and adding a specific description on this page

– ‘What is their role in relation to earthquakes?’ The more specific the topics on the website, the better.

- *“I like this – this is golden” “The bullets under ‘Frequency of damaging earthquakes around US’ the ‘How to read this map’, ‘How to use this map’ “I would LOVE to have that ... I’d send that to elected officials ...”*

### ➤ **Web Content Language Level**

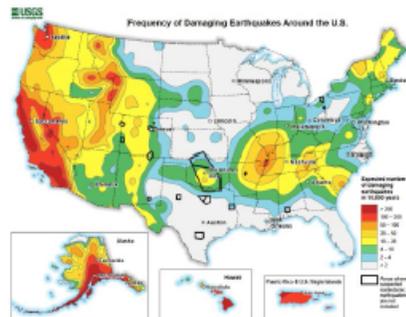
After reading selections from the revised web content [Figs. 8 and 9] most participants initially read and commented on the content in terms of how appropriate it would be for the audiences they explain earthquakes to (local officials, community groups, media and public audiences)..

- *“I like the explanation on this. It’s excellent.” “My parents live on a fault border. They are very intelligent, but not technical.” Difficult to explain hazard to them. Something like this would be a good tool. “Very valuable for the general public and EMs who might need it”*
- *“EMs are used to seeing maps and thinking about in terms of 100 year floods; given to EMs for their own use, this could be “a little condescending.” However, there are people that you need to teach how to use the map – so city planners, town council people – they need this kind of [information]. This could be used as a tool by EMs to help others understand the map. That’s a GREAT beginning.”*
- *“Everybody gets treated like they are in 8<sup>th</sup> grade. So, for “EMs, state legislature [that] doesn’t differ from how I’d present to the ‘general public’.”*
- *“I like this” – content just right.*

When asked to reflect on how appropriate the content was for themselves as EMs we did not find consensus on the level of the material. A few of the participants thought the information should be written at a higher level.

- *“That’s ok if I really wanted to read the map - this would be something I could leave behind. Or if I don’t really understand something and don’t want to ask someone. I don’t want to lose credibility.”*
- *This page could be “kick[ed] up a couple of levels. They need “Earthquake map reading 101”, not map reading 101 – the first few steps were a “little easy”*
- *“This is like kindergarten” – we want to be at 5<sup>th</sup> and 6<sup>th</sup> grade. EMs are going to understand damage, epicenter, etc., you’ll lose them at %g.”*
- *“Simplicity of this page would be a ‘turn-off’”*
- *Finally, one participant was skeptical that any information would be read. People are “not reading ... we write all these things and nobody reads it.”*

## Figures 8 and 9 – Sample Web Content Text



Here's how to use the map:

**Step 1**—Take a look at the map. Notice that the map has 3 parts – the title of the map, the map itself, and a legend. The title tells you what you can see on the map, and the legend explains what the colors mean - how often to expect damaging ground shaking in each area.

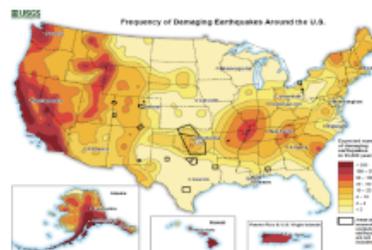
**Step 2**—Find a state or geographic area you are interested in and take a few minutes to review the area. What color is it? Are nearby areas in the same color? What other parts of the country share that color?

**Step 3**—Look at the legend on the right side of the map. You may be surprised to see that there is a chance of damaging shaking everywhere in the United States. Most people pay particular attention to areas that are the hottest colors. True, these areas will most often have damage from earthquake ground shaking, but don't ignore the cooler shades. Damaging earthquakes can and will happen in those areas, too, but less often. In fact, damaging earthquakes are possible in all fifty states. The cooler color areas are low hazard but not 'no' hazard.

**Step 4** – Notice that in some states there are black outlines. These show areas where the number of damaging earthquakes could go up because recently there have been "induced" earthquakes there. As a reminder, Induced earthquakes are caused by human activity while natural earthquakes are caused by the earth. The colors on this map only show the expected number of natural earthquakes that could cause damage. In the areas with induced earthquakes, the number of damaging earthquakes could be much higher than the value shown on this map, and could drop lower again if the human activities that are causing the earthquakes stop, change, or move.

### How to read this map

This map shows how often scientists expect *natural* earthquakes that cause at least some damage from ground shaking - and with damage comes the chance of injuries. Remember, sometimes people cause induced earthquakes. On the map, areas with the same color should expect a similar number of damaging earthquakes. However, the level of damage caused by each earthquake could be very different. For example, a smaller earthquake that produced a little bit of damage, and a larger earthquake that caused widespread damage, are both counted as damaging earthquakes.



This map shows how many times earthquakes could cause damaging ground shaking in 10,000 years and yes, that is a very long time! But that doesn't mean the earthquakes are guaranteed to be far in the future. They could happen any time, including today.

### ➤ Language Barriers

There were specific terms and phrasing that users pointed out as problematic. This was particularly true with the language referring to nontectonic earthquakes.

- *“People don’t know what ‘nontectonic’ means.”*
- *“Add a simpler description without the \$5 words in there” “take that down to 6<sup>th</sup> or 9<sup>th</sup> grade reading level.”*
- *“Saying ‘people cause earthquakes’ makes it sound like we’re all causing these nontectonic earthquakes. We’re not all jumping up and down [to cause them].”*

Some participants stated that they perceived the message as untrustworthy and that it implied the USGS was concealing something. Some recommended explanations that would be a good addition to accompanying materials.

- *“Why didn’t you include that [nontectonic earthquakes]?” Are they hiding something from us. Do they not want to take a stand on fracking? “*
- *“The jump is always – well, why aren’t they included in the calculation? Why did the USGS remove them?”*
- *“I would comment that the USGS is still trying to figure out the information – the map was created for a long term view of natural earthquakes. Some newer earthquakes might be induced, and could be short – term -- so if what is causing them goes away, the earthquakes might go away. The USGS is still working to figure this out.”*
- *“If I were the USGS I’d want to say something positive. It’s an area that they’re looking at. Shows some transparency. They just don’t have a lot of data yet. [It’s] ‘Under development’.”*
- *“The USGS map is a long-term hazard map. The map was built for engineers to understand natural hazard events. Until we understand whether these earthquakes are induced--which could be short-term hazard--they are being left off the map.”*
- *“An earthquake is tectonic whether natural or man-made. You could use man-made or induced.”*

## IV. RECOMMENDATIONS

This section is divided into two sections: **A) recommendations for the existing maps; B) recommendations for accompanying information** that may be found on the caption, website, fact sheets or other collateral materials.

In sum, participants want an earthquake map/s to function in two ways:

- 1) to provide clear not overly technical information on earthquake hazards to assist them in their mitigation planning;
- 2) to serve as a talking/teaching tool for them to present and explain earthquake hazard to various constituents including their superiors, colleagues, local town councils, community groups and the public.

In terms of barriers they encountered with the maps:

- Legends and color schemes could be misinterpreted
- Differences between scenario and probabilistic maps are not made clear
- Terms such as ‘non-tectonic’ and ‘damaging earthquakes’ are not clearly defined
- Use of highly technical terms and concepts like “%g” and “2% chance of occurring” are difficult and can impede use with other audiences

Based on these study findings we recommend the following:

### A. Map Recommendations

#### A.1. New NSHM Public Map

**Recommendation: Revise and produce Map #/VI as the primary map. This would be the map that is used for printing on postcard and should appear in primary position as first map in the new web content. MMI Map as 2<sup>nd</sup> and Map %g as 3<sup>rd</sup> map.**

When asked, there was not a clear preference for Map #/VI or the MMI Map as the primary map for EMs. Though users suggested improvements to both maps to assist understanding and use of both of these maps.

**They all agreed that %g should not be the primary map.**

**All participants believed it was important to have access to differently themed or focused EQ maps.**

- *“People often appreciate being able to look at multiple representations. One may get a lot more from the frequency. Others from the intensity.”*
- *“Most important is understanding that there are 3 maps telling 3 stories; here are the 3 maps, here is what they tell”*
- *“Pull in a different map to talk about different things”*

**Most felt that maps worked best in conjunction, each telling an important piece of the story.**

*“Number of damaging earthquakes – helps them understand that there is a risk of damaging earthquake in any area. And in some areas the risk is greater*

*than in other areas.* The intensity map is another good product to communicate what kinds of earthquakes people are likely to get.”

## **A.2. Map Elements (Map #/VI)**

**A.2.i. Recommendation (Overall Map Design): Follow good principles of map design** [17, 18]; in particular: map hierarchy, title, legend, lines, explanatory text/notes/data source and color.

**A.2.ii. Recommendation (Title): Rename the title;** “Expected Number of Damaging Earthquakes ...” or “Forecasted Number of Damaging Earthquakes ...”

**A.2.iii. Recommendation (Legend): Include a written as well as a numeric label for each level of the legend.** Consider limiting the legend categories to 5.

**A.2.iv. Recommendation (Color): Use a warm color pallet** if the intention is to show that earthquake hazard exists everywhere. Be highly strategic when choosing color palettes, taking into consideration that color choice influences hazard perceptions. Study participants interpreted cool colors (green/blue/gray) as meaning no hazard. Previous research has shown that Western audiences associate the colors red, orange, and yellow with gradations of hazard (higher to lower) [19-21]. Other colors (besides black, which can also be associated with hazard) connote little or no hazard. If legend is limited to fewer categories, testing with users is the most effective way to determine if fewer colors still maintain adequate contrast for accurate interpretation.

If the legend is limited to 5 categories rather than 8 there is the possibility that reducing the map colors to 5 will not accurately present the hazard information. In this case the map could be kept at 8 colors but the color bar on the legend could be designed to have each bar contain two colors moving from lighter to darker. This would still allow for the full range of colors on the map. We did not test this so make this as a suggestion to try, not a recommendation based on evidence.

**A.2.v. Recommendation (Polygons to show areas with suspected non-tectonic earthquakes): Use graphic elements with rounded and thinner lines.**

The angular lines are too distinctive relative to the curves of the hazard levels. Because of their visual prominence they disrupt the hierarchy of the map information. That is, they seem more important than other features. Users were confused and distracted by these polygons. Designers should revisit and redesign the drawing elements currently used to designate non-tectonic areas. Respondents said the icons/polygons were “*throwing me off*”. Specific confusing elements were the irregular shapes and sizes, the lines drawn through some polygons but not others and the line weighting, which was judged as too heavy.

## **A.3. Written Materials**

**Recommendation: Use accompanying written materials to address common**

## **misunderstandings and misinterpretations about the NSHM map.**

This report details many of these. The most important include:

- confusions about probabilistic vs. scenario maps
- confusion about forecasts vs. predictions
- uncertainty doesn't mean the science is wrong
- what intensity means and how each intensity relates to damage
- the 10,000 year time frame on the #/VI map
- what it means (and doesn't mean) when two different areas are the same color on the map
- why induced earthquakes are excluded from some NSHM maps

In the coming weeks we will revise the new web material for a non-technical audience, based on results of this study, then work with Lisa Wald, Sue Perry, and of course NSHM staff to finalize that content and formatting. We will also give input as the fact sheet about the one-year map develops.

### **A.4. Communication Technology**

**Recommendation: Expand efforts to produce maps and associated information that match user expectations – such as interactive maps, hyperlinks in narrative text, and easy navigation akin to GoogleMaps.**

All study participants agreed that it is a good idea to expand the reach of the maps via information technology.

- “I recall seeing ways that the MMI descriptors have used, including animations – these things exist. Might be useful to link to the existing resources.”
- “In the social media world that we live in, with cute little graphics...any visual representation can play a role”
- “When there were ‘felt’ earthquakes or discussion of earthquakes in media – social media, like “twitter goes crazy” “people will guess” Magnitude numbers (it’s a 3.2, it’s a 2.6, etc.) and *piece together information to try and understand what is going on*”

## Localized Maps

We recognize that NSHM maps are national maps, not local ones. However, all study participants needed local information. We recommend that NSHM produce an interactive web-based map that allows zooming into the local level. If that is not feasible, at a minimum, provide references and resources to more localized maps. This information should be contained in the accompanying materials. Almost all participants agreed that they needed to be able to hone in on their specific locality for much of their work.

An interactive map (or provision of other references and resources) would also allow addition of other information that is important, but outside the purview of NSHM, such as risk information, or what other hazards exist at a locale.

- “Scale is another issue.” “If you’re looking for a place in the country to put your server farm, then a national hazard map might work. But most EMs are looking at an urban scale – national not honed enough.”
- “Really need maps which allow jurisdictions, counties, localities to see the colors in their area – zoom in – maybe a 1/10,000 map (county level) ... As a city/local EM need to be able to “put my finger where the city is and look to the legend to see what color”
- Local (state/county) really want a local map, need to be able to look at other hazards, rank which one is “first”
- National maps were seen as a “starting point” from which they could “build a picture” of earthquake hazard.
- “A national map is only useful as starting point. This is a “suite of maps” --how often is it going to happen, what is it going to feel like, what kind of damage, how can I mitigate it.”
- The public map can “open the door to preparedness and information”
- That’s not to say that there are only a certain number of maps that can be included. A series is OK – can have as many tools as necessary as it takes to “build a picture”

## **B. Recommendations for Accompanying Information**

By "accompanying information" we are referring to the website, fact sheets, the public postcard, and any other collateral materials. The story of NSHM maps is complicated and cannot be told with maps alone.

### **B.1. Manage User expectations**

**Recommendation: Materials created to accompany NSHM maps should make it clear what readers can and cannot find in the maps and how they can be used.** It is very important to manage expectations for the maps, to avoid needless frustration and misinterpretations. No single map can meet all needs. As evidenced in participant responses throughout this report, EMs have a number of needs, many of which cannot be met by NSHM products.

### **B.2. Language**

**Recommendation: Use universally accepted clear language principles [22-25]**

Understanding of NSHM maps will be increased with revisions to the public map but a map can't capture all the complexities, so clear text will also be essential.

We recommend the following:

- Target an approximate 8-10<sup>th</sup> grade language level
- Keep sentence length to approximately 15 words. Vary sentence style and clauses—many people erroneously use only simple declarative sentences but in fact this reduces clarity;
- Use good cohesion and logic between sentences and paragraphs—limit the number of ideas in a single sentence or paragraph repeating terms and concepts can help;
- Don't try to explain everything in one piece—select the most important scientific / technical terms and concepts and provide clear language definitions; for those few important terms, don't use synonyms;
- Keep in mind that terms which are common to earthquake experts - 'frequency', 'tectonic', 'scenario', 'hazard and risk' - can have a different meaning for non-technically sophisticated readers.
- Avoid all jargon – this is often perceived as deceptive or exclusionary. Eg. The current language on the #/VI map legend about nontectonic earthquakes.

We recognize that it is easier to list such recommendations than it will be to follow them, at least at first. As part of the same contract that funded this study, we are developing a tutorial about how to conduct basic user testing of written material.

Whether or not you conduct formal testing, the best way to know whether you are using jargon, have the right number of technical terms, or are writing to suit a particular audience is to try the material with members of that audience.

### **B.3. Illustrate Damage**

**Recommendation: Use photos and other illustrations to specify degree of damage.** All participants wanted help understanding what different levels of damage would be like. If possible, on the web, these images would be interactive – reader could scroll over-mouse-

over and click on them. Specifically include images of that represent different levels of damage corresponding to MMI levels. Geolocate photos of earthquake damage from real events including events in areas that appear to be "low" hazard on the map.

#### **B.4. Clarify Risk Information**

**Recommendation: Provide risk information whenever and however appropriate.**

Emergency managers and those who worked closely with them agreed that hazard information is important, but that it also lacked one important piece of the story -- the need for risk information. Wherever possible, NSHM should include risk (such as on an interactive map). At a minimum, help point users to other resources.

- *"EMs want to understand risk and elements of risk". "In EM, hazard is just the first step ... we don't care if [an area is high hazard, but] no risk."*
- *"I wish there was some product that bridged hazard and risk."*
- *"I want to know where there can be loss or where they can't be."*
- *"You can tell an EM how hard the ground will shake but that is "only part of the story" - "what are the consequences?" They really need risk maps otherwise the information is incomplete."*
- *"Want information on soils, URM, population overlay"*
- *Where do the earthquakes most happen, what shaking extent, info from the past to make future predictions*

#### **B.5. Address Common Questions**

**Recommendation: Include Q & A format.**

Some questions and confusions arose repeatedly. A Q & A format is an effective way to tackle such issues people are comfortable with the "Frequently Asked Questions" format. Such a format would be appropriate for these topics:

- Explain each map. What does it tell me? What can I use it for?
- What is the relationship between magnitude and other [measures?] of earthquake hazard?
- Why doesn't the USGS talk about earthquake hazard in terms of magnitude/Richter scale?
- What is the difference between a scenario and a probabilistic hazard map?
- Does X frequency in X time frame mean it can only happen once in that time?
- If I step across a border to a cooler hazard color, does it mean my risk went down?
- Do these maps predict earthquakes?

**Finally, we recommend NSHM staff work to incorporate a user-centered design approach with new audiences.** This will result in maps and accompanying materials that are best matched to the needs and interpretive skills of various target audiences. NSHM staff has already demonstrated success of this method in their close interactions with their primary audiences. This H2HL study demonstrates that a user-centered approach yields

critical feedback from other users and directly provides information for design. It is well established in the human computer interaction and information systems literature that involving stakeholders in the design and development of technology applications and other tools enhances the likelihood of developing more usable tools and ultimately of user acceptance and use of tools [26, 27].

### **Implications**

The goal of this study was to learn more about what EMs need from NSHM maps and to use usability testing methods to make recommendations for map design and associated content materials. To do this we spoke to EMs as well as individuals who worked closely with EMs around Emergency Preparedness and Response.

Professionals, other than EMs included in the sample were individuals in communications / outreach and education. The results of this study and the recommendations first and foremost pertain to these users.

All participants in this study were highly educated; most were nontechnical. Based on published research over many years, and our experience, it is likely that the results of this study are extensible to other highly educated, nontechnical audiences. Additional study could test this hypothesis.

The traditional wisdom has been that NSHM maps are not particularly relevant to EMs because EMs focus on disaster response. Participants in this study contradicted this view, and indicated that for mitigation, planning, education, and discussions with a wide range of constituents, they could make repeated use of NSHM maps, provided they had a map and accompanying materials that they could understand.

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