2023 Montana GeoHazards Workshop–April 26-27, 2023

Day 1, Wednesday April 26, 2023
Motivation for 2023 meeting:

- Present results from recent geohazards projects in MT
- Updates from various agencies addressing geohazards mitigation in MT
- Special session on earthquake hazards and risks for city of Helena
- Identify priorities and opportunities for collaborative projects
    - Build database for vulnerable buildings
- Plans for setting up virtual MT Earthquake Clearinghouse; table-top exercise; MT Seismic Safety Commission

Geohazards research and monitoring in Montana

Yann Gavillot (MBMG) Fault and landslide investigations in southwest and western Montana.

- Fairly new; Bureau has been involved in earthquake studies but hasn't been formalized into program until the 2 years
- 3 parts:
    - Active faults program
    - Earthquake monitoring
    - Landslides – mapping and site-specific investigations
- Website is continually evolving; new updates to come soon
    - Geodatabases available soon through upcoming GIS Hub Sites
- Active faults in Montana – defined by displacement in Quaternary (last 2.6 Ma)
    - Most hazardous are faults active in the last 10-15 kya
    - Mostly in western MT; only faults with surface expression mapped (blind faults not mapped)

Most of the previously known active faults in Montana are based on an USGS inventory (Quaternary Fault and Fold Database)up until 2018; since then, left to state to take responsibility to maintain and build new fault database (MBMG is in the progress of releasing MT Quaternary Fault Database).

    - In the past, active faults mostly mapped before LiDAR; new opportunity using LiDAR from MT State Library to create new statewide Fault and Landslide Maps and Database.
- Fault mapping completed in Jefferson and Deer Lodge counties
- Next: Powell, Ravalli, and Lincoln counties
- Lots of LiDAR coming soon; Lots of work mapping for several years.
- More earthquake hazards in western MT and is the current focus of MBMG
- Questions about how LiDAR is funded: USGS and local contributions
    - USGS 3DEP program – cover entire nation with 3 m or less DEM
    - LiDAR not usually driven by geohazards, but by floods/forestry/NPS/etc.
- Fault mapping supported by USGS NEHRP and FEMA-NEHRP-MTDES.
- MT has a growing population in areas with earthquake hazards; more tangible funding opportunities with federal and state to investigate hazards.
- Recent work: Jefferson county and Deer Lodge county

- Finding new faults: characterize length, geometry, slip rate for it to be included in Seismic Hazard Model
    - This is a slow process
- Example of Jefferson county pre-LiDAR vs. LiDAR mapping – Jefferson county "became a lot more hazardous"
    - Not a very populous county, but there is risk to infrastructure
- Longer faults = more potential to generate large EQ
- Landslide inventory maps: same thing – identifying ~7x more landslides with LiDAR
- What's driving landslide generation? Geology? Looking at potential factors, it's clear that it is an abundance of factors
    - Working on this with landslide suitability model
- Landslide classification
    - More youthful: sharp head scarps
    - As they get older, they are eroded and vegetated
        - Older landslides can be harder to identify
    - Use hillshade, slope color index
- Landslide morphology looks different in different settings (in different counties)
- Database and web app almost ready to go
    - Scalable so we can zoom in and see parameters for specific landslides and faults
- Site specific investigations:
  1. Bitterroot fault: mapping, slip rates, paleoseismic and seismic hazard modelling studies
  2. Continental and Elk Park faults – drone mapping
  3. Ruby Range
  4. Mission fault
  5. East Gallatin Range fault
- Recent publications on Bitterroot fault – ages of surfaces constrain fault displacement history
    - 2 EQs in last 10-15 kya – Camas Creek and Big Creek Trench sites
    - Bitterroot fault looks like it ruptured all at once along multiple places
        - Trench studies suggest big earthquake events are possible
- Bitterroot fault ongoing and planned work
    - Core lake beds to ID seismites/turbidites
    - Hope to have results by end of this year/early next year

Questions:

- Permitting? Some sites owned by BOR – they are motivated to investigate hazards and understand risks to infrastructure. In terms of locals, try to disseminate these results through press releases. Rocky Mountain National lab reached out following this; goal is for local emergency planning committees to discuss these things.
    - This is a goal of this workshop – to share new information so that it can be shared with communities to mitigate/plan in ways such as restricting development in high-risk areas.

John Sanford (MBMG) GIS modeling approaches to estimate landslide potential and Wed Map.

- Why? → MT does not have a model or data on landslide potential at this time
    - This is NOT a predictive tool
- Two methods:

1. Suitability modeler – canned GIS tool
    - Aspect, slope, fire scars, soils, geology, REAP (relative effective, annual precipitation), and vegetation
    - Stacks layers with attribute ranking index for each attribute within each parameter
        i. E.g., N facing slope is wetter, more susceptible to landslide
    - Each parameter has weighted multiplier (1-10)
2. Logistic regression
    - Reliable and most used landslide potential modeling approach
    - Does not take weighted index for parameters into account
    - 2 step process: want to train the model
        - Take map of known landslides – put 500 points inside those known landslides
        - Put 500 points outside landslides
        - Scale this up to 10,000 pts to increase resolution and accuracy of dataset
    - Same input parameters as suitability model
    - Coefficients represent strength and type (+ or -) of relationship between each variable and landslide occurrence
    - For Jefferson County, Model run 1 included fire
        - Removed fire for run 2 because it had a negative correlation (since there were no fire scars in this county)
    - Different model parameters (i.e., weighting parameters and attributes differently) produce different results
    - As model is refined, it gets better at predicting where landslides are mapped
    - Continued work: continue to refine SM and LR models
        - review best model iterations to determine what seems geologically feasible
        - publish Jefferson county results
        - continue work in other counties using methods from final Jefferson county results as fully funded and ongoing GIS and mapping projects

Questions: Why did we start with Jefferson county? → because this county has a published map of landslides mapped with LiDAR
Stepwise process: start by mapping landslides; then try to understand why it's occurring.
What are most important predictors? → depends on inputs (coefficients). Slope, soil, and geology are influencing Jefferson county the most
Are we solving for coefficients (weights of each parameter)? → yes
Current models are not accounting for age of landslides (qualitative)

Mike Stickney (MBMG) Montana Regional Seismic Network and recent seismicity.

- Why do we care about EQs in MT?
    - We live along Intermountain Seismic Belt
- Most large EQs occur along west coast
- Of particular concern is the ISB extending somewhere through Utah up through western WY
- Centennial Tectonic Belt extends through extreme SW most MT into Idaho (trends NE/SW)

    - Belt is 100 miles wide in places, extends from Butte to Bozeman, goes right through Helena
- Any betting person would think the next big EQ will happen in this area
- Question: tectonic setting → extensional – E-W to NE-SW extension → normal faults plus some strike slip faulting
    - Except for right around Yellowstone NNE-SSW extension
- The SW ¼ of the state has experience MMI shaking level 6 – "strong shaking"
- Since 2000, EQs felt in most of western MT
- Map of MRSN: 45 stations – only 7 are modern, rest are "antiquated" – in the ground, running, paid for…
    - Modern studies depend on full waveform digital data provided by modern broadband stations
    - University of Utah runs Yellowstone seismic network; we record their data
    - Idaho National labs has facility
    - Idaho Geologic Survey has growing network of stations
    - A lot of data sharing is involved
- Why do we care about broadband stations? Example of M 4 – analog station is clipped and does not show arrival of S wave → strong motivation to upgrade to broadband stations
- Recent grant from DNRC – RDP grant – to add 10 broadband stations to network
    - 2 field seasons to locate specific sites and install them
    - Some will be in areas where we lack sufficient coverage
    - Others will be upgrades of existing stations

Question: how much does a station cost? → sensor and data logger alone are ~$25k

Where do we put them? Private property? → some on private property, some on federal land, some on state land

- Experiment in the 80's – Transportable Array – leapfrog stations eastward across US
- Different sensors: broadband measures up-down, N-S, and E-W simultaneously
    - Strong motion sensor is less sensitive
    - Can measure wide range of amplitude with both sensors
- Small installations
- Recent installation last November: strong motion and broadband sensors combined in one package
- Since last geohazards workshop, MBMG located 4231 quakes
    - 2020 – M 6.5 EQ near Stanley – lots of aftershocks
    - 2 largest events: Nov 16 – M 4.5 a couple miles S of St. Ignatius – widely felt in region – max shaking intensity – 5 on MMI scale – enough to wake everybody up but not cause a lot of damage
        - Occurred near S end of Flathead valley at depth of ~12.8 km
        - USGS put together focal mechanism – normal faulting on N-S trending fault
            - Can't ID if it was W or E dipping fault
            - Mission fault – normal fault dips W under valley
            - Assuming W dipping nodal plane represents the fault, schematic XC shows hypocenter 9 km west of fault and 12 km deep – a dip of 57° on fault – middle of the range for normal fault (55° ± 10°)

        - Most of seismicity does not fit on faults we can map in MT

    - Jan 30, 2023 – Livingston – also normal faulting event – no mapped faults nearby
        - This is typical for routine EQs in western MT
- Raspberry shake network – small, inexpensive seismometers that you can purchase ($350)
    - We get signals from 23 of these and use them in hypocenter locations
    - Great way to inexpensively add to network density

Hilary Martens (UofM) University of Montana seismic network and current investigations in western Montana using GPS data and micro-earthquakes.

Drought and EQ monitoring

- Drought plaguing this area; getting a bit better in the past year
- Drought really intense a couple of years ago; affects society broadly: agriculture, economy, trout fishing – permeates through much of society
- US Drought Monitor – July 2021 – particularly intense period of drought
    - More than 20% of western US was in "exceptional drought" category (worst category)
    - 100% of MT was at least abnormally dry
- LA Times/Borsa et al. 2014 – vertical displacement of earth's crust from March 2011 – March 2014 – upward rise of 3 cm – because of water loss from western US (estimated 63 trillion gallons) – loading and unloading the crust
- Earth changes shape every day due to the weight of groundwater and surface water (rivers, lakes, snowpack in mountains, subsurface water)
    - Not tracking absolute water resources – but changes through time (relative changes)
- Big rainstorm – atmospheric river, or big snowfall
    - GNSS tracks motion associated with these events
- How to turn estimates of displacement into estimates of water loss??
    - How much water loss explains this much uplift?
    - Up to about 1 m of water thickness lost during drought
- Research has been focused on CA
- Expanding study into MT where there is not a dense GPS network
    - Network of GPS receivers in Bitterroot – collocated with weather system, soil moisture sensor
    - Lots of students involved
    - Track water resources in MT
- Summary:
    - shape of earth is constantly changing due to global redistribution of water
    - Can use satellites to track surface changes and infer drought conditions
- UM runs seismic network; reestablished in 2017
    - First 3 stations arrived after Lincoln EQ – stations clustered around Lincoln
    - Data are available but not telemetered (not incorporated into USGS catalog)
    - 12 stations centered around Lincoln; some have been decommissioned
        - Personnel issue – no technician, students come and go
        - Stations still in basement of science complex at U of M (broadband)
- Lincoln aftershock sequence (July 2017)
    - Evidence for bookshelf faulting – several distinct clusters – mainshock changed stress field
        - All roughly perpendicular to Lewis and Clark faults

        - Stress field accommodated by bookshelf faulting mechanism
        - Shear between books is opposite to sense of shear of bounding blocks
- Other M.S. student working on updated seismic velocity models for western MT
- Summary:
    - Broadband network reestablished in 2017; registered with FDSN
    - Lincoln aftershocks indicating bookshelf faulting mechanism
        - Aftershocks ruptured oblique to main LCL faults
    - New crustal velocity models

Questions: Based on drought data, any projects to mitigate drought? → partnership with water management agencies (mostly in CA). goal is to provide best estimates of water resources and how they are changing with time – provide this to management agencies to figure out how to fix. Our role is to say "here is the state of things" and get estimates as close to real time as possible. Geodetically – helpful – because not limited to only surface water – historically very hard to get estimate of subsurface water storage. GW is an important source of water to communities and agriculture.

Conversations with stakeholders in Great Falls – what do these conversations look like in communities?

- ➔ More of an educational lecture, spoke about drought, local ranchers stayed after and shared anecdotes of impact – having to dig wells deeper (not as much discussion about mitigation)
- ➔ Seeking examples of best practices

Reservoir impoundments – linked to EQ – is there anything related to drought?

Stress changes – loading and unloading – changing stress field – correlations during significant periods of loading and unloading (mass loss of glaciers/ice sheets) – slight increase in seismicity during transition (seasonal)

Water gets into pore spaces in fractures in rocks, soils – can lubricate fault planes – can bring them closer to failure if enough water gets in – pretty minor effect, and small EQs

Change in GW/precipitation can affect microseismicity

Have you thought about looking into induced seismicity? S.D. – wastewater injection – how much water does it take to induce seismicity/failure? → controlled experiment

Seeing up to M 4 – lots of events

Depends on antecedent stress conditions…how close was that fault to failure already?

Discussion

- Getting information out to local community
    - Best thing to do is be poised and ready as soon as something happens
    - "exercise" earthquakes – it's about marketing – you've got to sell it
        - make a virtual EQ clearinghouse
    - pretend EQ – get everybody involved
    - Great Shakeout – are emergency planners involved?
    - EQ is "lurking in the darkness" – you've got drought, flooding, fires in your face
    - If schools don't teach drop, cover, and hold – we can lose people because they're not doing this simple exercise
    - Geohazards DB coming soon…
        - With downloadable data sets
- When people are impacted by a disaster, that's when they're interested
    - How many EQs actually are felt/cause damage?
    - Dashboards are interactive ways to show hazards to people – need to bring this tool to local officials that make decisions; approve developments, etc.

    - Having discussion with elected officials as they start going through development and growth – put tools in their hands
- Political will to develop guidance is sometimes not there – fear that it will diminish value of property – local officials do not want to be involved in this type of code adoption
    - What would your messaging be to local officials and decision makers? Balance with property value…
    - Anna Lang – wouldn't target to decision makers
        - STORYTELLING – to locals
        - Grant for public education; advertising campaign
        - Disclosure laws?? – homeowners' insurance can get dropped
        - Has to be locally driven – from the populous
            - NOT the decision makers….
    - Need to have better relationship with insurance commissioner – insurance companies are excluding specific perils…(wildfires)
    - Have to figure out how to address these specific perils
    - Pricing people out of homes
- Mike: Seismic Safety Commission could help bridge this gap?
- Knowledge puts it in the hands of the locals: How do I prevent something happening to me?
- This is a slow process…
- Need to find a voice in the legislature to convey this message
    - Pilot project: people care about schools. Are schools safe for our kids? People may not care about insurance, but they care that their kids are safe. Good way to sell it. This worked well in Utah
- Having dashboards that "paint the picture" is really beneficial
    - Uphill conversations…
- Colleens thought: everybody should take a geology class and we need to come at this from all angles

Presentations and updates from agencies across Montana

Andrew Long and Jake Ganieany (MT-DES)

- Drought – a year ago this time, low snowpack
- More snow and rain in May into June
- June 11, 12, 13 – major flooding event
    - Caught everyone by surprise how quickly water came off of mountains
    - Lost a lot of roads and bridges (including private)
    - Huge economic impact – hard to capture – close to a quarter billion
        - Yellowstone shut down
        - Tribes coming together for 150-year anniversary
    - 7" of rain in 24 hours in Glacier
- More cost effective to remove rock from river beds than fix infrastructure damage
- Nye Road by Stillwater – destroyed – working to fix
- Still working closely with floodplain managers to fix problems from last year
- Any type of disaster you have, it's going to involve floodplain
- NFID – National Flood Insurance Program – these communities have to comply with floodplain management regulations
- Community rating system can determine discounts to flood insurance

- Risk rating 2.0 – risk rating tool, mapped channel migration zones, dam inundation; calculates premium – has to be vetted by state
    - Premiums going up a lot (doubling)
    - Risk Rating 2.0 went into effect Oct 2021
- After disaster event – damage estimates
- Cost of repairs exceed 50% of home value, consider substantially damaged
    - You get additional funding
- Staffing not available to do damage estimates; brought in people from SC, OR, CO
- Multiple post disaster assessments happening simultaneously (7 or 8 assessments – property owners getting inundated)
- No enforcement mechanisms to keep people out of unsafe buildings; only thing they can do is evict people
- DNRC Recovery Assistance: Floodplain Community Assistance Program
    - 476 structures assessed by 5 SDE (Substantial Damage Assessments) teams conducted on properties in and around the Special Flood Hazard Area
    - Payout maxes out at $250k regardless of property value – underinsured
- Post disaster – funding from FEMA to fly new LiDAR
    - High watermark surveys for high watermark indicators
    - New flood map studies – hope new maps go into effect by 2028-2029
- Working on right now:
    - Debris removal, erosion issues
- Road to recovery – multiple year process
    - Staff shortages
    - Permitting issues
    - Need for a lot of collaboration
    - How to inform people about risks moving forward? We are still in the timeframe where this is still very real to people

Jeff Jackson (Montana Department of Transportation)

- We have these hazards – what do we do about them?
- Types: landslides, rockslides, rockfalls, earthquakes, avalanches, subsidence, sinkholes, frost heave, swelling clays, dispersive clays, flooding, erosion
- Example project: Helena bridge replacement
    - Capitol/Cedar interchange bridge project – $35 mil
    - Old bridge build in 1962 – fracture critical, foundations were shallow footings, did not meet current width criteria or seismic design standards
    - American Association of state highway transportation (AASHTO)
    - Seismic codes follow work by USGS – DOT is more conservative
- Probabilistic approach – 7% exceedance in 75 years (~1000 year)
    - PGA = 0.198; effective PGA = 0.237, importance category = essential (some detours available)
    - Evaluate loading conditions – need foundation deep enough that it won't just tip over
- MT DOT drilled to perform subsurface investigation
- Foundation analysis –
    - Deep foundation needed to support loading (vertical, lateral, uplift, overturning)

    - Drilled shafts? Expensive, fewer contractors available – looking at this option because of cobble/boulder layer
        - Driven piles easier
- Lateral/seismic loads
    - Can you drive pile through cobbles and boulders? MDT has done a lot of this
        - Uncertainty with lateral resistance of piling
        - Concerns with ability to drive them through cobbles/boulders
        - Risk too high to "figure this out" during construction….
        - So, performed load tests during design phase (uncommon for an MDT bridge)
    - Tested pile for drivability, axial compression, uplift, and lateral – measured with load cell
        - Did a lateral test – what kind of resistance are we getting for an EQ?
        - Able to reduce pile length!
    - Benefits of test program
        - Verify foundation capacities for lateral conditions
        - Testing cost was $150 k but saved ~$2 mil over having to use drilled shafts
- Summary:
    - MDT designed essential structure for seismic risk to ensure public safety and to remain useable to emergency vehicles after seismic event
    - Liquefaction not predicted
- MDT also does retrofit projects
- Other projects:
    - 3 recent rock slope projects
    - Large landslide project (Mobridge)
    - Liquefaction mitigation for bridge near Bigfork
    - Continuing to improve rock slope asset management program
    - Starting a retaining wall program
    - Ongoing research projects – geotechnical in nature – both formal and informal
    - Geotechnical asset management – plugging this to upper management

Michele Lemieux – Seismic analysis of non-federal dams of Montana (MT DRNC)

- Problem #1
    - Engineering required to evaluate a dam for seismic stability can be very expensive
    - Dam owners would rather spend money on tangible items like construction or monitoring instead of studies
    - Few engineers specialize in dam seismic analysis
    - Although EQs can damage dams, they rarely cause catastrophic failure
        - Dams can have more significant issues that are a priority
- Solution #1
    - Screening criteria – screen out dams that are well built based on assumption that they will not be damaged in an EQ
    - Pathway that can be (a) followed by most geotechnical engineers and (b) provides options to stabilize the dam without needing to do an advanced analysis
- Punchline: dams constructed in a manner that makes them resistant to damage in ground shaking should justify a lower level of analysis

- Problem #2
    - Dams follow probabilistic design criteria – many faults in MT are hidden (blind)
    - Wong and Stickney (2005)– probabilistic ground shaking maps for Montana not included in USGS unified hazard tool – starting to become a bit outdated
    - Dams required to withstand 5,000- or 10,000-year return intervals for ground shaking
- Solution #2
    - Fudge factor
    - Ratios of PGA calculated using Wong (2005) Probabilistic maps and USGS Unified Hazard Tool to artificially adjust PGA
- Punchline
    - This is only a temporary solution and a better method to determine 5,000- and 10,000-year return interval ground shaking is needed

Question: legally, where does it put things if we are using a fudge factor? Can't point to this legally…does this open up door for DNRC to be in a legal bind? → No, because technical notes are not a legal requirement – up to engineer to use their judgement

Troy Blandford (Montana State Library) - Lidar, Flood Hub, ShakeMaps and dams, RTN, and Grants

- LiDAR – yellow – planned acquisition, much of central portion of state – this will complete the dataset
    - Goal: statewide high res (1 m) high accuracy (<1') DEM
    - Statewide coverage by ~end of 2025
- 2022 Floods GIS Data Hub
    - Helps to know which agencies are collecting what data
- ShakeMaps and dams
    - Stemmed from DNRC – need to figure out which dams are affected in the event of an EQ
    - USGS EQ notification system – sends email
        - State Library wants to cut out step of downloading USGS ShakeMap shaking intensity contours
        - Brought in and analysis completed through scripting – Python API for ShakeMap
- MT Real time Network – fixed, permanent, GNSS (centimeters in seconds, no post-processing)
        - Senate Bill 60
- Montana Land Information Act grant
    - House Bill 343
    - Assist state agencies, local governments, tribal governments implementing priorities of land information plan

Jeff Blend and Meranda Bass (MT-DEQ) – ESF-12 – Energy

- MT Energy Office within DEQ is primary agency
- Energy emergencies may involve:
    - Damage to infrastructure
    - Cascading effects from regional or national events (market)
- Energy includes all major sectors

    - Electricity; refined fuels; crude oil; natural gas
- There are a number of causes of energy outages from natural events, to sabotage, to cyber hacks, to international incidents
- EQs affect transmission
- Things break down within 24 hours without energy
- Natural gas transmission system overlaid on top of seismicity map
- Similar map but with PGA instead of seismicity
    - Northwestern's system is at a higher risk than eastern system
    - Petroleum pipelines: Yellowstone pipeline is in the riskiest area; crude is fairly safe
    - Electrical transmission system – biggest risk is in western part of state
- US DOE is requiring identification of threats and vulnerabilities in plans
- GIS team is developing at DEQ
- Utilities have incentive to do these inspections; don't want to interrupt service
- Are pipelines designed for seismic safety? → over half were built before 1970
    - New natural gas lines parallel existing; unsure of seismic specifications

Anna Lang (Zylient, Inc) – Reoccupy for Resilience: Strengthening post-earthquake community resilience

- If we can get to reoccupancy, we can get to resilience
- Anna is co-chair of Public Policy and Advocacy Committee of the EQ Engineering Research Institute
- Disaster impacts on community
    - Physical: casualties; buildings, infrastructure, land
    - Social: sociodemographic (disruption of social networks); psychosocial; physical; sociopolitical
        - Psychosocial: for 3 years in counties where there is a federally declared disaster, suicide rate increases by 20%
    - 2005 – New Orleans – population – people fled and never returned, societal fabric has changed; types of businesses and demographics changed
    - **Disasters can diversify and strengthen our economies
- Community Resilience and Buildings
    - Resilience is an attribute of the community…and buildings facilitate our communities
    - We rely on our buildings for the ability to bounce back
- Building recovery timeline
    - What does a building owner experience after an event?
        - Earthquake occurs → inspection → financing; engineers; contractors → permitting; long lead times → building repairs → functional recovery
        - OR if it's not that bad: EQ occurs → utilities restored or back-up systems → functional recovery
    - Inspection/tagging
        - Green tag: functional recovery after ~10 days
        - Yellow tag: functional recovery after ~100+ days
    - How do we reduce the amount of time for people to reoccupy buildings?
    - Safety Assessment Program – only adopted by a handful of states currently
        - Massive coordination across state agencies

        - New York does not have a SAP, but…DOB conducted inspections on 82,000 buildings within *weeks* (there's not just one way to do it)
- B2B – Back to Business and BORP – Building Occupancy Resumption Program
    - Municipal building departments deputize engineers ahead of time so that when and EQ happens, that engineer can go right to his client and get started
    - Building officials busy inspecting critical structures (govt owned, schools, etc.); not private structures
    - Limitations of B2B and BORP – need to raise awareness and expand program
- FORWARD: Functional Occupancy and Recovery Work Agreement for Reducing Downtime
    - Understand building occupant and functions
    - Recognize hazards
    - ID performance objectives
    - Evaluate building, determine anticipated performance
- Recovery-based code development
    - Ranking list of what is important so that they can be prioritized by engineers
- Inventories: find the bad buildings

Sean McGowan (FEMA) – What's a "NEHRP?": Intro to Coordination with FEMA

- How to get EQs on the radar when things are literally on fire or flooding at the same time…
- National Earthquake Hazard Reduction Program:
    - National Institute of Standards and Technology
    - National Science Foundation
    - USGS
    - FEMA
        - FEMA takes science and makes it applicable
- FEMA NEHRP Priorities
    - Current
        - Building codes and design guides
        - Outreach campaigns
        - Disaster support and post event studies
        - Support state EQ programs
        - Training
    - Where we're headed
        - EQ insurance
        - Building inventories
        - Support states to access retrofit funds (BRIC)
        - Linking with other programs
- Perishable Data → Building codes
    - Using info to improve building codes
- National EQ Technical Assistance Program (NETAP)
    - Free training by top notch P.E. instructors
        - Pre-EQ inspections of vulnerable buildings (Rapid Visual Screening)
        - School safety
        - EQ construction for Homebuilders
        - ATC-20: Red/Yellow/Green tags
- Design currently for life safety; working toward functional recovery – "resilient design"

- NEHRP Direct State Assistance
    - NEHRP funding to support EQ mitigation activities
        - Develop seismic mitigation plans
        - Develop inventories and conduct seismic safety inspections of critical structures/infrastructure
        - Update building codes, zoning codes, ordinances to enhance seismic safety
        - Participation in exercises that substantially benefit EQ mitigation
        - Educate about EQ insurance
        - Assistance to Multi-State groups for any of the above
- FEMA P-154
    - Quick ID of highest risk structures
    - Uniform methodology; national standard
    - How do we do a lot with a little?
    - You can do everything you want, but if your neighbor doesn't retrofit their building…….
- Schools inventory
- Communicate the findings to the public
- How can FEMA help?
    - Structural engineering
    - Building code enforcement
    - Education and outreach
    - Identifying funding opportunities
    - Mitigation planning
    - Environmental and historic preservation
    - GIS and risk modeling (Hazus)
    - Training
    - Coalition building – other states interested in same things – team up
    - Share best practices (Utah is a model)
        - Partner with Structural Engineers Association of Montana
        - Establish a Montana Seismic Safety Commission; convene quarterly
    - Hazard Mitigation Assistance (HMA) Program
        - Disaster cycle grant programs and annual cycle grant programs
        - Technical assistance provided by FEMA to secure grants
    - External expertise via contract support

Earthquake Hazards for the Helena metropolitan area (Past, Present, Future)

Mike Stickney (MBMG) Review of the 1935 Helena Earthquake

- Lewis and Clark Fault Zone – may still be influencing seismicity today
- History of several M 5+ events since the 19th century
- Tent community set up following Oct 18 EQ
- 1935 Helena EQ epicenter estimation
    - Can make educated inferences based on compiled observations
    - Observers in Helena reported sounds coming from NW
- Coast and Geodetic Survey rushed a seismometer to Helena in 72 hours
    - Triggered seismograph – doesn't record P waves since that's what triggers it
    - Estimated 6 km from federal building
    - Vertical oriented fault, 8 km epicentral depth
- 100 pg document – inventory of 1000+ aftershocks

    - 185 consecutive days of one or more EQs
- Anxiety and fear heightened in community
- Report issued by Scott at MBMG – "Program of Investigation" drawn up by a group of Helena citizens
    - BUT station is a legacy of this
    - Money from public works allocated
    - Wanted a damage survey designed by CalTech prof, executed by MSU

Sean McGowan (FEMA) Seismic Hazards and Earthquake *HAZUS* Model for Helena.

- M 6.3 Helena Valley Fault Earthquake Exercise
- Strong shaking in downtown Helena
- USGS Prompt Assessment of Global EQs for Response (PAGER)
    - Designed as a 1 pager
- MMI VIII is where you start to see damage
- Hazus – "this hazard hit with this intensity; tell me the damage"
    - Pinpoints high risk areas
    - Highlights mitigation opportunities
- PAGER vs Hazus
    - PAGER – fast (~20 min); user friendly output; coarse resolution
    - Hazus – very detailed results; run GIS model; slow (2-4 hours), results are technical
- USGS and FEMA decided to make twoPAGER – takes greatest hits from Hazus
    - More detail: losses at a county level
        - Quantity and degree of building damage
        - Inspectors needed
        - Anticipated debris

Question: what's going into the model? → soil conditions, time of day (occupancy), infrastructure (power, roads, etc)

- Hazus:
    - Casualties = 20
    - Building damage is based on a coarse/generic estimate – building inventories help with this
    - Utility damage
        - None in this Hazus run, but gas pipe bursts can cause fire
    - 2,200 people without electricity on day 1
    - Millions of tons of debris:
        - Total = 540 million pounds; over 10,000 truck loads
    - Sheltering needs: >500 displaced households
    - Persons seeking temporary shelter = 250
    - Lots of cascading problems
    - Economic losses
        - Total = $1.15 billion
        - Non-structural – sprinklers – can ruin a structure that is otherwise structurally OK
    - Web based loss estimation delivery – can check in with local emergency services
    - Canyon Ferry Dam – 668 billion gallons; downstream: Great Falls
    - Aftershocks

- Key takeaways:
    - Search and rescue – want to make sure they don't become victims
    - Damage to potable water and wastewater lines – firefighting impaired?
    - 2250+ buildings without power

Questions: Hazus model output does not have error bars. Can that be added? → short answer: I don't know; long answer: probably
Do these models account for behavioral aspects of people in community? → no
This seems like a great educational tool; is it available to the public? To play with the model? → you can download Hazus software and run yourself but you need some knowledge about EQs and GIS

Andrew Long/Sara Hartley (MT-DES): Mitigation and Disaster Planning Strategies for the city of Helena.

- Grant programs for seismic projects
    - Building resilient Infrastructures and Communities (BRIC) – newer over last couple of years (nationally competitive) – large pot of money
    - Hazard Mitigation Grant Program (HMGP) – 3-5 year period of performance; can request two 1 year extensions
    - National EQ Hazard Reduction Program (NEHRP) – MBMG gets this
    - *FEMA – High Hazard Potential Dam project – rolled out in last couple of years
- Structural retrofits
    - Automated isolation valves with seismic sensors
        - 7 valves and sensors installed at city of Helena's water reservoirs
    - UM-Western Main Hall Seismic Stabilization
    - MSU Creative Arts Complex Seismic Retrofit
        - Upgrade to building as it was URM and not sufficient due to lateral loads that would be present during an EQ
- Mapping – MBMG
- Non-structural retrofits
    - Importance of securing infrastructure (e.g., water heaters, bookshelves, sprinklers, chimney bracing
- Scoping
    - Mapping unknown areas to find fault lines and areas of concern
    - Surveying communities to locate URMs
- New eligible activities (B.12.2.1.1)
    - Seismometers, GNSS, associated infrastructure
    - Regional seismic networks
    - Geodetic networks
    - Can fund projects but not maintenance
    -
- Management costs associated with grants – these have to be given back though if not spent Would be best if these funds did not have to be returned if federal government wants us to "build capacity" (preparedness, collaborative group).
- State agencies can apply for these grants; private agencies can apply for HMGP.
- Grants for planning? → flood study that led to mitigation plan

Concluding remarks:

- Group Discussion Seismic Safety Commission – how do we make it eligible through our programs?
- Start with MOU (Memorandum of Understanding) or Letter of Interest.
- Start disseminating these ideas higher up starting with a strategic plan and earthquake working group as a stepping stone towards a Montana Seismic Safety Commission
- Have to tie it to deliverables at end.
- Need to establish Montana Earthquake Clearinghouse.
- Start a pilot project building a database repository of school buildings vulnerable to earthquake damage (e.g., Helena School District). Has to fit within timeline. FEMA and Earthquake Working Group support would help.
- Projects can be phased; doesn't have to all happen at once. Funding for construction/physical projects is more easily secured if assessment has been completed through funding from same agency (FEMA)