SUMMARY
TENTH MEETING
WORKING GROUP ON UTAH EARTHQUAKE PROBABILITIES
Thursday & Friday, September 12 & 13, 2013
Utah Department of Natural Resources Building, Room 2000 (2nd floor)
1594 West North Temple, Salt Lake City, Utah

WELCOME AND INTRODUCTION

Working Group on Utah Earthquake Probabilities (WGUEP) Chair Ivan Wong called WGUEP Meeting Ten to order at 8:30 a.m. After welcoming the Working Group members, Utah Geological Survey (UGS) staff, and visitors (attachment 1), Ivan reviewed the meeting agenda (attachment 2), and the "To Do" list for completing the WGUEP final report established at Meeting Nine in February. Following the review, Ivan stated that the principal goals of Meeting Ten were to (1) address the still outstanding components of the WGUEP process (consensus Wasatch Front earthquake catalog, characterization of the Oquirrh-Great Salt Lake fault system, recurrence interval calculations, use of M_{max} regression relations, and the use of geodetic data in the WGUEP analysis), (2) review the "draft" final earthquake probability numbers for the WGUEP Wasatch Front study region, and (3) set a firm schedule for completing the outstanding sections of the WGUEP final report.

PRESENTATIONS

Technical presentations are summarized below. The input data and results of the earthquake recurrence and probability calculations are proprietary to this process and are not part of public records under the Utah Government Records Access and Management Act until released in the WGUEP final report. Therefore, PowerPoint presentations and other information relevant to the input data and preliminary recurrence and probability calculations are not posted on the WGUEP website at http://geology.utah.gov/ghp/workgroups/wguep.htm.

Update on Consensus Wasatch Front Earthquake Catalog, and Unbiased Rate Calculations for Background Seismicity in the WGUEP Region

Walter Arabasz

Walter summarized his progress on the tasks required to create a unified earthquake catalog and make unbiased background seismicity rate calculations for the WGUEP region. The ultimate goal is to combine the University of Utah Seismograph Stations (UUSS) catalog with the U.S. Geological Survey (USGS) National Seismic Hazard Maps (NSHM) catalog to create a multi-purpose catalog for the entire Utah region (larger than the WGUEP Wasatch Front study area). For the unified earthquake catalog, the goals are to:

- Create a combined UUSS-USGS earthquake catalog for the entire Utah region (including the WGUEP region) that is declustered for the period 1850 through September 2012; the catalog format will be the same as the USGS format used for the NSHM catalog.

- Unify the catalog in terms of moment magnitude (**M**).

- "Complete" catalog accounting for all significant earthquakes in the catalogs being unified.

- Determine magnitude uncertainty σ (aka sigM) for each event.

- Determine the rounding error for each event.

- Calculate N* for each event, which is an equivalent earthquake count that incorporates corrections for σ, and is used to compute unbiased earthquake recurrence parameters.

Walter discussed (1) the boundaries of the catalog area (WGUEP region, Utah region, and extended Utah region), (2) the characteristics of the earthquake catalogs and sub-catalogs he merged to yield the 5394 events in the new unified catalog, (3) the instrumental and non-instrumental conversion relations employed to unify the catalog for moment magnitude, and (4) the methodology employed and subsequent pitfalls encountered to determine an unbiased earthquake recurrence rate.

The results to date of the above process are a clustered (no MIS) catalog with N = 5394 earthquakes, and a declustered catalog with N = 2423 earthquakes. Magnitude completeness periods for the WGUEP region are:

2.9 < **M** < 3.6	1986
3.6 < **M** < 4.3	1978
4.3 < **M** < 5.0	1958
5.0 < **M** < 5.7	1900
5.7 < **M** < 6.4	1880
6.4 < **M** < 7.1	1850

Walter then discussed the Weichert recurrence parameters resulting from the new catalog (plots of magnitude versus cumulative annual frequency), and the remaining methodology issues that require resolution including (1) adjusting σ from regressions, (2) adjusting variance weighting, and (3) making rounding corrections.

Oquirrh – Great Salt Lake Fault Zone Wrap Up

Susan Olig

Susan's wrap up discussion of the Oquirrh – Great Salt Lake fault zone (O-GSLFZ) characterization covered (1) modeling displacements for the Northern Oquirrh (NO) and Southern Oquirrh (SO) segments of the O-GSLFZ, (2) NO segment OxCal analysis, (3) SO segment OxCal analysis, and (4) the approaches and weights used for calculating rates for the O-GSLFZ segments.

Susan reviewed the trench site locations and the displacement inputs per site and per surface-rupture earthquake for the NO and SO segments and a combined NO + SO segment. She gave an example of modeling displacement for event P1 on the NO segment, and presented the following table showing the results of displacement modeling for both segments and the combined segments.

Rupture Source	**Preferred D[1] (weighted 0.6)**	**Minimum D[1] (weighted 0.2)**	**Maximum D[1] (weighted 0.2)**	**Number of Observations**
SO	1.56	0.62	2.65	5
NO	2.075	1.61	2.67	3
SO + NO	2.055	1.68	2.52	5

[1]D= Vertical displacement in meters.

Susan then discussed the OxCal analysis for the NO segment. She used an approach similar to that employed for the central Wasatch fault zone (WFZ) segments, with the exception that a Matlab analysis was not required, because the two paleoearthquakes (P1 and P2) identified on the NO segment were identified at different sites, so the events could not be correlated between sites. The OxCal analysis incorporated a total of six radiocarbon (^{14}C) ages, and produced the following earthquake timing for the NO segment.

Rupture Event	**Mean[1]**	**2σ[1]**	**5th[1]**	**50th[1]**	**95th[1]**
P1	6.3	1.6	5.0	6.3	7.6
P2	27.6	3.8	24.4	27.6	30.8

[1]Earthquake times in thousands of years before 1950.

The mean closed recurrence interval derived from the above data is ~ 21 kyr, and the maximum time used in the OxCal model was 30.9 ± 0.3 ka from sample OFPC_RC3.

The OxCal analysis for the SO segment was similar to the analysis performed for the NO segment. Because all of the earthquake timing data for the SO segment come from just one trench site, a Matlab analysis to correlate earthquakes between sites was not required. The SO segment OxCal model incorporated six optically stimulated luminescence ages and two ^{14}C ages, and produced the following earthquake timing for the SO segment.

Rupture Event	**Mean[1]**	**2σ[1]**	**5th[1]**	**50th[1]**	**95th[1]**

P1	3.0	1.9	1.5	3.0	4.6
P2	15.6	15.6	4.6	14.2	30.5
P3	26.5	16.0	10.5	27.6	39.8
P4	59.6	16.6	44.4	59.5	74.6
P5 (?)	-	-	-	-	-
P6 (?)	-	-	-	-	-
P7	81	11.4	70.0	80.8	92.2

[1]All earthquake times in thousands of years before 1950.

The mean closed recurrence interval determined from the above data is ~ 13 to 19.5 kyr, and the maximum time used in the OxCal model was 88.9 ± 8.5 ka from samples MCET2-L5Y and MCET2-L5Z.

Nico Luco used earthquake timing data derived from paleoseismic investigations of the O-GSLFZ segments to calculate recurrence interval probability distributions using the Poisson rate parameter λ (lambda). Nico adopted the approach used in the Central and Eastern United States (CEUS) Seismic Source Characterization (SSC) report (http://pbadupws.nrc.gov/docs/ML1204/ML12048A804.pdf) for calculating λ. The CEUS SSC study uses two approaches to develop probability distributions for λ. Approach 1 is based on the number (N) of earthquakes in time (T); approach 2 requires earthquake timing information, and is based on the inter-event intervals between individual earthquakes. Both approaches include open time intervals since the most recent and oldest events in the earthquake record for each segment. Nico noted that the two approaches typically do not give the same results, and both are not always applicable to available data sets. The tables presenting the results of Nico's analysis for the individual O-GSLFZ segments and for the WGUEP proposed multi-segment ruptures are extensive, and can be viewed in Susan's PowerPoint presentation, available at http://geology.utah.gov/ghp/workgroups/pdf/wguep/WGUEP-2013B_Presentations.pdf.

Calculation of Recurrence Intervals

Nico Luco

Nico summarized the current status of the effort to calculate recurrence rates for the WGUEP process as follows.

- Time-independent (Poisson) mean recurrence rates (λ) for

- Single-segment (SS) ruptures of the central segments of the WFZ, which are the Brigham City (BC), Weber (W), Salt Lake City (SLC), Provo (P), and Nephi (N) segments.
- Multi-segment (MS) ruptures of the central segments of WFZ (BC+W, W+SLC, SLC+P+N, SLC+P, P+N).
- SS ruptures of Antelope Island (AI) and Fremont Island (FI) segments of the O-GSLFZ.
- SO and NO segments of O-GSLFZ.

- Time-dependent (Brownian Passage Time [BPT]) mean recurrence intervals (*m*) for COV's (a) of 0.3, 0.5, and 0.7 for
  - SS rupture of the BC, W, SLC, P, and N segments of the WFZ.
  - SS ruptures of the AI and FI segments of the O-GSLFZ.
- Poisson λ calculated using CEUS SSC Section 5.3.3.1.2 (Earthquake Recurrence Intervals), except for SO.

  Exception: Included open time interval before oldest earthquake, in addition to open time interval since most recent earthquake.

- For SO, Poisson λ calculated using CEUS SSC Section 5.3.3.1.1 (Earthquake Count in a Time Interval).
- BPT *m* calculated via CEUS SSC Section 5.3.3.2 (Estimation of Occurrence Rates for a Renewal Model).

  Exception: Same as above.

- Impacts of CEUS SSC Section 5.3.3.3 (Incorporating Uncertainty in the Input) found to be negligible in comparison to uncertainty arising from relatively small sample sizes of past earthquakes.

Update on Calculating $\mathbf{M}_{max}$
Chris DuRoss
(No PowerPoint available)

Chris stated that in evaluating and selecting M_{max} regressions for the WGUEP process, the primary goal was to adequately represent epistemic uncertainties in **M** while logically and consistently using the best available and most up-to-date regressions. **M** estimates (as a function of surface rupture length) span about 0.3–0.4 magnitude units owing to differences in the fault parameter used; age, quality, and size of historical earthquake databases; and fault type and region considered. **M** regressions were preferred that (1) characterize the upper and lower bounds of the **M** uncertainty, (2) are commonly used for Basin and Range Province (BRP) faults, (3) include the most up-to-date and well-vetted earthquake datasets, and (4) yield relatively large magnitudes consistent with the central WFZ paleoseismic data. Less confidence was placed in regressions that (1) are based on limited earthquake datasets (N < 20), (2) use fault parameters such as average displacement, maximum displacement, or slip rate; parameters that generally are not well resolved for most BRP faults, or (3) include earthquake types that are not applicable to the BRP (*e.g.*, megathrust events). After evaluating 19 **M** regressions, six that gave the most statistically robust results based on global, all-fault-type earthquake data sets were selected and weighted to characterize earthquake magnitudes for WGUEP faults (see table below).

Magnitude Regression[1]			**Regression Parameters**[2]			**WGUEP Fault Category**[3]			
			N	$\mathbf{R^2}$	**σ**	**A**	**B**	**C**	**AF**
Hanks and Kanamori (1979)	M_0, all	$2/3\log(M_0)–10.7$	NR	NA	NA	0.45	0.4	0	-
Stirling and others (2002) (censored instrumental)	SRL, all	5.88+0.80log(SRL)	50	NR	0.3	0.45	0.4	0.34	-
Wesnousky (2008)	SRL, all	5.30+1.02log(SRL)	27	0.81	0.28	0.05	0.1	0.33	-
Wells and Coppersmith (1994)	SRL, all	5.08+1.16log(SRL)	77	0.89	0.28	0.05	0.1	0.33	-
Stirling and others (2002) (censored instrumental)	RA, all	5.09+0.73log(RA)	47	NR	0.26	-	-	-	0.5
Wells and Coppersmith (1994)	RA, all	4.07+0.98log(RA)	148	0.95	0.24	-	-	-	0.5

[1]M_0 – seismic moment (μ*L*W*D), RA – rupture area (SRL*W; see text for discussion), SRL – linear surface rupture length. All – implies regressions based on strike-slip, normal, and reverse faulting earthquakes.
[2]N is number of earthquakes, R^2 is regression coefficient, σ is standard deviation in magnitude. NA - not applicable. NR - not reported.
[3]WGUEP fault categories: A – segmented with good displacement data, B – segmented with limited displacement data, C – unsegmented with limited displacement data, AF – antithetic faults where the down-dip width is truncated at a relatively shallow seismogenic depth.

Preliminary Comparison of Geodetic and Geological/Seismological Moment Rates in the WGUEP Wasatch Front Region

Jim Pechmann

Jim reviewed Kostrov's equation, which relates extension strain to deformation in a block of the earth's crust. For a 45-degree-dipping normal fault, Kostrov's equation reduces to the following scalar relation.

$$\dot{M}o = 2\mu A H_s \dot{e}$$

Mo = seismic moment rate = "geodetic moment rate"

μ = rigidity (3 x 10^{11} dynes/cm^2)

A = surface area of region

H_s = thickness of the seismogenic layer

$\dot{e}$ = extensional strain rate normal to faults; assume this equals principal strain

Jim divided the WGUEP region into four subregions along WFZ segment boundaries (Levan/Fayette, Nephi/Provo, Salt Lake City/Weber, and Brigham City/North) and applied Kostrov's equation. As observed by other investigators, the east-west directed geodetic strain across the WFZ is highest on the Levan and Fayette segments at the south end of the fault, which seems anomalous considering those segments have comparatively low activity rates compared to the central, more active WFZ segments farther north. However, a comparison of the resulting geodetic moment rates (10^{24} dyne-cm/yr) for the Wasatch Front region with geologic extension rates for the region that incorporate strain from the WFZ, other significant faults in the study region, and background strain show better than anticipated correlation between geologic and geodetic moment rates. The results are shown in the following table.

What this all means is still under consideration; Jim is working to develop his conclusions for the final WGUEP report.

Source	Mean	5th	95th
Wasatch fault zone	3.20	0.86	7.26
Other faults	2.90	0.58	7.53
Background	0.25	0.18	0.33
Total for WGUEP model	6.34	1.62	15.1
	H_s = 15 km	H_s = 12 km	H_s = 18 km
Geodetic	8.09	6.47	9.70

"Draft" Final WGUEP Probability Results:

Patricia Thomas

(No PowerPoint available)

Patricia presented her draft final results of the WGUEP earthquake probability calculations for the WGUEP Wasatch Front region. These data are proprietary to the WGUEP process, and therefore Patricia's PowerPoint presentations are not available on the UGS website. It is anticipated that the final WGUEP report containing final probability estimates will be available by mid-2014.

Part 1: Wasatch Fault and Antithetic Fault Pairs

Patricia began by reviewing the component parts of the WGUEP WFZ earthquake forecast model:

- Methodology
- Fault models
- Earthquake rate models
- Magnitude recurrence models for faults and floating ruptures

- Calculation sequence to obtain rupture source rates
- Monte Carlo sampling correlations
- Probability models – Poisson and BPT model probabilities

Patricia showed a slide illustrating the strong effect coefficient of variation (COV) has on the BPT model. COV is a measure of periodicity, which in this instance, influences the regularity of fault rupture. Because the WGUEP BPT model incorporates a wide range of COV values (0.3 to 0.7), the periodicity of fault rupture can range from near Poissonian to very regular (characteristic).

Five Central WFZ Segments

Patricia reviewed the input parameters used for the five central WFZ segments in her probability calculations: segment length, segment slip rate, seismogenic thickness, fault dip, rupture length, and average displacement for both single-segment and multi-segment rupture models. She reviewed the weights assigned to the rupture models—an unsegmented model, a single-segment model, and four alternative multi-segment models.

Patricia presented characteristic magnitude (M_{char}) values (weighted mean and 5th and 95th percentiles) for the five central WFZ segments individually and for the multi-segment ruptures that she obtained from the M_{char} relations adopted by the WGUEP for category A faults (see Chris DuRoss presentation above). She reviewed the magnitude distributions for the M_{char} values, and the two methods used to calculate rupture source rates (recurrence intervals and slip rates). Patricia then showed two slides, one presenting Poisson recurrence intervals and the other BPT recurrence intervals (both weighted means) for the five central WFZ segments. The BPT recurrence intervals were consistently longer than the Poisson rates by 200 – 400 years. Patricia then showed a table of implied slip rates determined from recurrence intervals for the WFZ central segments single-segment rupture model. Finally, Patricia displayed a series of bar graph slides showing moment rates for WFZ central segments single-segment and multi-segment rupture models.

Antithetic Faults

Patricia reviewed how antithetic faults are being incorporated in the WGUEP earthquake forecast model – either rupturing independently or coseismicly with a master fault. The M_{char} relations used for antithetic faults are the Wells and Coppersmith (1994) area relation and the Stirling and others (2002) censored area relation (see Chris DuRoss presentation above), each weighted 0.5. The fault areas are based on ranges in average fault separation distance and fault dips. For coseismic rupture of master and subsidiary faults, Patricia computed M_{char} for both faults, combined their moment, and computed M_{char} for a coseismic rupture. The rate is based on the recurrence interval of the master fault. Patricia showed a table of average separation distance, subsidiary fault lengths, subsidiary M_{char}, and coseismic weight for the four antithetic fault pairs in the WGUEP study area (West Valley fault zone/Salt Lake City segment, Utah Lake faults/Provo segment, Hansel Valley fault/North Promontory fault, and Western Bear Lake/Eastern Bear Lake).

Probabilities – Central Wasatch Models/Recurrence Intervals (M_T)

Patricia computed conditional probabilities for $M_T > 6.0$ and 6.75 in 30, 50, and 100 years for the five central WFZ segments using recurrence intervals. The Poisson model was weighted 0.8 and the BPT model 0.2. The probabilities for the Salt Lake City and Provo segments include coseismic rupture of the West Valley fault zone and Utah Lake faults, respectively. Patricia showed a series of tables presenting probabilities for each segment.

Probabilities – Central Wasatch Models Using Slip Rates (moment-balanced rates)

Patricia next showed probabilities computed using moment-balanced rates. For the WFZ single-segment model, rupture rate is the segment moment rate (μ*area*slip rate) divided by the mean moment of the characteristic event. Patricia showed tables presenting Poisson and BPT probabilities for the Wasatch single-segment model for **M** > 6.0 and **M** > 6.75 events in 50 years, and a composite table (combined Poisson and BPT probabilities) for the Wasatch single-segment model for 30, 50, and 100 years.

Wasatch End Segments

The rupture models (segmented and floating) for northern end segments (Malad City, Clarkston Mountain, and Collinston) are weighted equally. The floating rupture model has a surface rupture length of 60 kilometers. The southern end segments (Levan and Fayette) have a segmented and a multi-segment rupture model that are weighted equally. The multi-segment rupture model for the southern end segments has a surface rupture length of 46 kilometers. The M_{char} magnitude relations applied to the WFZ end segments are the same relations used for the five central WFZ segments, but the relations are weighted differently (Hanks and Kanamori, 1979 [0.4]; Stirling and others, 2002, surface rupture length – censored [0.4]; Wells and Coppersmith, 1994 [0.1]; Wesnousky, 2008 [0.1]). Patricia presented a table of WFZ end segment lengths (mean and 5^{th} and 95^{th} percentiles) and segment slip rates (mean and 5^{th} and 95^{th} percentiles). A second table showed weighted mean M_{char}, slip rate, and moment balanced recurrence (1/λ) values for the end segments. A bar graph followed showing moment rates for the different end segment rupture scenarios. Patricia then presented tables that showed WFZ end segment probabilities for an **M** > 6.0 earthquake in 30, 50, and 100 years.

Wasatch Unsegmented Model

Patricia presented Poisson probabilities for three WFZ floating rupture models for an **M** > 6.0 earthquake in 30, 50, and 100 years. The floating rupture is represented by a truncated exponential model with an M_{min} of 6.75, M_{max} of 7.6, and b-value of 0.8. The three rupture models were (1) entire fault, (2) five central segments, and (3) unsegmented. Additionally, two floating ruptures were used to model higher slip on the central segments. Patricia then showed two bar graphs: the first presented the distribution of floating rupture rates in an unsegmented model among all ten WFZ segments, and the second compared moment rates for a 100 percent Poisson model, a Poisson segment model only, and for the unsegmented model. A table followed showing probabilities for an **M** > 6.0 earthquake in 30, 50, and 100 years.

Summary

Patricia summarized her presentation by showing a table of probabilities for **M** > 6.0 and **M** > 6.75 earthquakes in 30, 50, and 100 years for the entire WFZ, and a second table showing the probabilities for similar earthquakes and time periods for each of the ten WFZ segments. Patricia's final two slides presented graphs of the mean and 5^{th} and 95^{th} ranges for various WFZ single-segment rupture probabilities.

Part 2: Oquirrh-Great Salt Lake Fault Zone, Other Faults, and Background Seismicity

Oquirrh-Great Salt Lake Fault Zone

Patricia described the current model for the O-GSLFZ, which consists of five submodels—four segmented and one unsegmented. Rupture rates for the O-GSLFZ segments come from a combination of slip rates for the Oquirrh fault zone (OFZ) segments, and recurrence intervals for the Great Salt Lake fault zone (GSLFZ) segments of the combined O-GSLFZ. Slip rates were used for the unsegmented scenario (higher slip rate on the GSLFZ). A BPT branch of the logic tree includes only the FI and AI segments of the GSLFZ.

Patricia then reviewed the five O-GSLFZ rupture models and the weights assigned to each of them. Next, she reviewed the rupture source characteristics (rupture length, slip rate, and recurrence interval) for each rupture source (segment) including multi-segment ruptures. She also reviewed the magnitude recurrence models used for the segmented (M_{max}) and unsegmented (truncated exponential) rupture scenarios.

Patricia then presented a table showing the WGUEP fault rupture category (A, B, or C), weighted mean surface rupture lengths, M_{char} mean magnitudes, and 5^{th} and 95^{th} percentile ranges for each O-GSLFZ segment and for the multi-segment O-GSLFZ ruptures. A second table showed weighted mean slip rates and recurrence intervals, and moment balanced weighted mean recurrence intervals for the O-GSLFZ segments and multi-segment ruptures. Patricia then presented a series of bar graphs showing moment rates for the various O-GSLFZ rupture scenarios and a magnitude recurrence plot for the O-GSLFZ.

Patricia presented a table showing O-GSLFZ segment probabilities for an **M** > 6.5 earthquake in 50 years, followed by a table showing the time-dependent segment probabilities for the FI and AI fault segments. Next, she presented a table of O-GSLFZ segment probabilities for **M** > 6.0 and **M** > 6.75 earthquakes for 30, 50, and 100 year time periods, and a table showing fault-wide probabilities for the same magnitude earthquakes and time distributions.

Other Faults

Patricia summarized the characteristics and assigned weights of the "Other" faults in the WGUEP study area.

- Fault Characteristics:
  - No length uncertainty

- Seismogenic thickness
    - West of WFZ: 12 km (0.2) 15 km (0.7) 18 km (0.1)
    - East of WFZ: 12 km (0.1) 15 km (0.7) 18 km (0.2)
    - Joes Valley fault zone and Snow Lake graben:
      4 km (0.6) 12 km (0.04) 15 km (0.28) 18 km (0.08)
    - Antithetic subsidiary faults: rupture width controlled by truncation by master fault
- Fault dips: 35 (0.3) 50 (0.4) 65 (0.3)
    - Joes Valley fault zone and Snow Lake graben dips: 55 (0.3) 70 (0.4) 85 (0.3)

- Magnitude Recurrence Model Weights:
    - 0.7 M_{max}
    - 0.3 Truncated Exponential with b-value = 0.8 (weighted 0.5) and b-value = 0 (weighted 0.5)

Patricia then presented a table of M_{char} relations and assigned weights as they apply to category B, C, and antithetic faults in the WGUEP study area. Follow-up tables summarized surface rupture lengths, weighted mean M_{char} magnitudes, weighted mean slip rates, and weighted 1/weighted mean λ for the segmented faults in the WGUEP "Other" fault database. Those tables were followed by tables that presented the Poisson probabilities for **M** > 6.0 and **M** > 6.75 earthquakes in 30, 50, and 100 years, which were followed by a slide showing a magnitude-frequency plot for the segmented faults.

A similar set of fault characteristic and probability tables were presented for the antithetic fault pairs and unsegmented "Other" faults in the WGUEP region. The Working Group's attention was drawn to the probability for the Martin Ranch fault, which was roughly an order of magnitude higher than the probabilities reported for the other unsegmented faults in the study area. Bill Lund stated that he would look into the paleoseismic and geomorphic data available for the Martin Ranch fault to determine if they support such a high probability, and that he would report back to the working group. Patricia then presented a magnitude-frequency plot for the "Other" faults in the WGUEP study area.

Patricia summarized her presentation with a table that showed the 30, 50, and 100 year probabilities for **M** > 6.0 and **M** > 6.5 earthquakes on the WFZ, O-GSLFZ, and "Other" faults in the WGUEP study area, as well as probabilities for background earthquakes and regional probabilities that consider all earthquake sources. The probabilities are high and are reason for concern.

FINAL REPORT PREPARATION SCHEDULE

Ivan stated that it is time for the Working Group members with parts of the final report assigned to them to finalize their sections and turn them in as soon as possible.

Assigned report sections and deadlines are as follows:

Section 1 Introduction, Ivan, October 1
Section 2 Methodology, Patricia/Ivan, October 15
Section 3.1 Segmentation, David, October 1
Section 3.3 Recurrence Models, Patricia, October 1
Section 3.4 Calculation of Recurrence Intervals, Nico, October 7
Section 3.5 Calculating Magnitudes, Susan, October 7
Antithetic Faults, Mike, October 15 (formerly Section 3.5, need to move section in report and re-number)
Section 4.2 Wasatch End Segments, Mike, October 15
Section 4.3 Oquirrh-Great Salt Lake Fault Zone, Susan/Jim, November 1
Oquirrh-Great Salt Lake Fault Zone Appendices, Susan, November 1
Section 5 Consensus Earthquake Catalog, Walter, November 1
Seismicity Appendices, Walter, November 1
Section 6 Deformation, Jim, November 1
Section 7 Calculating Probabilities, Patricia/Ivan, November 1
Section 8 Probabilities, Ivan/Patricia, November 1
Section 9 Future Directions, Ivan/all, November 1

The following report sections are ready to review:

Section 3.2 Seismogenic Depth
Section 4.1 Wasatch Central Segments
Section 4.4 Other Faults

The goal is to have a completed draft report by the end of the year, after which Working Group members will have one month to review the report, followed by a meeting (Meeting Eleven) in February 2014 to resolve any remaining issues before submitting the report to outside review.

MEETING ADJOURNED

WGUEP Meeting Ten was adjourned at 2:30 p.m. Meeting Eleven is scheduled for February 5, 2014.

ATTACHMENT 1

Attendance
Working Group on Utah Earthquake Probabilities
Meeting 10
Thursday & Friday, September 12 & 13, 2013

Walter Arabasz, UUSS
Tony Crone, USGS retired
Chris DuRoss, UGS
Mike Hylland, UGS
Nico Luco, USGS
Bill Lund, UGS, Coordinator
Susan Olig, URS Corporation
James Pechmann, UUSS
Steve Personius, USGS
Mark Petersen, USGS, by phone
Dave Schwartz, USGS
Bob Smith, UUGG
Patricia Thomas, URS Corporation
Ivan Wong, URS Corporation, Chair

Others attending
Steve Bowman, UGS Liaison to WGUEP
Rich Briggs, USGS

ATTACHMENT 2

AGENDA
WORKING GROUP ON UTAH EARTHQUAKE PROBABILITIES
MEETING 10
Thursday/Friday 12 & 13 September 2013
Utah Department of Natural Resources Building, Room 2000 (2nd floor)
1594 West North Temple, Salt Lake City

<u>Thursday, 12 September</u>

8:00 – 8:30	Continental Breakfast	
8:30 – 8:45	Overview of Agenda and Review of Last Meeting's To Do List	Ivan
8:45 – 9:15	Update on Consensus Wasatch Front Earthquake Catalog	Walter
9:15 – 9:45	Update on Oquirrh-Great Salt Lake Fault System	Susan/Jim
9:45 – 10:15	Calculation of Recurrence Intervals	Nico
10:15 – 10:30	Break	
10:30 – 10:45	Update on Calculating M_{max}	Chris/Susan
10:45 – 11:15	Update on Geodetic	Jim/Mark/Bob
11:15 – 12:00	Final Results	Patricia
12:00 – 1:00	Lunch	
1:00 – 5:00	Final Results (continued)	Patricia

<u>Friday, 13 September</u>

8:00 – 8:30	Continental Breakfast	
8:30 – 10:00	Final Results (continued)	Patricia
10:00 – 10:15	Break	
10:15 – 12:00	Report	Ivan
12:00 – 1:00	Lunch	
1:00 – 3:00	Report/To Do List/Schedule	Ivan

<u>WGUEP Members</u>

Ivan Wong, URS (Chair)
Bill Lund, UGS (Coordinator)
Walter Arabasz, UUSS
Jim Pechmann, UUSS
Tony Crone, USGS
Mark Petersen, USGS (phone)
Steve Personius, USGS
David Schwartz, USGS
Nico Luco, USGS
Bob Smith, UUGG
Chris DuRoss, UGS
Mike Hylland, UGS
Susan Olig, URS
Patricia Thomas, URS

<u>Other Participants</u>

Steve Bowman, UGS Liaison to WGUEP
Rich Briggs, USGS visitor