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PRELIMINARY TABLE OF CHARACTERISTICS OF KNOWN AND SUSPECTED QUATERNARY FAULTS IN THE YUCCA MOUNTAIN AREA

By Silvio K. Pezzopane

U.S. GEOLOGICAL SURVEY

Administrative Report

Prepared in cooperation with the
U.S. DEPARTMENT OF ENERGY under
Interagency Agreement DE-AI08-92NV10874

Denver, Colorado
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U.S. DEPARTMENT OF THE INTERIOR

BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY

Gordon P. Eaton, Director

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Preliminary Table of Characteristics of Known and Suspected Quaternary Faults in the Yucca Mountain Region

Administrative Report for Activity 8.3.1.17.3.1

November, 1994

Silvio K. Pezzopane

United States Geological Survey, Yucca Mountain Project Branch, Denver, Colorado

Introduction

Identification and characterization of relevant seismic sources is required as part of the Preclosure (8.3.1.17) and Postclosure (8.3.1.8) Tectonics Program in order to evaluate the earthquake ground motion and fault displacement hazards for the potential nuclear waste repository at Yucca Mountain, Nevada. Data about the style of deformation, rate of activity, and length of Quaternary faults are needed in order to identify and characterize relevant sources (e.g., USDOE, 1988). This report summarizes the characteristics and references for version IV of the preliminary table of geologic and paleoseismic data for known and suspected Quaternary faults in the Yucca Mountain region, which is an updated compilation from version III (Pezzopane and others, 1993; USDOE, 1994). For 88 different faults and fault rupture combinations located within 100 km of the Yucca Mountain site, Table 1 lists source characteristics that are most useful to seismic hazard analyses, including: the style of faulting, whether there is documented evidence for Quaternary displacement, maximum fault lengths, expected maximum-moment magnitudes, expected average and maximum displacements, minimum source-to-site distances, and average Quaternary slip rates and recurrence intervals. Table 1 is a shortened version of a larger list being compiled by the author that includes several other characteristics; such as, fault dips, cumulative and single-event displacements, age of displaced deposits, and number of paleoseismic events. The faults are listed

in order of increasing distance from the mapped fault trace to the potential repository site. For this report, the characteristics of faults local to Yucca Mountain are based on preliminary results of paleoseismic investigations and site characterization activities, whereas the activities and characteristics of outlying faults are based mostly on literature reviews and reconnaissance investigations. A brief description of the important source characteristics and citations for the tabulated fault data are summarized in the next section. The methods used to calculate expected maximum magnitudes and surface rupture displacements are discussed in the following section. Values presented here are preliminary, are based on presently accepted methodologies, and are deemed adequate only for preliminary assessments.

The Fault Data

Most of the data in Table 1 are from two sources: Simonds and others (in press) provides information for faults within ~10 km of the site; and Piety (in press) provides information for faults within ~100 km of the site. Other data sources are results of recent geologic and paleoseismic investigations. References for the data sources are listed in Table 1. Neither Simonds and others (in press) nor Piety (in press) calculate maximum magnitudes or expected displacements in their compilations. This report provides these data and includes preliminary assessments for faults that are assumed to form compound ruptures, described below. The maximum fault lengths reported here are considered as approximations because the lengths are directly dependent upon how faults and lineaments are combined into fault zones, and the accuracy of the measurements is variable.

Local Faults

Local faults are those located within ~10 km of the potential repository site. Figure 1 is a map of the local faults, showing the Yucca Mountain site, faults that may be important to repository investigations, and possible interpretations of maximum rupture lengths. Simonds and others (in press) map and tabulate evidence of Quaternary activity, fault type, and fault lengths, in

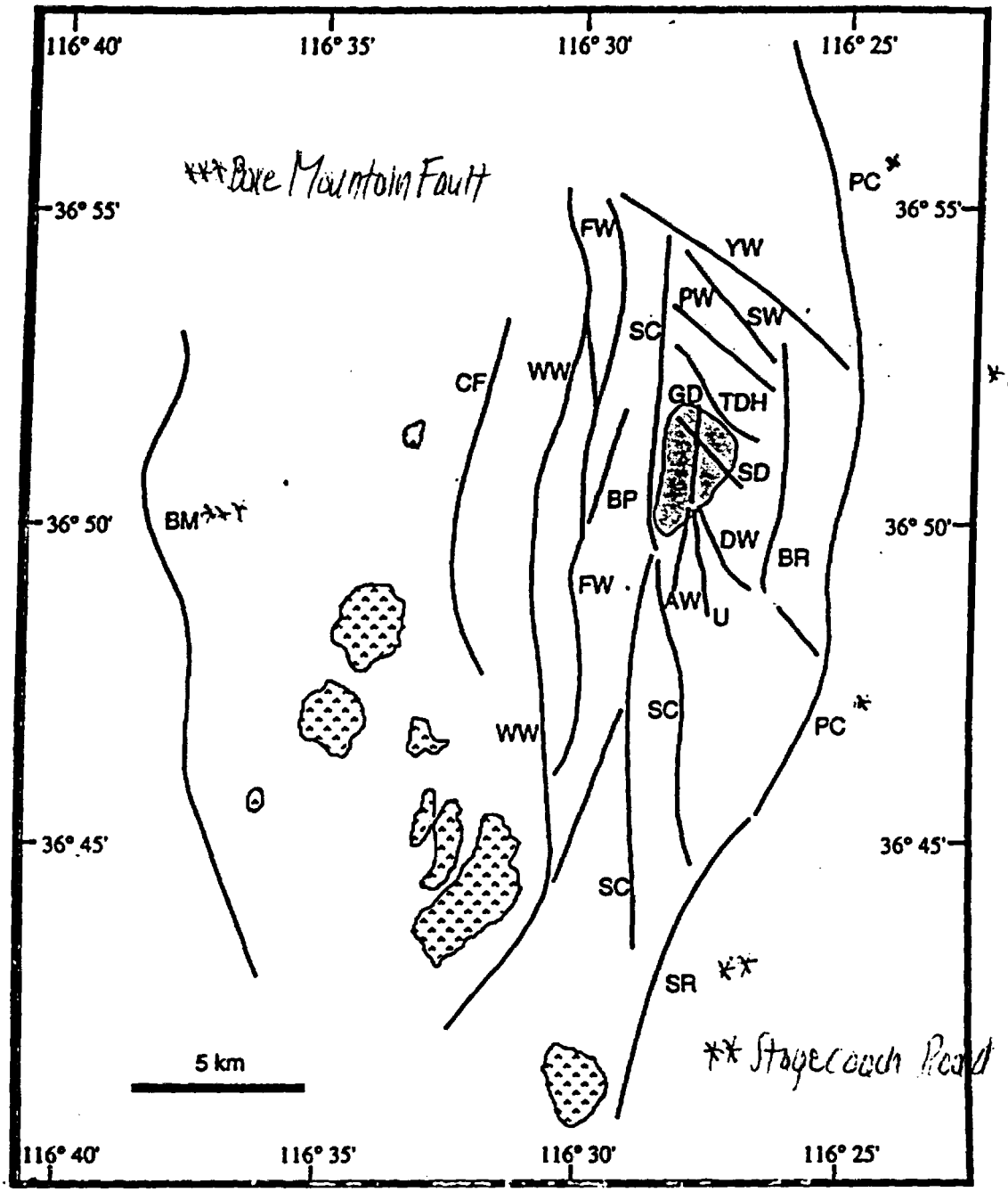

Figure 1. Idealized map of local faults near Yucca Mountain, showing known and suspected Quaternary faults that may be important to repository investigations (modified from Simonds and others, in press; Scott and Bonk, 1984; and Frizzell and Shulters, 1990). Beside each fault is an abbreviation of the fault's name, which corresponds to faults listed in table 1. Minimum distances were measured from the center of the dark stipple, the conceptual repository outline. Light stipple indicates Quaternary volcanic deposits.

addition to other information, for most of the local Quaternary faults. Parameters for these faults were taken directly from Simonds and others (in press), with minor modifications. For faults that lack evidence of Quaternary displacement, but could be potentially important to repository investigations, fault lengths are measured from Scott and Bonk (1984). Minimum source-to-site distances were measured from Simonds and others (in press) and Scott and Bonk (1984). Average slip rates and recurrence intervals are derived from a variety of sources, mainly paleoseismic studies by the U.S. Geological Survey, University of Nevada-Reno, Bureau of Reclamation, and Geomatrix Consultants (Table 1). Data for most of the local Quaternary faults are the result of site characterization studies and are preliminary in many cases. Additional details regarding the fault data are summarized in the footnotes to Table 1.

Regional Faults

Regional faults are those located more than ~10 km from the potential repository site (Figure 2). Almost all of the characteristics for regional faults are derived from map compilations, published literature, and reconnaissance investigations described by Piety (in press). Table 1 does not include faults (from Piety, in press) with lengths less than 20 km (M < 6.6) located at distances beyond 60 km of the site. Faults capable of great earthquakes with lengths greater than ~85 km (M > 7.3) located at distances between 100 and 300 km from the site are included for ground motion assessments. These are: the Pahranagat, Owens Valley, Fish Lake Valley, Garlock, the White and Cedar Mountains, and San Andreas faults. Data for the Pahranagat, Owens Valley, and Fish Lake Valley faults are directly from Piety (in press). The minimum distances, fault types, Quaternary activities, and expected rupture lengths for the Garlock, the White and Cedar Mountains, and San Andreas faults are derived from published literature and measurements described below.

Expected rupture lengths for the Garlock fault are from McGill and Sieh (1991) for combined rupture of the central and eastern segments and for the entire fault. The minimum distance to the rupture is measured from a site at ~35.6°N latitude and ~117°W longitude, at the

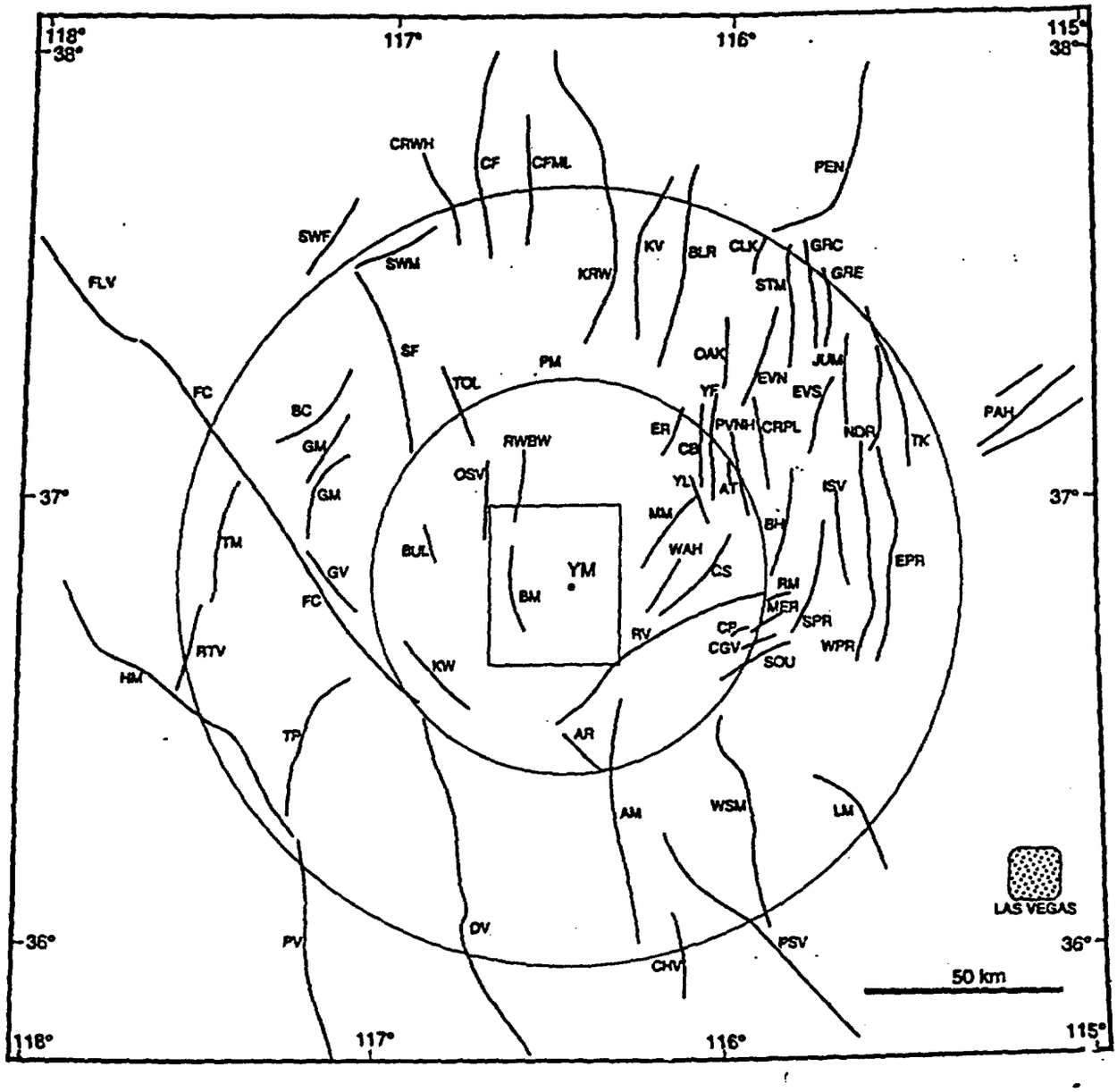

Figure 2. Idealized map of regional faults with known or suspected Quaternary activity near Yucca Mountain (modified from Piety, in press). Beside each fault is an abbreviation of the fault's name, which corresponds to faults listed in table 1. The Yucca Mountain site is indicated by YM. The rectangle surrounding the YM site is the outline of Figure 1. Circles are 50-km and 100-km radii about the YM site.

eastern end of the Garlock fault, east of its junction with the Panamint Valley fault, not far from paleoseismic study sites that document Quaternary displacements, slip rates, and recurrence intervals (e.g., McGill and Sieh, 1991; 1993).

The White Mountains - Cedar Mountain fault source combines several large faults within a broad area located between the 1872 Owens Valley earthquake rupture and the 1932 Cedar Mountains rupture. The normal and oblique-slip faults in this area have documented Quaternary activity, have fault lengths between 20 and 70 km, and are considered capable of magnitude 6.8 to 7.4 earthquakes (e.g., dePolo and others, 1993). This idealized fault source has an assumed moment magnitude of 7.5, which is larger than the expected magnitudes for rupture of the largest faults in the region, such as M 7.4 on the Fish Lake Valley fault, M 7.3 on the White Mountains fault zone (e.g., dePolo and others, 1993), and the historical M 7.2 Cedar Mountain earthquake. The minimum distance of 185 km is measured from ~37.5°N latitude and ~118°W longitude, which is ~10 to 20 km closer to Yucca Mountain than the minimum distances from the 1932 Cedar Mountain earthquake ruptures and from the White Mountains fault zone.

The 420-km rupture length for the San Andreas fault (Table 1) represents an event equivalent to, or slightly larger than, the great 1857 and 1906 earthquakes; both were larger than magnitude 8 (Sieh, 1978,1984; USGS, 1988). The 1857 event ruptured segments of the fault that are closest to the site. The minimum distance was measured to a site at ~34.5°N latitude and ~118°W longitude, which is near Pallet Creek, a paleoseismic study site that provides evidence for the fault's Quaternary displacement, slip rate, and recurrence interval (Sieh, 1978,1984).

Expected Earthquake Magnitudes and Fault Displacements

The maximum magnitudes and average and maximum surface displacements listed in Table 1 are used to characterize earthquake sources relevant to Yucca Mountain investigations (e.g., Pezzopane and others, 1993). The methodology established for evaluating maximum earthquake magnitudes in the Yucca Mountain area is summarized by Pezzopane (1994). Methods for

assessing expected fault displacements are summarized below. Fault displacement values are included for preliminary site characterization design and performance studies; hence, they are of interest mainly for local faults.

Maximum Earthquake Magnitudes

Studies of historic earthquakes have developed empirical relationships between earthquake magnitude and surface rupture length and surface displacement (Bonilla and others, 1984; Wells and Coppersmith, 1994). The most comprehensive and up-to-date empirical regressions are by Wells and Coppersmith (1994), which are used in this report.

The relationship between surface rupture length (*SRL*) and moment magnitude determined by Wells and Coppersmith for all-slip type events (earthquakes with strike-slip, normal, and reverse mechanisms) is given by the equation:

$$M_W = 5.08 + 1.16 * \log(SRL). \qquad (1)$$

This regression includes 77 historical events with rupture lengths between ~1 and 432 km, and has a standard deviation of 0.28 and correlation coefficient of 0.89 (Wells and Coppersmith, 1994). Equation (1) is used with maximum fault lengths to derive moment magnitudes. The magnitude-rupture length regression forms the basis of this evaluation because, at this time, the lengths of faults in the Yucca Mountain region are established better than event displacements and downdip fault geometries. Magnitudes calculated in this way are listed in Table 1 under Maximum Moment Magnitude. In most cases, uncertainties in the maximum fault lengths are much less than a factor of 2, and, therefore, confidence in the fault lengths is moderate. Factor-of-2 uncertainties in the maximum fault lengths are almost completely encompassed by the standard deviation of the empirical relationship between fault length and moment magnitude, which is approximately ± 0.3 moment magnitude units about the mean value listed in Table 1.

One of the major uncertainties associated with magnitude calculations in this report is the downdip fault geometry, which is poorly understood for most faults in the YM region. Magnitudes calculated from inferred rupture lengths using equation 1 are consistent with planar faults having moderate to steep dips. Without discussing the many tectonic models that have been proposed for the YM region, end-member models show faults that either dip steeply to the base of the seismogenic crust or faults that rapidly flatten at shallow depths, merging into one or more shallow detachment structures. If local faults merge into a shallow detachment, that hypothetically starts at the 33-km-long Paintbrush Canyon-Stagecoach Road fault and curves westward into a subhorizontal geometry at a shallow depth (~1 to 5 km) to abut against the Bare Mountain fault, preliminary estimates (not shown in table 1) of its rupture area and the magnitude-rupture area regressions (Wells and Coppersmith, 1994) indicate that expected maximum magnitude may increase about 0.1 to 0.3 magnitude units (to M_W ~6.8 to 7.0), assuming that the detachment does not continue beneath or west of the downdip projection of the Bare Mountain fault. In other words, the rupture area of a shallow west-dipping detachment fault that continues westward ~14 km to the Bare Mountain fault is only slightly greater than the rupture area of a high angle planar fault that continues to a depth of 15 km.

Average and Maximum Fault Displacements

The expected average and expected maximum displacements are the amounts of slip expected on the fault at the surface during an earthquake that ruptures the entire length of the fault. Average and maximum displacements are determined using maximum fault lengths and the empirical relationships between surface rupture length (*SRL*) and average and maximum displacement (*AD* and *MD*).

The relation between surface rupture length (*SRL*) and average displacement (*AD*) determined by Wells and Coppersmith (1994) for all-slip type events (earthquakes with strike-slip, normal, and reverse mechanisms) is given by the equation:

$$\log(AD) = -1.43 + 0.88 * \log(SRL). \quad (2)$$

This regression includes 66 events with surface rupture lengths ranging from ~4 to 432 km, and has a standard deviation of 0.36 and correlation coefficient of 0.71 (Wells and Coppersmith, 1994). Equation (2) is used with maximum fault lengths to derive expected average displacements for faults in the Yucca Mountain region; results are listed as the first value under Expected Ave-Max Displacement in Table 1.

The relationship between surface rupture length (*SRL*) and maximum displacement (*MD*) determined by Wells and Coppersmith for all-slip type events is given by the equation:

$$\log(MD) = -1.38 + 1.02 * \log(SRL). \quad (3)$$

This regression includes 95 events with surface rupture lengths ranging from ~1 to 432 km, and has a standard deviation of 0.41 and correlation coefficient of 0.75 (Wells and Coppersmith, 1994). Equation (3) is used with maximum fault lengths to derive expected maximum displacements for faults in the Yucca Mountain region; results are listed as the second value under Expected Ave-Max Displacement in Table 1.

Fault Slip Rates and Paleoseismic Recurrence Intervals

Fault slip rates reflect the long-term, or average, activity of a fault. Slip rates are determined from the net amount of slip that has occurred during a measurable period of time. Average fault slip rates in Table 1 are based on the ages and measured displacements of Quaternary deposits, where available, and derived mostly from recent paleoseismic studies (e.g., Menges and others, 1994), map compilations, and published literature (e.g., Piety, in press). For most faults, slip rates are calculated from cumulative displacements that are >10 m in late Quaternary deposits, which is assumed to represent the slip from at least 3 or more paleo-earthquakes. Slip rates for most local faults and many regional faults are for the vertical component only, as the vertical component is the

only one directly measured in the field, in most cases. Accounting for the oblique component on local faults could increase rates by as much as 5% to 40% (Menges and others, 1994; Simonds and others, in press). Slip rates for a few faults are based on the ages and displacements of pre-Quaternary deposits (parentheses in Table 1).

The time period between geologically recognizable earthquakes is the paleoseismic recurrence interval. The geologic record captures the occurrence of earthquakes by recording direct stratigraphic displacements within the fault zone (in addition to other tectonic deformation such as uplift and subsidence or secondary effects related to seismic shaking such as liquefaction and landslides). Typically, recurrence data are gathered from trench excavations across fault-related deposits and structures that are preserved at or near the ground surface. As a result, recurrence intervals refer to the frequency of surface-rupturing earthquakes that occurred prehistorically. Recurrence intervals in Table 1 are based on the number and timing of maximum or near-maximum earthquakes that are commonly recorded in late Quaternary (middle to late Pleistocene and younger) deposits. The values are derived mostly from recent paleoseismic studies (e.g., Menges and others, 1994) and published literature (e.g., Piety, in press). Recurrence intervals for local faults are preliminary and are pending age determinations and refined interpretations of fault-related deposits. More paleoseismic studies are needed to evaluate confidently the recurrence intervals for most structures, especially regional faults.

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TABLE 1. Preliminary table of characteristics of known and suspected Quaternary faults in the Yucca Mountain Region

Minimum Distance to YM [a] (kilometers)	Fault Name and Abbreviation	Fault Type [b]	Documented Quaternary Displacement [c]	Maximum Fault Length [d] (kilometers)	Maximum Moment Magnitude [e] (Mw)	Expected Ave-Max Displacement [f] (centimeters)	Average Quaternary Slip Rate [g] (meters/10^3years)	Average Recurrence Interval [h] (10^3 years)	References [i]
0.5	Ghost Dance GD	n	No?	1-3	5.6	10-13	— —	— —	1, 2, 3
0.5	Ghost Dance-Abandoned Wash GDAW	n	No?	3-7	6.1	21-30	— —	— —	1, 2
0.5	Sundance SD	rl-n?	No?	1-3	5.6	10-13	— —	— —	3
1	Solitario Canyon SC	n-ll	Yes	13-22	6.6	56-98	0.01-0.02	40-100	1, 2, 4, 5
1.5	Teacup-Drill Hole Wash TDH	rl	No?	1-5	5.9	15-22	— —	— —	1, 2, 6
2	Boomerang Point BP	n	No?	3-5	5.9	15-22	— —	— —	1, 2
2	Dune Wash DW	n-rl?	No?	1-3	5.6	10-13	— —	— —	1, 2
2.5	Bow Ridge BR	n-ll	Yes	6-10	6.2	28-44	0.001-0.003	30-100	1, 2, 5, 7
2.5	Pagany Wash PW	rl	No?	3-5	5.9	15-22	— —	— —	1, 2, 6
3	Sever Wash SW	rl	No?	3-5	5.9	15-22	— —	— —	1, 2, 6
3.5	Fatigue Wash FW	n-ll	Yes	10-17	6.5	45-75	0.001-0.01	50-130	1, 2, 5, 8
4	Paintbrush Canyon PC	n-ll	Yes	10-24	6.7	61-107	0.005-0.02	30-100	1, 2, 5, 7, 9

TABLE 1. (continued)

Minimum Distance to YM [a] (kilometers)	Fault Name and Abbreviation	Fault Type [b]	Documented Quaternary Displacement [c]	Maximum Fault Length [d] (kilometers)	Maximum Moment Magnitude [e] (Mw)	Expected Ave-Max Displacement [f] (centimeters)	Average Quaternary Slip Rate [g] (meters/10^3years)	Average Recurrence Interval [h] (10^3 years)	References [i]
4	Paintbrush Canyon-Stagecoach Road PCSR	n-ll	Yes	26-33	6.8	81-148	0.005-0.04 [j]	20-100 [k]	1, 2, 5, 7, 9
4.5	Windy Wash WW	n-ll	Yes	14-25	6.7	63-111	0.001-0.03	60-75	1, 2, 5
5	Yucca Wash YW	rl?	No?	3-9	6.2	26-39	— —	— —	2, 9, 10
6	Crater Flat CF	n-ll?	Yes	3-10	6.2	28-44	— —	— —	[illegible]
10	Stagecoach Road SR	n-ll	Yes	4-10	6.2	28-44	0.005-0.04	20-60	1, 2, 5, 7
14	Bare Mountain BM	n-rl	Yes	10-16	6.5	43-71	0.015-0.19	20-160	5, 11
19	Mine Mountain MM	ll	No?	16-27	6.7	68-120	— —	— —	5
19	Rocket Wash-Beatty Wash RWBW	n-ll?	Yes?	5-17	6.5	45-75	— —	— —	5
22	Wahmonie WAH	ll	Yes?	14-15	6.4	40-66	— —	— —	5
24	Oasis Valley OSV	n	Yes?	7-20	6.6	52-89	0.001-0.004	— —	5
27	Rock Valley RV	ll-n?	Yes	19-65	7.2	146-295	0.0003-0.01	— —	5
29	Cane Spring CS	ll	No?	14-27	6.7	68-120	— —	— —	5

TABLE 1. (continued)

Minimum Distance to YM [a] (kilometers)	Fault Name and Abbreviation	Fault Type [b]	Documented Quaternary Displacement [c]	Maximum Fault Length [d] (kilometers)	Maximum Moment Magnitude [e] (Mw)	Expected Ave-Max Displacement [f] (centimeters)	Average Quaternary Slip Rate [g] (meters/10^3years)	Average Recurrence Interval [h] (10^3 years)	References [i]
34	Ash Meadows AM	n	Yes	48-60	7.1	136-271	(0.016)-0.04	— —	5
36	Yucca Lake YL	n	Yes?	13-17	6.5	45-75	— —	— —	5
37	Eleana Range ER	n	Yes	6-13	6.4	36-57	— —	— —	5
38	Bullfrog Hills BUL	n-rl?	Yes?	4-7	6.1	21-30	— —	— —	5
40	Yucca Fault YF	n-rl?	Yes	24-32	6.8	78-143	— —	— —	5
40	Amargosa River AR	rl?	Yes	9-15	6.4	40-66	— —	— —	5
40	Amargosa River-Pahrump -Stewart Valley [l] ARPS	rl?	Yes	65-130 [l]	7.5	269-597	— —	— —	5
42	Tolicha Peak TOL	rl-n?	Yes?	7-22	6.6	56-98	— —	— —	5
43	Carpetbag CB	n-rl	Yes	16-30	6.8	74-134	— —	— —	5
43	Keane Wonder KW	n-rl?	Yes?	20-25	6.7	63-111	— —	— —	5
44	Area Three AT	n	Yes?	9-12	6.3	33-53	— —	— —	5
44	Checkpoint Pass CP	n-ll	No?	3-8	6.1	23-35	— —	— —	5

TABLE 1. (continued)

Minimum Distance to YM [a] (kilometers)	Fault Name and Abbreviation	Fault Type [b]	Documented Quaternary Displacement [c]	Maximum Fault Length [d] (kilometers)	Maximum Moment Magnitude [e] (Mw)	Expected Ave-Max Displacement [f] (centimeters)	Average Quaternary Slip Rate [g] (meters/10^3years)	Average Recurrence Interval [h] (10^3 years)	References [i]
46	Plutonium Valley-North Halfpint Range PVNH	n	No?	6-26	6.7	65-116	— —	— —	5
48	Mercury Ridge MER	n-ll?	No?	3-10	6.2	28-44	— —	— —	5
48	Crossgrain Valley CGV	n-ll	Yes?	3-9	6.2	26-39	— —	— —	5
48	Pahute Mesa PM	n-rl?	Yes?	3-9	6.2	26-39	— —	— —	5
49	Ranger Mountains RM	n	Yes?	3-5	5.9	15-22	— —	— —	5
50	Furnace Creek FC	rl	Yes	105-145	7.6	296-668	2.3-12.0	0.5-3.0 [m]	5, 12, 13
50	Death Valley-Furnace Creek DVFC	rl-n	Yes	185-205	7.8	402-950	2.3-12.0 [j]	0.5-3.7 [k]	5, 12, 13
50	Death Valley-Furnace Creek-Fish Lake Valley DFFL	rl-n	Yes	247-288 [n]	7.9	542-1345	2.3-12.0 [j]	0.5-3.7 [k]	5, 12, 13
50	South Ridge SOU	ll-n?	Yes?	5-19	6.6	50-84	— —	— —	5
52	Sarcobatus Flat SF	n	Yes?	27-51	7.1	118-230	— —	— —	5
53	West Springs Mountain WSM	n	Yes	30-60	7.1	136-271	0.02-0.2	— —	5
53	Buried Hills BH	n	Yes?	10-26	6.7	65-116	— —	— —	5

TABLE 1. (continued)

Minimum Distance to YM [a] (kilometers)	Fault Name and Abbreviation	Fault Type [b]	Documented Quaternary Displacement [c]	Maximum Fault Length [d] (kilometers)	Maximum Moment Magnitude [e] (Mw)	Expected Ave-Max Displacement [f] (centimeters)	Average Quaternary Slip Rate [g] (meters/10^3years)	Average Recurrence Interval [h] (10^3 years)	References [i]
53	Cockeyed Ridge-Papoose Lake CRPL	n	Yes?	5-21	6.6	54-93	— —	— —	5
55	Death Valley DV	n-rl	Yes	75-100 [o]	7.4	214-457	3.0-5.0	3.3-3.7	5, 12
55	Belted Range BLR	n	Yes	38-54	7.1	124-244	— —	— —	5
57	Kawich Range West KRW	n	Yes?	40-84	7.3	183-383	— —	— —	5
57	Oak Spring Butte OAK	n	Yes?	19-21	6.6	54-93	— —	— —	5
58	Grapevine GV	n-rl?	Yes	5-20	6.6	52-89	— —	— —	5
59	Kawich Valley KV	n	Yes?	9-43	7.0	102-193	— —	— —	5
59	Spotted Range SPR	n	Yes?	20-30	6.8	74-134	— —	— —	5
60	Emigrant Valley North EVN	n-rl?	Yes?	7-28	6.8	70-125	— —	— —	5
61	North Desert Range NDR	n	Yes?	4-24	6.7	61-107	— —	— —	5
66	Emigrant Valley South EVS	n-rl?	Yes?	7-20	6.6	52-89	— —	— —	5
67	Indian Springs Valley ISV	n	Yes?	23-28	6.8	70-125	— —	— —	5

TABLE 1. (continued)

Minimum Distance to YM [a] (kilometers)	Fault Name and Abbreviation	Fault Type [b]	Documented Quaternary Displacement [c]	Maximum Fault Length [d] (kilometers)	Maximum Moment Magnitude [e] (Mw)	Expected Ave-Max Displacement [f] (centimeters)	Average Quaternary Slip Rate [g] (meters/10^3years)	Average Recurrence Interval [h] (10^3 years)	References [i]
67	Grapevine Mountains GM	n-ll?	Yes?	9-31 [p]	6.8	76-138	— —	— —	5
70	Pahrump-Stewart Valley PSV	rl-n	Yes	65-70	7.2	156-318	— —	— —	5
74	Stumble STM	n	Yes?	31-33	6.8	81-148	— —	— —	5
74	Bonnie Claire BC	n-ll?	Yes?	8-27	6.7	68-120	— —	— —	5
76	West Pintwater Range WPR	n	Yes	60-82	7.3	180-373	— —	— —	5
76	Towne Pass TP	n	Yes	3-38	6.9	91-170	— —	— —	5
77	Jumbled Hills JUM	n	Yes?	3-27	6.7	68-120	— —	— —	5
80	Cactus Flat-Mellan CFM	n	Yes?	5-35	6.9	85-157	— —	— —	5
81	East Pintwater Range EPR	n	Yes?	45-58	7.1	132-262	— —	— —	5
82	Groom Range Central GRC	n	Yes?	9-31	6.8	76-138	— —	— —	5
82	La Madre LM	n	Yes?	7-24	6.7	61-107	— —	— —	5
84	Cactus Flat CF	n	Yes?	5-50	7.1	116-225	— —	— —	5

TABLE 1. (continued)

Minimum Distance to YM [a] (kilometers)	Fault Name and Abbreviation	Fault Type [b]	Documented Quaternary Displacement [c]	Maximum Fault Length [d] (kilometers)	Maximum Moment Magnitude [e] (Mw)	Expected Ave-Max Displacement [f] (centimeters)	Average Quaternary Slip Rate [g] (meters/10^3years)	Average Recurrence Interval [h] (10^3 years)	References [i]
85	Groom Range East GRE	n	No?	10-20	6.6	52-89	— —	— —	5
87	Cactus Range-Wellington Hills CRWH	n	No?	25-28	6.8	70-125	— —	— —	5
87	Chalk Mountain CLK	n	Yes?	8-20	6.6	52-89	— —	— —	5
90	Chicago Valley CHV	n	Yes	4-20	6.6	52-89	— —	— —	5
92	Tikaboo Valley TKV	n	Yes	10-33	6.8	81-148	— —	— —	5
92	Tin Mountain TM	n	Yes	3-29	6.8	72-129	— —	— —	5
92	Stonewall Mountain SWM	n-ll	Yes	10-22	6.6	56-98	— —	— —	5
95	Hunter Mountain-Panamint Valley HMPV	rl-n	Yes	78-160	7.6	323-738	1.6-3.2 [q]	— —	5
97	Penoyer PEN	n	Yes	25-56	7.1	128-253	— —	— —	5
97	Racetrack Valley RTV	n	Yes?	22-28	6.8	70-125	— —	— —	5
106	Pahranagat PAH	ll-n	Yes	66-91	7.4	197-415	— —	— —	5
126	Owens Valley OWV	rl-n	Yes	90-110	7.4	233-504	1.0-3.0	3.3-5.0	5

TABLE 1. (continued)

Minimum Distance to YM [a] (kilometers)	Fault Name and Abbreviation	Fault Type [b]	Documented Quaternary Displacement [c]	Maximum Fault Length [d] (kilometers)	Maximum Moment Magnitude [e] (Mw)	Expected Ave-Max Displacement [f] (centimeters)	Average Quaternary Slip Rate [g] (meters/10^3years)	Average Recurrence Interval [h] (10^3 years)	References [i]
130	Fish Lake Valley FLV	rl-n	Yes	67-83	7.3	181-378	4.0-12.0	0.5-3.0	5, 13
150	Garlock GAR	ll	Yes	148-248	7.9	481-1169	5.0-7.0	0.2-3.0	14, 15
185	White Mountains - Cedar Mountain [r] WMCM	rl-n	Yes	60-115 [r]	7.5 [r]	242-527	0.1-3.0	— —	5, 16
310	San Andreas SAF	rl	Yes	350-420	8.1	756-1976	25.0-35.0	0.1-0.2	17 thru 20

a Minimum Distance refers to the closest distance (in km) from the surface trace of the fault to the center of the conceptual repository outline (approximately 36.85°N latitude and 116.45° W longitude, Figure 1), measured in plan view. Ramps and development levels that connect the potential repository to surface facilities continue eastward about 3 km.

b Fault Type is: normal (n); right lateral (rl); and left lateral (ll). These are compounded for oblique slip faults; the second notation represents the subordinate component of slip.

c Documented Quaternary Displacement designates the evidence for Quaternary fault activity with three alternatives: Yes; Yes?; and No?. Yes indicates there are published studies which document fault displacement that is Quaternary in age (≤2 Ma). Yes? indicates the available data provide evidence to suspect Quaternary displacement, but the fault has not been studied in sufficient detail to document Quaternary activity. Mostly these are faults that aerial photography studies or reconnaissance examinations show to have relatively youthful geomorphic expressions, pronounced fault-related geomorphology, and commonly appear to offset middle to late Quaternary deposits; however, there are no detailed studies to confirm this. Faults shown with a No? are those for which the available data indicate there have not been Quaternary displacements; but, either the data are incomplete or interpretations of the data are inconclusive, which still marks them as suspect and potentially relevant. Commonly, these are faults for which the Quaternary record is incomplete, that

aerial photography studies or reconnaissance examinations indicate are buried beneath Quaternary deposits, or are characterized by a general absence of steep bedrock slopes, faceted spurs, and fault-related geomorphology; but, in some cases, appear to juxtapose Quaternary deposits against bedrock, for example.

d Maximum Fault Length is the length of the fault zone (in km) as reported in published references or as estimated from maps and plates in cited references (e.g., Simonds and others, in press; Piety, in press). The first value commonly represents the cumulative length of continuous fault sections or sections of the fault zone that have scarps or both. The second value, taken here as the maximum, represents the entire length of the zone including sections portrayed as concealed or discontinuous or both. The measurements should be considered as approximations because the lengths are directly dependent upon how faults and lineaments are combined into fault zones, and the accuracy of the measurements is variable.

e Maximum Moment Magnitude (M_W) is the size of the earthquake expected for rupture of the maximum fault length. Moment magnitudes are calculated using maximum fault lengths and the empirical relationship between surface rupture length and moment magnitude determined by Wells and Coppersmith (1994).

f Expected Average Displacement and Expected Maximum Displacement (in cm) are the amounts of slip expected on the fault at the surface during an earthquake that ruptures the entire length of the fault. Average and maximum displacements are determined using empirical relationships between surface rupture length (maximum fault length) and average and maximum displacement by Wells and Coppersmith (1994).

g Average Slip Rates (in meters/10^3 years or mm/yr) are based on ages and measured displacements of Quaternary deposits. Values in parentheses indicate calculations based on the ages and measured displacements of pre-Quaternary deposits.

h Average Recurrence Intervals (in 10^3 years) refer to the frequency of surface-rupturing earthquakes, which are based upon paleoseismic trenching studies to determine the number of recognized events and the ages of fault-related deposits. Recurrence intervals for local faults are preliminary and are pending age determinations and refined interpretations of fault-related deposits.

i References for fault characteristics are keyed by number. 1 is Simonds and others (in press); 2 is Scott and Bonk (1984); 3 is Spengler and others (1994); 4 is Ramelli and others (1994); 5 is Piety (in press); 6 is Scott and others (1984); 7 is Menges and others (1994); 8 is Coe (1994); 9 is Dickerson and Spengler (1994); 10 is Langenheim and Ponce (1994); 11 is Anderson and Klinger (1994); 12 is Klinger and Piety (1994); 13 is Reheis (1994); 14 is McGill and Sieh (1993); 15 is McGill and Sieh (1991); 16 is dePolo and others (1993); 17 is Sieh (1978); 18 is Sieh (1984); 19 is Clark and others (1984); and 20 is USGS (1988).

j Range of slip rate based on the minimum and maximum slip rate of either fault involved in the presumed compound rupture.

k Range of recurrence interval based on the minimum and maximum recurrence interval of either fault involved in the presumed compound rupture.

l Considerable diversity of interpretation exists for the length (hence, minimum distance and expected magnitude) for the Pahrump-Stewart Valley fault zone, which has been interpreted to continue for a length of ~130 km. If so, the fault appears to be concealed for as much as one-half of this length. The northernmost traces may merge with other zones including the Amargosa River, Ash Meadows, and Rock Valley fault zones. This table includes this interpretation by considering that the Amargosa River fault is the northern continuation of the Pahrump-Stewart Valley zone. Given this interpretation, there is an additional 40 km of fault length that is unaccounted for at the southeastern projection of the Pahrump-Stewart Valley fault zone.

m Recurrence interval is considered to be equivalent to recurrence interval of the Fish Lake Valley fault, which is the northern continuation of the Furnace Creek fault.

n Maximum fault length includes the combined maximum lengths of the Death Valley and Fish Lake Valley faults and about 105 km for the Furnace Creek fault, from the southern end of the Fish Lake Valley fault in the Cucomungo Canyon area to the northern end of the Death Valley fault where the fault changes to a more northward strike.

o Maximum fault length includes the southernmost part of the Death Valley fault zone south of Shoreline Butte almost to the Garlock fault.

p Grapevine Mountains fault zone consists of an eastern and a western fault (e.g., Piety, in press). The maximum fault length is measured from the southern end of the eastern fault to the northern end of the western fault.

q Average slip rate determined for the Panamint Valley fault zone.

r The White Mountains - Cedar Mountain source is an idealized fault source that represents several of the larger faults in a broad area located between the 1872 Owens Valley earthquake rupture and the 1932 Cedar Mountains rupture (e.g., dePolo and others, 1993). See text for additional explanation.