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To: MR. TOM OSTROM, CHIEF
OFFICE OF EARTHQUAKE ENGINEERING

Date: April 23, 2013

File: 01-HUM-101, PM 86.33
0000001016 6SSCN
11th Street Overcrossing
Bridge No. 4-242

Attention: Mr. Mark Yashinsky

From: DEPARTMENT OF TRANSPORTATION
DIVISION OF ENGINEERING SERVICES
Materials Engineering and Testing Services and Geotechnical Services
Office of Geotechnical Support – Geotechnical Instrumentation

Subject: Preliminary Evaluation of Fault Rupture Potential, 11th street Overcrossing (OC), Humboldt County, CA

SUMMARY

11th Street Overcrossing (OC), No. 4-242, is near to or crossed by a trace of the Mad River fault zone (main trace of the Fickle Hill fault). Assuming the trace crosses beneath the OC, net offset is estimated at 3-2/3 ft deterministically and 2/3 ft probabilistically. These values may be further broken down into following vectors: 2 ft vertical and 3 ft horizontal in a southwest direction (deterministic), and 1/3 ft vertical and ½ ft horizontal in a southwest direction (probabilistic). The probabilistic value is lower because of the fault's low level of activity.

Per Memo To Designers (MTD) 20-8**,** the larger of the deterministic and probabilistic values or a site-specific value should be used for design. However, given sufficient reason a probabilistic value may be used with permission from the Office of Earthquake Engineering. **Please respond with either permission to use the probabilistic value, or requirements to use the deterministic value in which case we will proceed with further evaluation at this bridge. In either case I will issue a final memo. Conclusions reached here will be applied to two nearby bridges.**

DISCUSSION

This preliminary evaluation was prepared as part of the statewide evaluation of fault rupture potential at Caltrans bridges. Caltrans' policies regarding fault rupture at bridges are described in Memo to Designers (MTD) 20-10. Caltrans requires a fault rupture evaluation if a bridge is located within an Alquist-Priolo Earthquake Fault Zone (EFZ) or within 1,000 ft of an un-zoned fault 15,000 years or younger in age. 11th Street Overcrossing (OC) is situated within the EFZ

established in 1983 for the Mad River fault zone (Fickle Hill fault) in the Arcata South 7-1/2' EFZ Map; therefore a fault evaluation was required. 11th Street OC was built in 1976, replacing the existing bridge 4-011, and consists of two spans. The OC is 271 ft long and 52 ft wide, and is supported on driven concrete piles.

The nearest Caltrans-active fault to 11th Street OC is the Fickle Hill fault, part of the Mad River fault zone (Figures 1-5), which may cross beneath the bridge. The Mad River fault zone is a 10-15 km wide zone composed of the reverse Fickle Hill, Mad River, McKinleyville, Blue Lake, and Trinidad faults each trending northwest and dipping 25-45 degrees northeast (McCrory, 2000). The Fickle Hill fault is described in FER-138 (Smith, 1982, issued along with the 1983 Arcata South EFZ Map) as a broad scarp that may possibly have originated as folding (figures 1 and 3).

No evidence of faulting was observed in Logs of Test Borings for the OC (1951; 1974). The main Fickle Hill fault trace has not been encountered in a trenching investigation, however secondary antithetic faults dipping southwest with between 3 to 15 inches of vertical offset were observed in trenches excavated 600 ft northwest of the OC (Busch, 1987) (figures 4 and 5). The major offset on this fault will likely be southwest of the bridge as shown in Figure 5, with antithetic faulting as described above occurring beneath the bridge. A **M**Max of 7 and slip rate of 0.6 mm/yr have been associated with the Fickle Hill fault (USGS, 2008; Dawson and Weldon, 2012). Slip rate quality is given an overall "B" rating in Dawson and Weldon (2012).

Potential offset was estimated based on an analysis developed by Division of Research and Innovation in collaboration with Geotechnical Services, using methods presented in Abrahamson (2008), Moss and Ross (2011), and Petersen, et al (2011) and the above parameters. If the main trace of the Fickle Hill fault crosses beneath the OC, the probabilistic (5% in 50 years or 1000 year return period) value of displacement based on Ross and Moss (2011) using a Gutenberg-Richter approach is 0.2 m or 2/3 ft (Figure 6). The deterministic value of displacement based on Wells and Coppersmith (1994) and Ross and Moss (2011) is 1.13 m or 3-2/3 ft. These values may be further broken down into following vectors: 2 ft vertical and 3 ft horizontal in a southwest direction (deterministic), and 1/3 ft vertical and ½ ft horizontal in a southwest direction (probabilistic). Mark Yashinsky and Fadel Alameddine reviewed the bridge plans and determined the OC could not withstand the larger of the two initial estimates of displacement per MTD 20-8 without modification.

RECOMMENDATIONS

According to MTD 20-8, the larger of the probabilistic and deterministic values should be used for design. However the memo also includes the caveat that a smaller probabilistic value may be used with consent from the Office of Earthquake Engineering (OEE). I recommend the use of the probabilistic value because of the fairly good estimate of slip rate which indicates a low level of activity. Additionally according to previous work in the area it is quite possible the OC is located off the main trace but it may be hard to prove. If OEE recommends we use the deterministic value for design, further work could include better defining the fault's location via air photo

interpretation and evaluation of local elevation differences that could reflect the fault scarp location. The main trace of the fault has never been observed in a trench and may be particularly difficult to find near the OC because of past construction activities and the presence of artificial fill.

If you have any questions, please contact Martha Merriam at (916) 227-7135. Please respond regarding the use of the deterministic or probabilistic value of displacement. Similar recommendations will be issued for the following nearby bridges located on another fault in the Mad River fault zone:

School Rd OC #4-168
Hiller Rd OC #4-173

Prepared by: Date: April 23, 2013

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Instrumentation Branch

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	GS (Instrumentation Branch) –	Gem-Yeu Ma
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	Earthquake Engineering –	Fadel Alameddine
	Earthquake Engineering –	Mark Yashinsky

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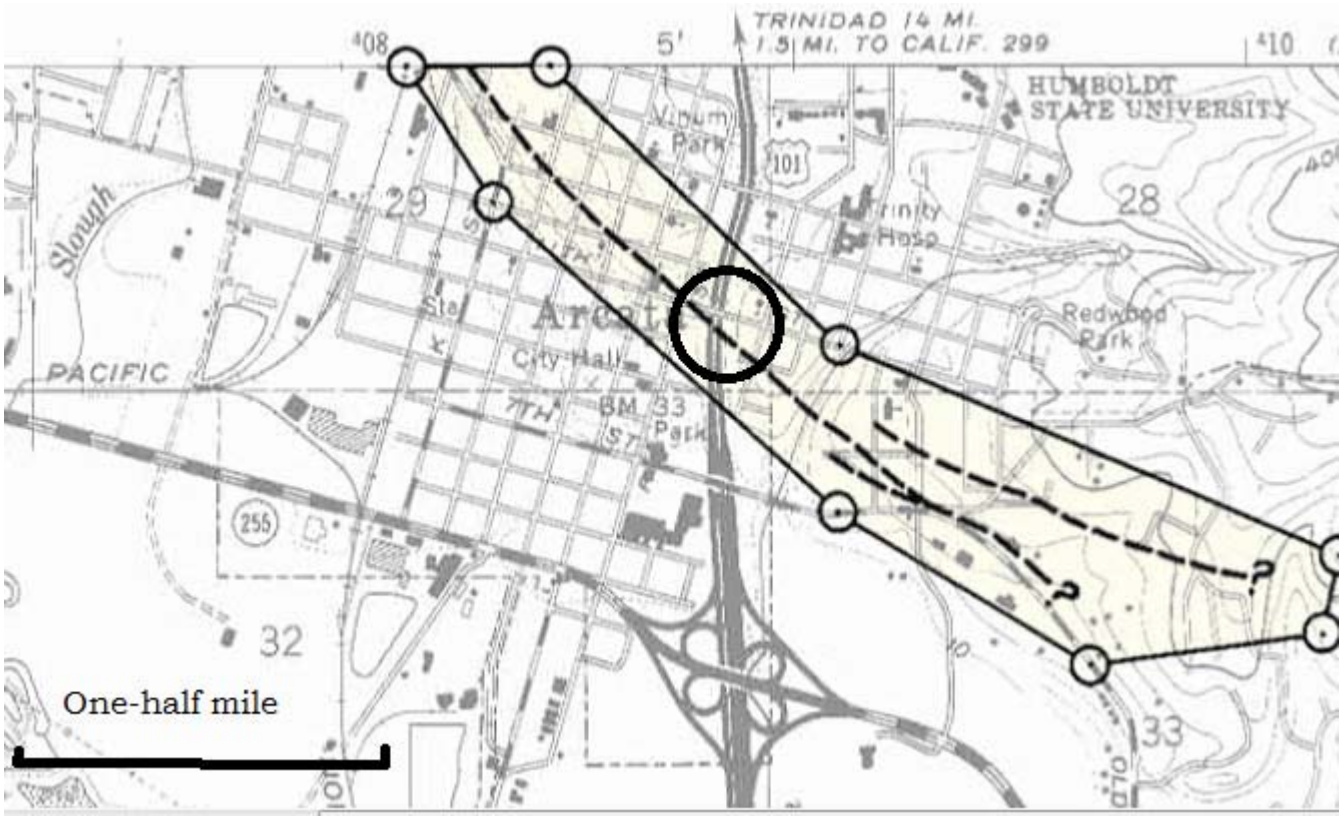

Figure 1. 1983 Arcata South 7-1/2' EFZ Map. Location of 11th Street OC is shown in black circle.

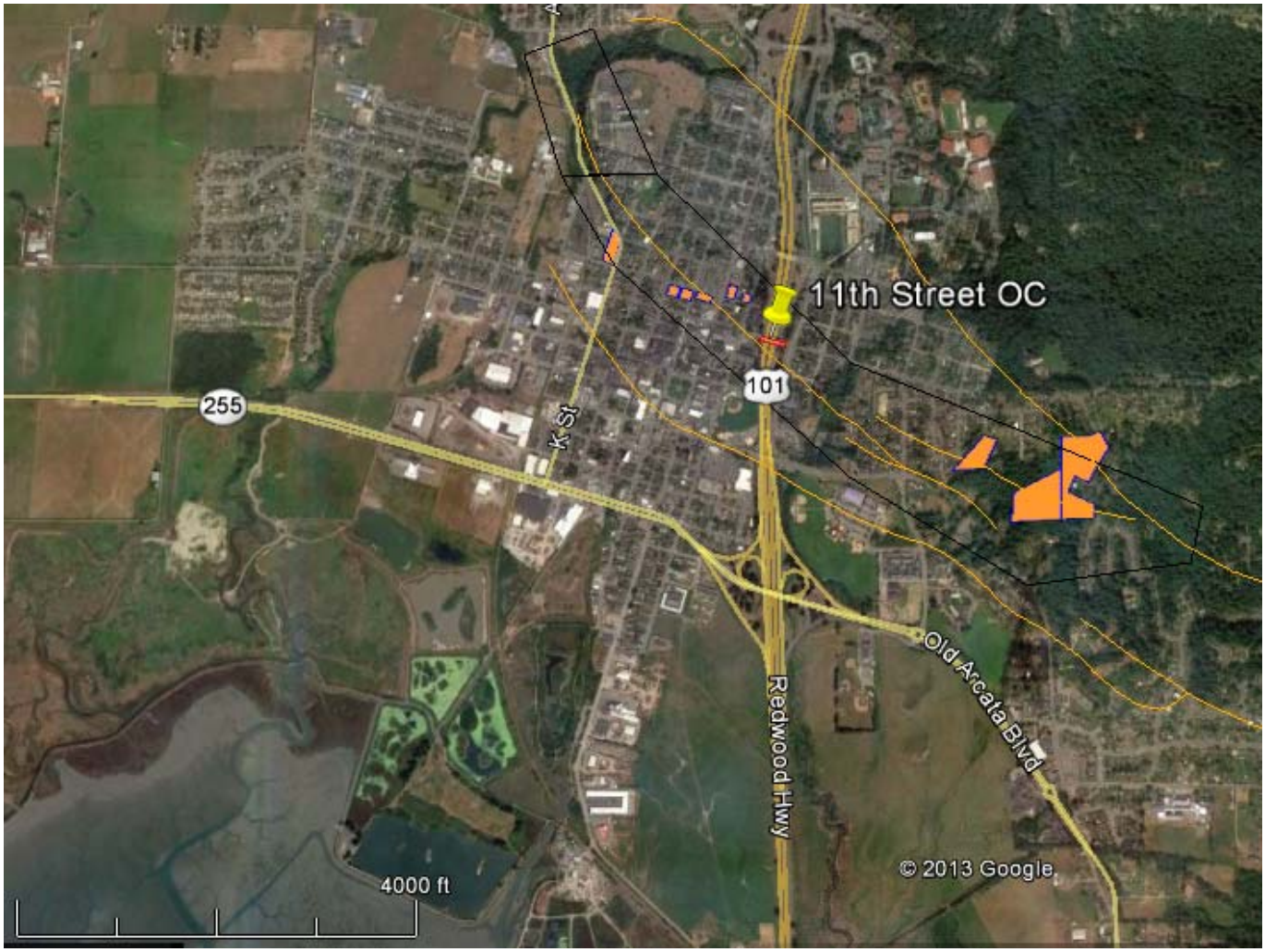

Figure 2. Google Earth view of OC, which includes fault traces in orange (Holocene-latest Pleistocene-age), EFZ in black, and locations of previous studies (orange polygons). (USGS, 2010, CGS, 2012). The main trace of the Fickle Hill was not encountered in trenches excavated for any of the previous studies shown above.

Figure 3.

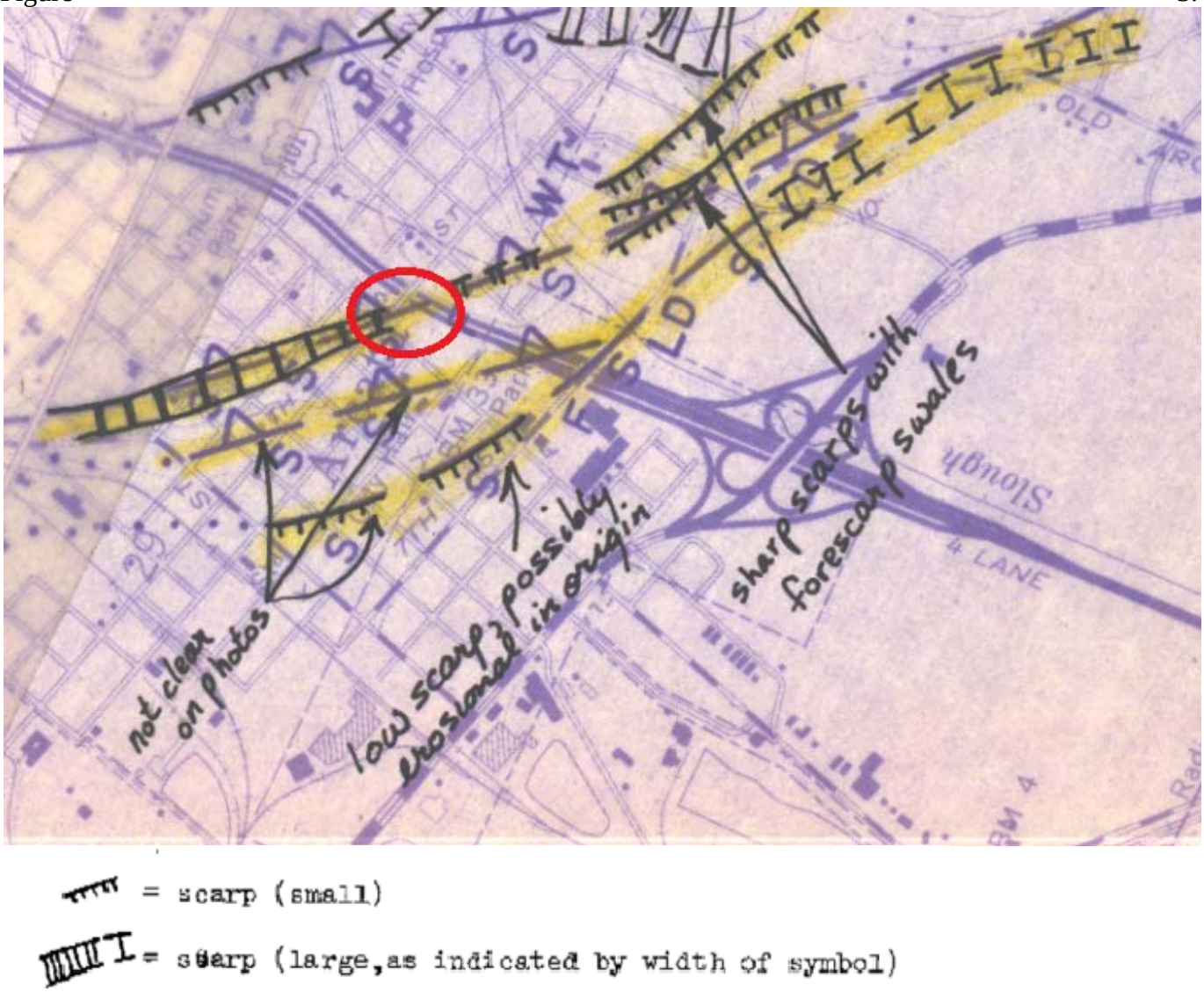

Figure 3. Large scarp associated with the Fickle Hill fault is denoted west of the OC. Freeway direction is north to the left.

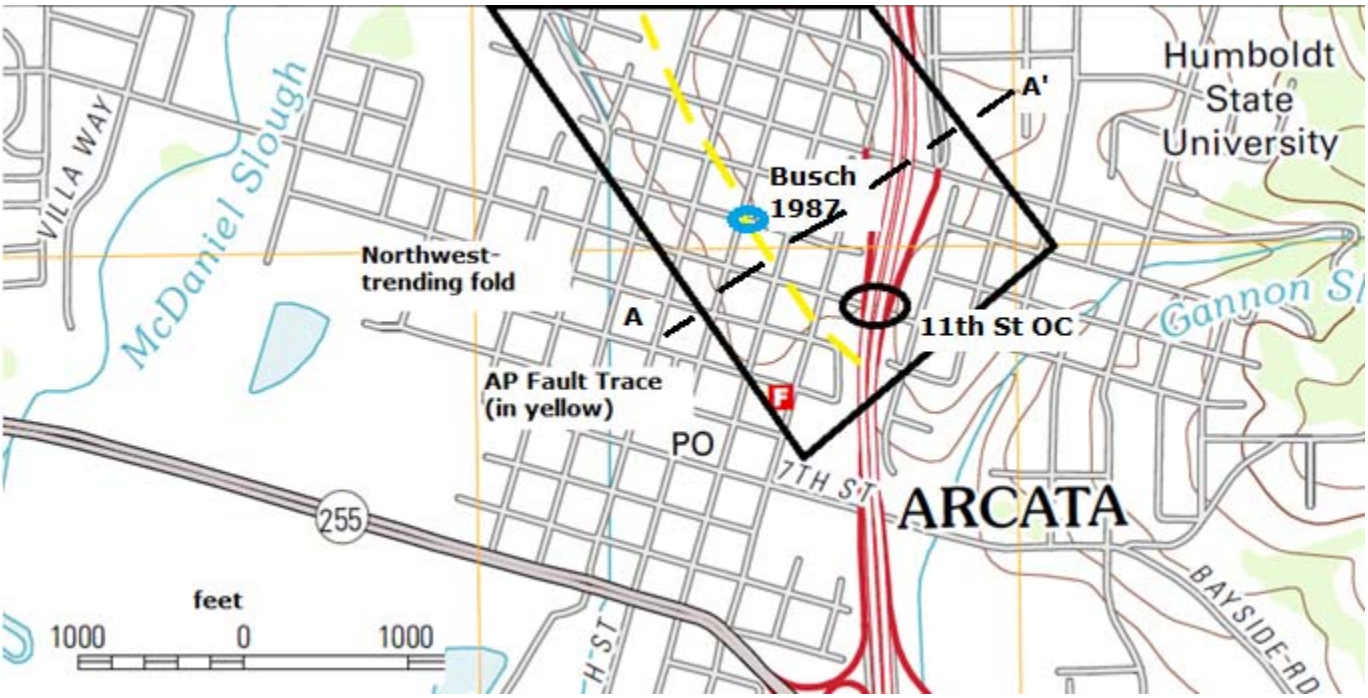

Figure 4. General location of large scarp shown on Figure 3. See below for schematic cross-section A-A'. (USGS Arcata South 7-1/2' Quad, 2012 edition)

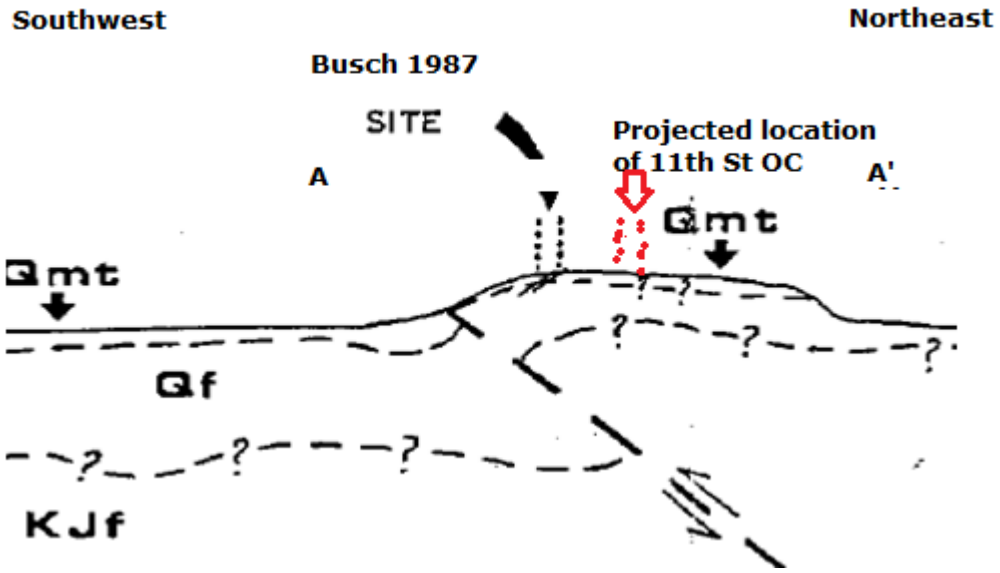

Figure 5. Interpretation by Busch (1987). See Figure 4 for location of schematic cross-section A-A'.
Qmt Late-Pleistocene-age marine terraces
Qf Early- to middle-Pleistocene-age Falor formation
Kjf Cretaceous/Jurassic Franciscan formation
Contacts are dashed when approximate; questioned when queried. Reverse fault is indicated dipping NE.

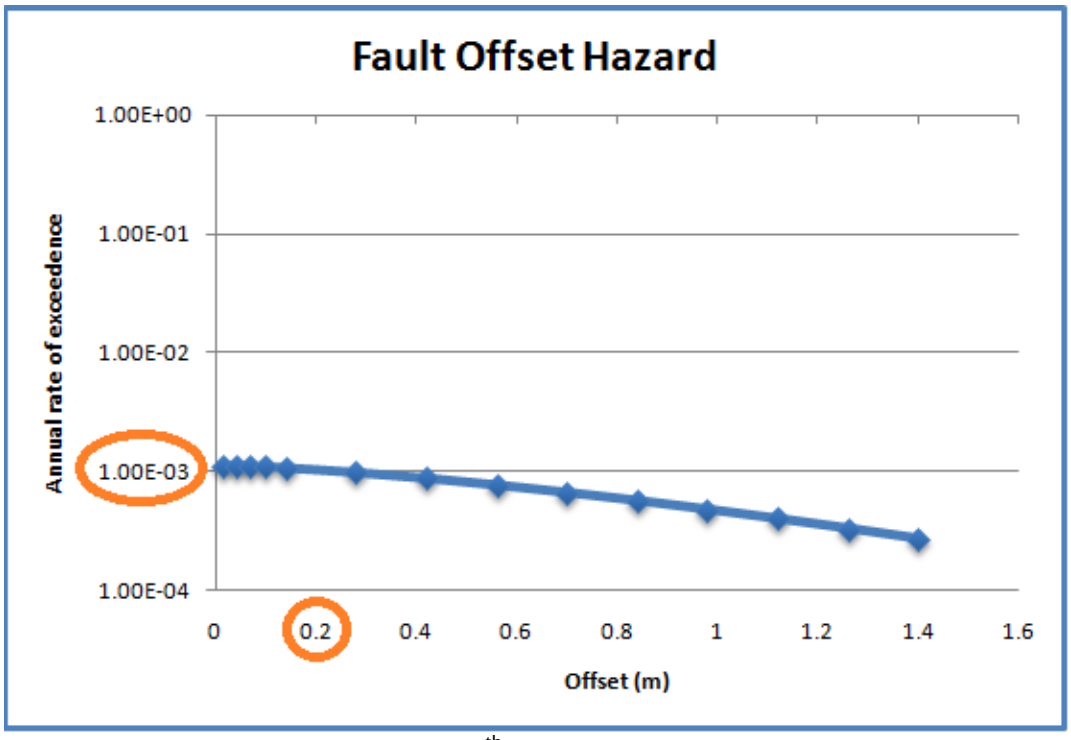

Figure 6. Estimated displacement at 11th Street OC assuming that the fault crosses beneath the bridge is 0.2 m (2/3 ft) probabilistically (shown above), or 1.13 m (3-2/3) ft deterministically.

OC looking north: http://db2.dot.ca.gov:7777/osmi_tmp/biris/BX8412102.pdf