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Hayward fault zone, Northern Hayward section (Class A) No. 55a

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Compiled in cooperation with the California Geological Survey

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Synopsis	**General:** Historically active dextral strike-slip fault zone that is part of the larger San Andreas fault system. The Hayward fault zone is located along the eastern margin of San Francisco Bay and generally forms the western front of the East Bay Hills. The fault zone has three sections (Working Group on Northern California Earthquake Probabilities, 1996 #1216; Petersen and others, 1996 #4860). The Northern [55a] and Southern Hayward [55b] sections are principally characterized by historically active dextral strike-slip displacement (Herd, 1977 #5484; 1978 #5485; Smith, 1980 #5497; 1980 #5498; 1981 #5499; Lienkaemper, 1992 #5486). The

Southeast Extension section [55c] is characterized by late Quaternary and Holocene dextral, dextral-reverse, and reverse displacement (Bryant, 1982 #5475). The Hayward fault is characterized by fault creep along the Northern and Southern sections. A preferred average creep rate of 4.6 mm/yr was reported by Lienkaemper and Galehouse (1997 #5488). Most of the fault creeps between 3 mm/yr and 6 mm/yr (Galehouse, 1995 #4853; Lienkaemper and Galehouse, 1997 #5488; 1999 #5500), although the historic creep rate has been as high as 9 mm/yr near the southern part of the Southern Hayward fault [section 55b] (Lienkaemper and others, 1991 #5487; Lienkaemper and Galehouse, 1997 #5488). The M_W7 1868 earthquake (Lawson, 1908 #4969; Yu and Segall, 1996 #5492) occurred on the Southern Hayward fault [55b] and extended into the Northern Hayward fault [55a]. Fault creep has not been observed along the Southeast Extension section [55c]. Toppozada and Borchardt (1998 #5493) showed that the June 10, 1836 earthquake, previously thought to have been on the Northern Hayward fault [55a], occurred further south, somewhere east of Monterey Bay. Cumulative dextral offset of the 6 Ma Roblar Tuff is 28?3 km (Sarna-Wojcicki, 1992 #5265). Lienkaemper and Borchardt (1996 #5297) reported a preferred Holocene deformation rate (minimum) of 8.0±0.7 mm/yr based on dextral offset of an alluvial-fan apex in Union City. A dated recurrence interval has not been determined for the Northern and Southern Hayward faults (sections 55a and 55b, respectively), but there have been at least four surface faulting earthquakes in the past 2,250 radiocarbon years along the Northern Hayward section (Leinkaemper and others, 1997 #5482). Williams (1992 #5495) reported that at least 6 and as many as eight events have occurred in the past 2.1 k.y. along the Southern Hayward section.

Sections: This fault has 3 sections. There is insufficient data to determine seismogenic segments. The segment boundary between the Northern and Southern Hayward faults was long considered to be delineated by the location of the northern boundary of rupture associated with the M_W7 1868 earthquake and the southern boundary of rupture associated with the 1836 (Working Group on California Earthquake Probabilities, 1988 #5494; 1990 #549). Toppozada and Borchardt (1998 #5493) re-evaluated the 1836 earthquake and demonstrated that it did not occur on the Hayward fault. Yu and Segall (1996 #5492) and Working Group on Northern California Earthquake Potential (1996 #1216) suggest that 1868 rupture may have extended as far north as northern

	Oakland. Petersen and others (1996 #4860) and Working Group on Northern California Earthquake Potential (1996 #1216) modeled the Hayward fault zone with two segments of equal length. The Northern and Southern sections of the Hayward fault zone were considered to rupture characteristically, with a dextral strike-slip deformation rate of 9 mm/yr. A possible third segment, the Southeast Extension, was modeled with a dextral reverse oblique slip rate of 3 mm/yr. The section boundaries proposed by Petersen and others (1996 #4860) and Working Group on Northern California Earthquake Potential (1996 #1216) are adopted here: from north to south they are the Northern Hayward [55a], Southern Hayward [55b], and Southeast Extension [55c] sections.
Name comments	**General:** The Hayward fault zone was first mapped by Lawson (1908 #4969) who named it for Haywards (now known as Hayward), the site of greatest damage caused by the 1868 earthquake (about M_W7). The southeast extension of the Hayward fault zone consists of several named faults, including the Mission, Evergreen, Quimby, Crosley, and Clayton faults as mapped by Dibblee (1972 #5477; 1972 #5478; 1973 #5480). **Section:** The Southeast Extension section consists of several named faults, including the Hayward (SE extension), Mission, Crosley, Quimby, and Evergreen faults. These faults were mapped and named by Dibblee (1972 #5477; 1972 #5478; 1972 #5479; 1973 #5480). **Fault ID:** Refers to number (Southern Hayward fault) of Jennings (1994 #2878) and number H1 (Hayward, south) of Working Group on Northern California Earthquake Potential (1996 #1216).
County(s) and State(s)	CONTRA COSTA COUNTY, CALIFORNIA ALAMEDA COUNTY, CALIFORNIA
Physiographic province(s)	PACIFIC BORDER
Reliability of location	Good Compiled at 1:24,000 scale. *Comments:* Location based on digital revisions to Jennings (1994 #2878) at 1:750,000 using original mapping by Smith (1980 #5497; 1980 #5498), Herd (1978 #5485), Radbruch-Hall (1974 #1243), and Lienkaemper (1992 #5486) at 1:24,000 scale.

Geologic setting	Major dextral strike-slip fault of the larger San Andreas fault system. This fault is located in the eastern San Francisco Bay region and generally trends along and bounds the western side of the East Bay Hills (Aydin, 1982 #5467). The fault zone extends from San Pablo Bay southeast to the Evergreen area in eastern San Jose. The northern end of fault probably connects with the Rodgers Creek fault [32] via a 6-km-wide, right-releasing stepover beneath San Pablo Bay (Wright and Smith, 1992 #5258). Slip is eventually transferred to the central part of the Calaveras fault [54b] in a complex manner. Andrews and others (1993 #5466) suggest that slip is transferred to the Calaveras fault zone [54] along a dextral reverse fault in the vicinity of Calaveras Reservoir. Dextral offset estimated to be 28±3 km in the past 6 m.y., based on offset of the Roblar Tuff (Sarna-Wojcicki, 1992 #5265).
Length (km)	This section is 42 km of a total fault length of 107 km.
Average strike	N34°W (for section) versus N39°W (for whole fault)
Sense of movement	Right lateral *Comments:* Geomorphic expression is characterized by stream channel offsets, and fault-creep displacement, which document predominantly dextral strike-slip displacement (Smith, 1980 #5497; 1980 #5498; Lienkaemper, 1992 #5486; Galehouse, 1995 #4853; 1997 #5488; 1999 #5500). Locally, some fault traces have an east-dipping reverse component as suggested by earthquake focal mechanisms (Oppenheimer and others, 1992 #5490).
Dip Direction	V *Comments:* Oppenheimer and others (1992 #5490) reported that the dip of the Hayward fault is near vertical, based on focal mechanisms of earthquakes. However, they also report secondary, generally northeast-dipping reverse mechanisms adjacent to the principal Hayward fault.
Paleoseismology studies	There are three detailed studies on the Northern Hayward fault zone: Site 55-1. Studies by Borchardt (1990 #5468; 1995 #5469) and Borchardt and Seelig (1991 #5471) involved logging of five fault-normal trenches, detailed descriptions of terraces on the northeast side of the fault, and correlation of borings on either side of the

	fault. Borchardt (1998 #5470) proposed a slip rate for the Northern Hayward section based on correlations of a marine platform interpreted from boring logs. Mira Vista golf course (site 55-6). This site was investigated by the Hayward Fault Paleoearthquake Group (1999 #5483). Two trenches excavated across a fault and sag pond at the Mira Vista golf course yielded data on the timing of the most recent event and partial data on recurrence intervals of surface-rupturing earthquakes. Montclair Park (site 55-7). Lienkaemper and Williams (1999 #5489) excavated a single trench across the principal active trace of the Hayward fault at Montclair Park in northern Oakland. They observed evidence of surface ruptures associated with the 1868 earthquake, which extends the northern rupture limit of this earthquake about 13 km farther north than the segment boundary proposed by Working Group on Northern California Earthquake Potential (1990 #549) and about 5 km north of the northern end of the 1868 rupture at Mills College as suggested by evidence in Lawson (1908 #4969). The penultimate event exposed at Montclair Park may correlate with the most recent event reported at the Mira Vista site [55a-2], which is considered to have occurred between 1640 and 1776 A.D.).
Geomorphic expression	The traces of the Northern Hayward section are characterized by well defined linear troughs and scarps, closed depressions, side-hill benches and dextrally deflected small and large drainages that indicate a relatively high Holocene dextral slip rate (Herd, 1978 #5485; Smith, 1980 #5497; 1980 #5498; Lienkaemper, 1992 #5486). Locally in the East Bay Hills, the fault is obscured by landslides.
Age of faulted surficial deposits	Faulted alluvium and soil were exposed in trenches in several site-specific investigations along the Northern Hayward section done in compliance with Alquist-Priolo Earthquake Fault Zoning Act (Hart and Bryant, 1997 #4856). Leinkaemper and others (1997 #5482) reported that faults of the Northern Hayward section offset late Holocene sag-pond deposits that range from modern to 2 ka, based on radiocarbon dating.
Historic earthquake	
Most recent	latest Quaternary (<15 ka)

prehistoric deformation	*Comments:* The most recent paleoevent on the Northern Hayward fault occurred after 1640 A.D. but before 1776 A.D., based on trenching at the Mira Vista (Hayward Fault Paleoearthquake Group, 1999 #5483).
Recurrence interval	*Comments:* A dated recurrence interval has not been determined, but there have been at least 4 to 7 surface faulting earthquakes in the past 1627 radiocarbon years (Hayward Fault Paleoearthquake Group, 1999 #5483). A minimum mean recurrence interval of <270 years is suggested if 7 surface rupturing events have occurred in the past 1627 radiocarbon years. A maximum mean recurrence interval of <710 years is indicated if the more conspicuous 4 paleoearthquakes are used (Hayward Fault Paleoearthquake Group, 1999 #5483).
Slip-rate category	Greater than 5.0 mm/yr *Comments:* Latest Pleistocene to Holocene slip rate for Northern Hayward section is poorly constrained. P.L. Williams (personal commun. 1999) reported a late Quaternary slip rate of about 10 mm/yr based on dextral offset of Strawberry Creek in Berkeley. Timing of the dextral displacement was based on radiocarbon dates of fluvial terraces. Borchardt (1998 #5470) estimated a long-term dextral slip rate of 3.5±0.5 mm/yr in the Point Pinole area (site 55-1). Based on borings, a buried marine-abrasion-platform embayment was interpreted to be dextrally offset 626±173 m in the past 112±4 k.y. and 674±21 m in the past 121 k.y. The age of the marine platform is based on soil-profile development and correlation with late Wisconsin sea-level high stands.
Date and Compiler(s)	2000 William A. Bryant, California Geological Survey Sereyna E. Cluett, California Geological Survey
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