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Quarterly Seismic Monitoring Report 96C

D.C. Hartshorn

S.P. Reidel

Westinghouse Hanford Co., Richland, WA 99352

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Abstract: This report summarizes the location, magnitude, and other pertinent information on earthquakes recorded on and near the Hanford Site by Westinghouse Seismic Monitoring during the period encompassing April 1, 1996 to June 30, 1996.

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TERMS

BWIP	Basalt Waste Isolation Project
CAM	Coda Amplitude Magnitude
CRBG	Columbia River Basalt Group
CUT	Coordinated Universal Time
DOE	U.S. Department of Energy
EWRN	Eastern Washington Regional Network
FY	fiscal year
GBB	Gable Butte
GPS	Global Positions Satellite System
HSN	Hanford Seismic Network
HTS	Hanford Technical Services
NEL	Nelson Butte
RAW	Rattlesnake Mountain-Wallula Alignment
RC1	Royal City
SMART	Seismic Monitoring Analysis and Repair Team
USGS	United States Geological Survey
WHC	Westinghouse Hanford Company

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1.0 INTRODUCTION

1.1 BACKGROUND

Seismic monitoring at the Hanford Site was established in 1969 by the United States Geological Survey (USGS) under a contract with the U.S. Atomic Energy Commission. In 1975 the University of Washington assumed responsibility for and expanded the network. In 1979 the Basalt Waste Isolation Program (BWIP) became responsible for collecting seismic data for the site as part of site characterization. Rockwell International Operations followed by Westinghouse Hanford Company (WHC), Geosciences Group, operated the local network and were the contract technical advisors for the Eastern Washington Regional Network operated by the University of Washington. Funding ended for BWIP in December 1988. Seismic Monitoring and the University of Washington contract was then transferred WHC's Environmental Division.

Seismic Monitoring is currently assigned to WHC's Hanford Technical Services (HTS), part of the Environmental Division. The Seismic Monitoring Analysis and Repair Team (SMART) operates, maintains, and analyzes data from the Hanford Seismic Network (HSN), extending the site historical seismic database and fulfilling U.S. Department of Energy, Richland Operations Office requirements and orders. The Seismic Monitoring Analysis and Repair Team also maintains the Eastern Washington Regional Network (EWRN). The University of Washington uses the data from the EWRN and other seismic networks in the Northwest to provide the SMART with necessary regional input for the seismic hazards analysis at the Hanford Site.

1.2 PURPOSE

The SMART is tasked to provide an uninterrupted collection of high-quality raw seismic data from the HSN located on and encircling the Hanford Site. These unprocessed data are permanently archived. The SMART is also tasked to locate and identify sources of seismic activity, monitor changes in the historical pattern of seismic activity at the Hanford Site, and build a "local" earthquake database (processed data). Local earthquakes are defined for this report and database as earthquakes that occur within 46 degrees to 47 degrees West Longitude and 119 degrees to 120 degrees North Latitude. The data are used by the SMART, Waste Management, and engineering activities at the Hanford Site to evaluate seismic hazards and seismic design for the Site. The processed database is also permanently archived.

1.3 REPORTS

The SMART issues brief monthly activity reports, quarterly reports with discussion of local activity, an annual catalog of earthquake activity on and near the Site, and bulletins on special-interest local seismic events. The SMART also provides information and reports to other functions, as well as educational assistance to area schools and programs when the assistance is requested and approved, and the workload permits.

2.0 NETWORK OPERATIONS

2.1 MONITORING STATIONS

The HSN and the EWRN have 40 individual sensor sites. Sixteen sites are shared by both networks, so that the Hanford Seismic Network has 21 sites (Table 1 and Figure 1) and the Eastern Washington Regional Network has 35 (Table 2 and Figure 2). The networks have 44 combined data channels because Gable Butte and Royal City are three-component sites, each consisting of one vertical, one north-south horizontal, and one east-west horizontal data channel. Both networks use 15 additional telemetry relay sites. All station data links pass through at least one of these relay sites. Some data links cross as many as three relay sites. The last section of the data link for all channels is commercial telephone lines. Three to eight channels are multiplexed per telephone line.

Most stations and five relay sites are powered by solar panels and batteries. A major outage is considered to be a failure of the HSN data recording computer or three or more data channels.

2.2 STATION MAINTENANCE

The HSN's station outages and a review of the station maintenance for the current quarter can be found in the Seismic Monitoring monthly reports. Table 3 shows the percentage of time the channel was operational for the period. One site in the EWRN, Nelson Butte (NEL), is currently inoperative. Access to repair NEL is prevented by damaged roads and the site's remote location. The site is located in the northern Cascades at 1,490 m elevation. A repair trip is scheduled for late August 1996.

Table 1. Stations Used for Location of Events.

This table lists stations of the Hanford Seismic Network. The first column is the three-letter seismic station designator. This is followed by the latitude-north in degrees, minutes, and hundredth of minutes; the longitude-west in degrees, minutes, and hundredth of minutes; elevation above sea level in meters; and the full station name. An asterisk before the three-letter designator means it is a three-component station. The locations of the stations were derived from a Global Positions Satellite system (GPS).

Station	Latitude Deg.Min.N	Longitude Deg.Min.W	Elevation (m)	Station Name
BEN	46-31.13	119-43.02	340	Benson Ranch
BRV	46-49.12	119-59.47	920	Black Rock Valley
BVW	46-48.66	119-52.99	670	Beverly, Washington
CRF	46-49.50	119-23.22	189	Corfu, Washington
ET3	46-34.64	118-56.25	286	Eltopia Three
*GBB	46-36.49	119-37.62	177	Gable Butte
GBL	46-35.92	119-27.58	330	Gable Mountain
H20	46-23.75	119-25.38	158	Water
LOC	46-43.02	119-25.85	210	Locke Island
MDW	46-36.79	119-45.66	330	Midway, Washington
MJ2	46-33.45	119-21.54	146	May Junction Two
OT3	46-40.14	119-13.98	322	Othello Three
PRO	46-12.73	119-41.15	550	Prosser, Washington
*RC1	46-56.71	119-26.66	485	Royal City One
RED	46-17.92	119-26.30	366	Red Mountain
RSW	46-23.67	119-35.48	1,045	Rattlesnake Mt. WA
SW1	46-27.85	119-39.60	312	Snively Ranch
WA2	46-45.32	119-33.94	244	Wahluke Slope
WG4	46-01.85	118-51.34	511	Wallula Gap Four
WIW	46-25.76	119-17.26	128	Wooded Island WA
WRD	46-58.20	119-08.69	375	Warden, Washington

Figure 1. Locations of Seismograph Stations.
(See Table 1 for exact locations.)

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Table 2. Station Locations for the Eastern Washington Regional Network.

This table lists stations of the Eastern Washington Regional Network. The first column is the three-letter seismic station designator. This is followed by the latitude-north in degrees, minutes, and hundredths of minutes; the longitude-west in degrees, minutes, and hundredths of minutes; elevation above sea level in meters; and the full station name. An asterisk before the three-letter designator means it is a three-component station. The locations of the stations were derived from a Global Position Satellite system (GPS).

Station	Latitude Deg.Min.W.	Longitude Deg.Min.W.	Elevation (m)	Station Name
BRV	46-29.12	119-59.47	920	Black Rock Valley
BVV	46-48.66	119-52.99	670	Beverly Washington
CBS	47-48.26	120-02.50	1,067	Chelan Butte, South
CRF	46-49.50	119-23.22	189	Corfu
DPW	47-52.25	118-12.17	892	Davenport Washington
DY2	47-59.11	119-46.28	890	Dyer Hill Two
ELL	46-54.58	120-33.98	789	Ellensburg
EPH	47-21.38	119-35.76	661	Ephrata
ET3	46-34.64	118-56.25	286	Eltopia Three
ETW	47-36.26	120-19.94	1,477	Entiat Washington
GBL	46-35.92	119-27.58	330	Gable Mountain
LNO	45-52.31	118-17.11	771	Lincoln Mt. Oregon
LOC	46-43.02	119-25.85	210	Locke Island
MDW	46-36.79	119-45.66	330	Midway Washington
MJ2	46-33.45	119-21.54	146	May Junction Two
MOX	46-34.64	120-17.89	501	Moxee City
NAC	46-43.99	120-49.42	728	Naches
NEL	48-04.21	120-20.41	1,500	Nelson Butte
OD2	47-23.26	118-42.58	553	Odessa Two
OT3	46-40.14	119-13.98	322	Othello Three
PAT	45-52.92	119-45.14	262	Paterson
PRO	46-12.73	119-41.15	550	Prosser
*RC1	46-56.71	119-26.66	485	Royal City One
RSW	46-23.67	119-35.48	1,045	Rattlesnake Mt. WA
SAW	47-42.10	119-24.03	701	St. Andrews
SN1	46-27.85	119-39.60	312	Snively Ranch
TBM	47-10.20	120-35.88	1,006	Table Mountain
TW	47-08.29	120-52.10	1,027	Teaaway Washington
VT2	46-58.04	119-58.95	1,270	Vantage Two
WA2	46-45.32	119-33.94	244	Wahluke Slope Two
WAT	47-41.92	119-57.24	821	Waterville
WGA	46-01.85	118-51.34	511	Wallula Gap Four
WIW	46-25.76	119-17.26	128	Wooded Island WA
WRD	46-58.20	119-08.69	375	Warden
YA2	46-31.60	120-31.80	652	Yakima Two

Figure 2. Locations of Seismograph Stations in the Eastern Washington Regional Network. (See Table 2 for exact locations.)

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Table 3. Seismic Channel Operational Time (%).

Network	April	May	June	2nd Quarter ^a	FY-Year ^b
Hanford	99.8	100.0	99.9	99.9	99.8
Regional	97.2	97.3	97.3	97.3	98.6

^aThis column is the average percentage for the second quarter.

^bThis column is the average percentage for fiscal year 1996.

Notes: The Hanford Seismic Network's goal is 98%.

The Eastern Washington Regional Network's goal is 97%.

The quarter period is April 1, 1996 through June 30, 1996.

3.0 EXPLANATION OF MAGNITUDE AND VELOCITY MODEL

All magnitudes given in this report are Coda Amplitude Magnitudes (CAM). CAMs are the equivalent of Richter Magnitudes and apply only to local earthquakes.

3.1 CODA AMPLITUDE MAGNITUDE

The AUTOSEIS program calculates the location, depth, and magnitude for earthquakes detected at the Hanford Site. This program uses the basic decay of the S wave. By quantifying the expected decay of the average absolute amplitude as a function of time, any portion of the coda of an earthquake (coda segment) can be used to assign a magnitude. For the high-frequency earthquakes analyzed at the Hanford Site, the coda segment length is a 1-second sample. A number of coda segments of each record can be averaged (or a median value selected) to produce a robust estimate of magnitude for each station. The average magnitudes for all stations are then averaged for an assigned CAM for that particular earthquake.

The CAM for each segment is computed from the following:

$$\text{CAM} = \text{Log } A + Q \text{ Log } (t-B)$$

where:

$$A = 1/256 \sum_{i=1}^{256} |S_i|$$

S_i = signal amplitude at sample

t = signal coda window in seconds = 1.0

Q describes the decay rate of the signal and B describes any DC bias for a particular station. Both parameters are station dependent.

3.2 VELOCITY MODEL

The velocities and layer depths presented in Table 4 are used by the AUTOSEIS program to locate all earthquakes on and near the Hanford Site.

Table 4. Velocity Model for the Columbia Basin.

Depth to top of velocity layer (km)	Stratigraphy	Velocity (km/sec)
0.0	Suprabasalt sediments, Saddle Mountains Basalt and intercalated Ellensburg Sediments	3.7
0.8	Wanapum Basalt	4.7
1.2	Grande Ronde Basalt	5.2
7.5	Prebasalt Sediments	6.1
19.0	Crystalline Basement, Layer 1	7.2
28.0	Crystalline Basement, Layer 2	8.0

Table 5. Seismic Event Data. (3 sheets)

Event ID:	The identification number assigned by the AUTOSEIS program		
Date:	The day of the year in Coordinated Universal Time (CUT).		
Time:	The origin time of the earthquake given in CUT. To convert CUT to Pacific Standard Time, subtract eight hours; to Pacific Daylight Time, subtract seven hours.		
Latitude:	North latitude, in degrees and minutes, of the earthquake epicenter.		
Longitude:	West longitude, in degrees and minutes, of the earthquake epicenter.		
Depth:	The depth of the earthquake in kilometers (km).		
Mag:	The Coda Amplitude Magnitude (CAM). The CAM is calculated using an algorithm modified for very local earthquakes: AUTOSEIS Reference Manual, October 20, 1983, Sierra Geophysics, Inc. (SGI-M-AS-0038). See Page 5 of this report: Explanation of Magnitude and Velocity Model.		
RMS:	The root mean square residual (observed P-WAVE arrival time minus the predicted arrival time) at all stations used to locate the earthquake. It is only useful as a measure of quality of the solution when five or more well distributed stations are used in the solution. Good solutions are normally characterized by RMS values of less than about 0.3 second.		
Q:	The solution quality of the hypocenter intended to indicate the general reliability of the solution: AUTOSEIS Reference Manual, October 20, 1983, Sierra Geophysics Inc. (SGI-M-AS-0038). The quality is rated using characters A, B, C, and D.		
	<u>Q</u>	<u>Error (km)</u>	<u>Epicenter</u>
	A	≤1.0	Excellent
	B	≤2.5	Good
	C	≤5.0	Fair
	D	> 5.0	Poor
			<u>Focal Depth</u>
			Good
			Fair
			Poor
			Poor
Events that occur at the edge or outside of the Hanford Seismic Network or are detected by fewer than five stations very often have a Q of C or D.			
*Denotes events that occurred during this quarter.			

Table 5. Seismic Event Data. (3 sheet)

EVENT ID	DATE	TIME	LATITUDE	LONGITUDE	DEPTH (KM)	MAG	RMS	Q	LOCATION
96676378*	6/24	09:07:58.08	46-42.28	119-18.69	27.80	1.43	0.05	B	~ 12 km E of the S end of Locke Island
96670943*	6/18	22:46:11.99	46-03.86	119-49.01	3.00	1.19	0.04	C	~ 16 km SSW of Prosser, VA
96662219*	6/10	05:17:35.30	46-36.91	119-54.74	6.12	1.22	0.03	C	~ 4 km S of Priest Rapids Dam
96651021*	5/30	00:30:25.89	46-13.43	119-18.51	16.26	1.68	0.05	C	SE flank of Badger Mountain
96647625*	5/26	15:05:54.04	46-42.09	119-35.19	1.08	0.52	0.04	B	~ 3 km W of "W" Reactor
96645738*	5/24	17:50:10.68	46-24.15	119-15.99	4.82	0.31	0.04	B	~ 1 km N of Johnson Island
96644274*	5/23	06:36:39.63	46-24.11	119-15.47	0.06	1.65	0.04	B	North end of Johnson Island
96641811*	5/20	19:35:24.81	46-24.19	119-14.83	0.05	1.49	0.05	B	~ 2 km NE of Johnson Island
96638157*	5/17	03:47:41.00	46-23.95	119-14.55	1.38	1.45	0.04	B	~ 4 km East of the North end of Johnson Island
96636419*	5/15	10:07:10.43	46-23.90	119-14.81	0.65	1.10	0.05	C	~ 3 km East of Johnson Island
96630310*	5/09	07:29:02.16	46-50.90	119-25.47	17.12	1.40	0.05	A	~ 3 km NE of Corfu, VA
96609591*	4/18	14:17:04.45	46-24.78	119-17.17	2.24	2.19	0.09	A	~ 1.5 km West of the South end of Wooded Island
96593615*	4/02	14:51:11.69	46-47.14	119-28.52	0.72	0.00	0.02	B	~ 5 km SW of Corfu, VA
96590046	3/30	01:06:01.34	46-27.57	119-34.75	16.88	0.29	0.05	A	~ 3 km south of Goose Egg Hill or 9 km south of 200E on Hanford
96586130	3/26	03:08:21.58	46-44.89	119-39.11	1.62	1.17	0.04	B	~ 7 km north of "W" Basins on Hanford
96583601	3/23	14:30:43.04	46-24.32	119-16.33	0.68	0.70	0.06	B	North end of Johnson Island on Hanford
96581589	3/21	09:23:15.58	46-30.90	119-30.57	22.42	0.93	0.05	A	~ 3 km SSE of 200E & ~ 10 km NW of the LIGD vertex on Hanford
96567505	3/07	12:11:26.76	46-40.33	119-08.39	3.39	0.34	0.04	B	South end of Eagle Lakes, ~ 15 km east of the eastern Hanford boundary

Table 5. Seismic Event Data. (3 sheet)

96564061	3/04	01:28:56.80	46-24.11	119-16.11	1.09	0.48	0.40	B	North end of Johnson Island on Hanford
96555502	2/24	12:07:14.38	46-54.19	119-34.38	0.39	1.48	0.04	B	~ 4 km east of Royal City, WA & ~ 23 km north of "W" Reactor
96530902	1/30	21:46:53.28	46-24.01	119-13.13	0.95	0.72	0.03	C	~ 5 km east of the north end of Johnson Is. and 7 km east of the 300 Area on Hanford
96525666	1/25	16:04:45.77	46-49.01	119-22.83	1.11	1.14	0.03	A	~ 5 km east of Corfu, WA
96525032	1/25	00:47:01.15	46-35.24	119-40.40	9.57	0.68	0.04	A	~ 1 km NW of 200M on Army Loop road on Hanford
95851288	12/17	06:58:05.49	46-43.40	119-33.47	1.95	0.41	0.03	A	~ 5 km north of "W" reactor on Hanford
96844874	12/10	21:07:05.81	46-39.31	119-41.49	12.84	0.31	0.05	B	~ 13 km east of Priest Rapids Dam on Hanford
95822745	11/18	18:00:24.89	46-27.63	119-45.00	18.66	1.43	0.07	B	~ 2 km SW of Lower Snively Spring
95820872	11/16	21:04:06.58	46-38.92	119-46.39	1.02	1.28	0.05	C	~ 7.5 km east of Priest Rapids Dam at the Hanford boundary
95806888	11/02	21:26:28.86	46-30.37	119-37.37	8.71	0.28	0.02	A	a SE corner of 200M, near Hanford Well # 699-29-70 on Hanford
95806600	11/02	14:30:14.44	46-09.00	119-34.55	18.17	3.25	0.08	C	~ 15 km ESE of Prosser WA
95806425	11/02	10:15:17.87	46-30.21	119-37.52	8.64	-0.29	0.01	B	a SE corner of 200M, near Hanford Well # 699-29-70
95806048	11/02	01:39:10.02	46-30.29	119-37.40	8.45	0.00	0.01	B	a SE corner of 200M, near Hanford Well # 699-29-70 on Hanford
95797647	10/24	15:37:10.55	46-47.52	119-37.84	13.52	0.75	0.02	B	~ 5 km SE of Smyrna WA
95793510	10/20	12:19:53.79	46-38.84	119-46.70	0.15	0.94	0.06	B	~ 7 km NW of 200M, near Juniper Springs on Hanford
95793000	10/20	00:00:35.16	46-31.04	119-35.37	8.07	-0.56	0.01	B	a SE corner of 200M, near Hanford Well # 699-29-70 on Hanford
9576509	10/03	12:17:49.16	46-20.91	119-36.96	21.52	2.37	0.06	B	~ 4 km WSW of McWhorter Springs

4.0 GEOLOGY AND TECTONIC ANALYSIS

4.1 DEPTH OF EARTHQUAKES

Studies of seismicity at the Hanford Site have shown that the seismicity is related to the following crustal stratigraphy (layers of rock types) (DOE 1988).

- The Columbia River Basalt Group (CRBG) (approximately 0-5 km deep)
- The prebasalt sediments (approximately 5-10 km deep)
- The crystalline basement (greater than approximately 10 km).

Since the early 1980s deep boreholes have been drilled for hydrocarbon exploration. These boreholes have provided accurate measurements of the physical properties of the CRBG and the prebasalt sediments (Reidel and others 1987, 1994). The thickness of the prebasalt sediments and nature of the crystalline basement, however, are still poorly understood. The difference between the thickness listed here and the thickness of the crustal layers in the velocity model in Table 4 reflect data specific for the Hanford Site rather than the University of Washington's crustal model for eastern Washington.

Since records have been kept, about 75 percent of the earthquakes at the Hanford Site have originated in the CRBG layer. The prebasalt sediments have had about 7 percent of the events and the crystalline basement has had 18 percent.

For fiscal year (FY) 1996, 35 events were located (Table 2); 19 events (54 percent) occurred in the basalt, 6 events (17 percent) in the prebasalt sediments, and 10 events (29 percent) in the crystalline basement.

For the current quarter, 13 events were located (Table 2); 9 events (69 percent) occurred in the basalt, 1 event (8 percent) occurred in the prebasalt sediments, and 3 events (23 percent) occurred in the crystalline basement.

4.2 TECTONIC PATTERN

Studies at the Hanford Site have concluded that earthquakes can occur in the following six different tectonic environments (earthquake sources) at the Hanford Site and in the Columbia Basin of eastern Washington (Geomatrix 1996).

- **Reverse thrust faults.** Reverse/thrust faults in the CRBG associated with major anticlinal ridges such as Rattlesnake Mountain, Yakima Ridge, and Umtanum Ridge could produce the largest earthquakes.

- **Secondary faults.** These are associated with the major anticlinal ridges.
- **Swarm areas.** Small geographic areas of unknown geologic structure produce clusters of events (swarms), usually in the CRBG in synclinal valleys. These clusters consist of a series of small shocks with no one outstanding principle event. Swarms occur over a period of days or months and the events may number into the hundreds and then quit, only to start again at a later date. This differs from the sequence of foreshocks, mainshock, and trailing-off aftershocks that have the same epicenter or are associated with the same fault system. Three principal swarm areas are known at the Hanford Site. One is the Wooded Island Swarm Area along the Columbia River near the 300 Area. The second area, the Coyote Rapids Swarm Area, extends from the vicinity of the 100 K Area north-northeast along the Columbia River Horn to the vicinity of the 100 N Area. The third major swarm area is along the Saddle Mountains on the northern boundary of the Hanford Site. Other earthquake swarm areas are present, but activity is less frequent.
- **The entire Columbia Basin.** The entire basin, including the Hanford Site, could produce a "floating" earthquake. A floating earthquake is one that, for seismic design purposes, can happen anywhere in a tectonic province and is not associated with any known geologic structure. It is classified as a random event by Seismic Monitoring for purposes of seismic design and vibratory ground motion studies.
- **Basement source structures.** Studies suggest that major earthquakes can originate in tectonic structures in the crystalline basement. Because little is known about geologic structures in the crystalline basement beneath the Hanford Site, earthquakes cannot be directly tied to a mapped fault. Earthquakes occurring in the crystalline basement without known sources are treated as random events for seismic hazards analysis and seismic design development.
- **The Cascadia Subduction Zone.** This source recently has been postulated to be capable of producing a 9-CAM earthquake. Because this source is along the western boundary of Washington State and outside the Hanford Array, the Cascadia Subduction Zone is not an earthquake source that is monitored at the Hanford Site, so subduction zone earthquakes are not reported here. Because any earthquake along the Cascadia Subduction zone can have a significant impact on the Hanford Site (Geomatrix 1996), the University of Washington monitors and reports on this earthquake source for the U.S. Department of Energy (DOE). Ground motion from any moderate or larger Cascadia Subduction Zone earthquake is detected by seismometers in the HSN.

4.3 CURRENT TECTONIC ACTIVITY

The locations of all events with CAMs greater than 1.0 for FY 1996 are shown on Figure 3. The locations of all seismic events for FY 1996 are shown

in Figure 4. Figure 5 is a tectonic map of the Yakima Fold Belt and Hanford Site. The Yakima Fold Belt is the main tectonic province of concern for the Hanford Site. The figure shows all the major mapped ridges and faults that are potential seismic sources. These figures should be referred to for the following discussions.

4.3.1 Reverse/Thrust Faults on Major Anticlinal Ridges

During this period, one event appears to be associated with one of the major anticlinal ridges. One small (<2.3 CAM) event (96662219) occurred either in the subbasalt sediments or at the base of the basalt under Umtanum Ridge. Projection of the Umtanum Ridge fault zone, including uncertainty of the dip angle of the fault, intersects the hypocenter of this earthquake.

4.3.2 Secondary Structures on Main Anticlinal Ridges

During this reporting period, one earthquake (96670943) appears to be associated with possible secondary structures of the Horse Heaven Hills anticlinal ridge. This event occurred on the south flank of the Horse Heaven Hills about 13 km from the crest of the fold and at a depth of 3 km. It does not appear to be on the main fault, but may be an unmapped secondary structure.

4.3.3 Swarm Area Activity

During this reporting period, 6 events (55 percent of all events located) were located in earthquake swarm areas. The swarm areas are discussed in Sections 4.3.3.1 through 4.3.3.4.

4.3.3.1 Saddle Mountains Swarm Area. The Saddle Mountains swarm area experienced one small (<1 CAM) event during the reporting period. This event occurred on April 2, 1996, in the Saddle Mountains at a shallow depth near a known fault that separates two segments of the Saddle Mountains structure. This earthquake might be fault controlled.

4.3.3.2 Coyote Rapids Swarm Area. One earthquake occurred in the Coyote Rapids swarm on May 26, 1996. This was a small-magnitude earthquake (<1 CAM) at the north end of the swarm area west of 100 D Area.

4.3.3.3 Wooded Island Swarm Area. Six events occurred here during the reporting period. Four events occurred between May 15 and May 24, 1996. These events occurred near Johnson Island, one near the north end of the swarm and three a few kilometers east of the island. The sixth event occurred on April 18, 1996, near the southwest end of Wooded Island. All events were less than 2.2 CAM.

4.3.3.4 Other Swarm Areas. No other swarm areas were active during this reporting period.

Figure 3. All Located Earthquakes: April 1, 1996,
and June 30, 1996. (Coda Amplitude Scale
is shown at the top of the Map.)

Figure 4. Locations of All FY 1996 Events: (Coda Amplitude Magnitude Scale is shown at the top of the map.)

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Figure 5. Structural and Tectonic Map of Columbia Basin Showing Major Seismic Source Structures.

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4.3.4 Random or Floating Event Areas

Four events that occurred during the reporting period (36 percent of all events located) are classified as random events. The areas are discussed in Sections 4.3.4.1 through 4.3.4.6.

4.3.4.1 Saddle Mountains Area. On May 9, 1996, a small (<2 CAM) event occurred at a depth of 17.1 km in the crystalline basement on the north flank of the Saddle Mountains. This is classified as a random event because no known fault occurs at this depth. This earthquake occurred in the Saddle Mountains earthquake swarm area, but could have been along the Frenchman Hills fault zone. Because the earthquake occurred below the basalt in the crystalline basement and studies of the Frenchman Hills fault suggest that it does not extend below the basalt, this event is presently not considered to be associated with that fault.

A second event (<1.5 CAM) occurred 8 km southwest of the crest of the Saddle Mountains anticline at a depth of 27.8 km. This earthquake occurred on the south flank of the Saddle Mountains, but could have been along the Saddle Mountains fault zone in the crystalline basement. Because the earthquake occurred below the basalt in the crystalline basement and studies of the Saddle Mountains fault suggest that it does not extend below the basalt, this event is presently not considered to be associated with that fault.

5.0 REFERENCES

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