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Pacific Northwest National Laboratory

Operated by Battelle for the
U.S. Department of Energy

Hanford Seismic Network

S.P. Reidel
D.C. Hartshorn

May 1997

Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

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SUMMARY

This report describes the Hanford Seismic Network. The network consists of two instrument arrays: seismometers and strong motion accelerometers. The seismometers determine the location and magnitude of earthquakes, and the strong motion accelerometers determine ground motion. Together these instrument arrays comply with the intent of DOE Order 5480.20, Natural Phenomena Hazards Mitigation.

Contents

1.0 Instrumentation Strategy 1

2.0 Instrumentation 1
2.1 Seismometer Sites 1
2.2 Strong Motion Accelerometer Sites 5

3.0 Operations of the Hanford Seismic Monitoring Network 7

Figures

1. Location of Seismometer Sites and Free-Field SMA at Hanford 2
2. Location of Eastern Washington Regional Network Seismometer Sites 3

Tables

1. Stations Comprising the Hanford Seismic Monitoring Network 1
2. Stations Comprising the Eastern Washington Regional Network 4
3. Free-Field SMA Sites 6
4. Instrument Specifications for Kinemetrics ETNA System 7

Terms

DOE	U.S. Department of Energy
GPS	Global Positioning Satellite
PFP	Plutonium Finishing Plant
PNNL	Pacific Northwest National Laboratory
SMA	strong motion accelerometer

1.0 Instrumentation Strategy

The U.S. Department of Energy (DOE) Order 5480.28 requires that facilities or sites that have structures or components in Performance Category 2 with hazardous material, and all Performance Category 3 and 4 shall have instrumentation or other means to detect and record the occurrence and severity of seismic events.

2.0 Instrumentation

The Hanford Seismic Monitoring network consists of two designs of equipment and sites: seismometer sites and strong motion accelerometer (SMA) sites. Seismometer sites are designed to locate earthquakes on and near the Hanford Site and determine their magnitude and hypocenter location. In order to comply with DOE Order 5480.28, the Hanford Seismic Monitoring Network seismometer sites needed to be complemented with strong motion accelerometers to record the ground motion at specific sites. SMA sites are designed to record ground motions at a specific site. The combined seismometer sites and strong motion accelerometer sites provide the Hanford Site with earthquake information to comply with DOE Order 5480.28.

2.1 Seismometer Sites

The seismometer network for the Hanford Site consists of 41 stations. Twenty-one stations are located on or adjacent to the Hanford Site (Figure 1; Table 1); the remaining stations are spread throughout Eastern Washington (Figure 2; Table 2). The design and distribution of the seismic monitoring stations ensure detailed coverage for the Hanford Site and regional coverage for the Yakima Fold Belt, the geologic/tectonic province where the Hanford Site is located but cannot provide a record of site-specific strong ground motion at the location of the instruments. The ground motion measurements made with strong motion accelerometers are discussed in Section 2.2.

Table 1. Stations Comprising the Hanford Seismic Monitoring Network

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 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 Positioning Satellite system (GPS).

Station	Latitude Deg.Min.N	Longitude Deg.Min.W	Elevation in Meters	Seismo-meter[a]	Station Name
BEN	46-31.13	119-43.02	340	S-13	Benson Ranch
BRV	46-49.12	119-59.47	920	L-4C	Black Rock Valley
BVW	46-48.66	119-52.99	670	SS-1	Beverly
CRF	46-49.50	119-23.22	189	SS-1	Corfu
ET3	46-34.64	118-56.25	286	S-13	Eltopia Three
*GBB	46-36.49	119-37.62	177	S-13	Gable Butte
GBL	46-35.92	119-27.58	330	S-13	Gable Mt.
H2O	46-23.75	119-25.38	158	SS-1	Water
LOC	46-43.02	119-25.85	210	SS-1	Locke Island

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 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 Positioning Satellite system (GPS).

Station	Latitude Deg.Min.N	Longitude Deg.Min.W	Elevation in Meters	Seismo-meter[a]	Station Name
MDW	46-36.79	119-45.66	330	S-13	Midway
MJ2	46-33.45	119-21.54	146	SS-1	May Junction Two
OT3	46-40.14	119-13.98	322	S-13	Othello Three
PRO	46-12.73	119-41.15	550	L-4C	Prosser
*RC1	46-56.71	119-26.66	485	S-13	Royal City One
RED	46-17.92	119-26.30	366	S-13	Red Mt.
RSW	46-23.67	119-35.48	1045	S-13	Rattlesnake
SNI	46-27.85	119-39.60	312	S-13	Snively Ranch
WA2	46-45.32	119-33.94	244	S-13	Wahluke Slope
WG4	46-01.85	118-51.34	511	L-4c	Wallula Gap Four
WIW	46-25.76	119-17.26	128	S-13	Wooded Island
WRD	46-58.20	119-08.69	375	S-13	Warden

[a] Manufacturers: SS-1--Kinemetrics. S-13--Geotech. L-4C--Mark Inc.

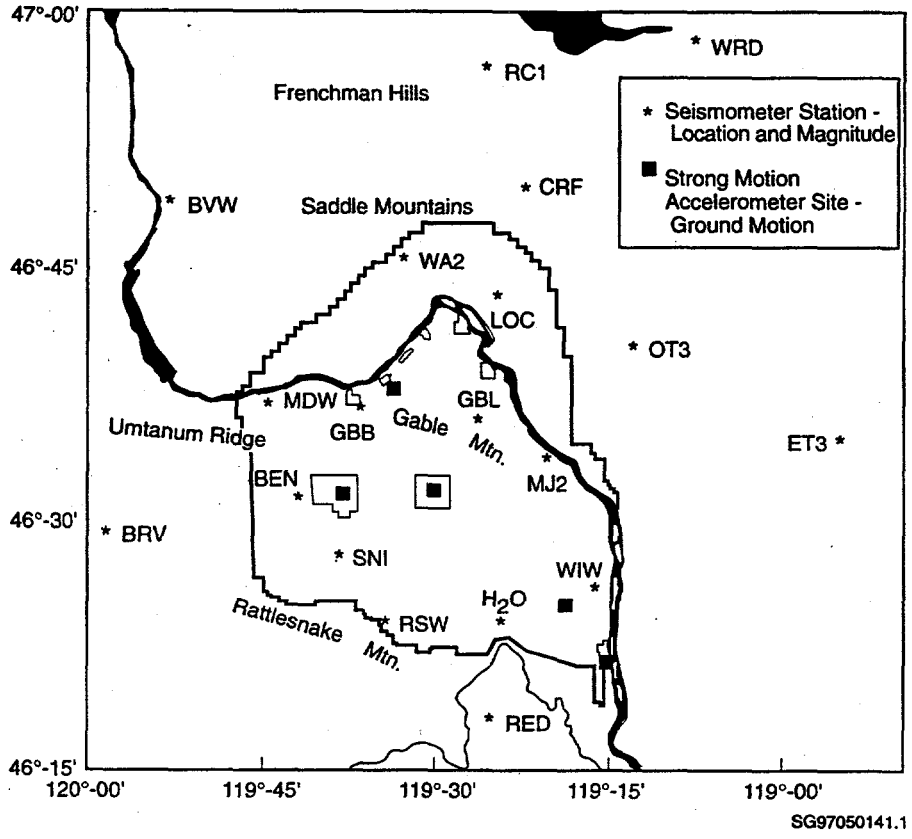

Figure 1. Location of Seismometer Sites and Free-Field SMA at Hanford.

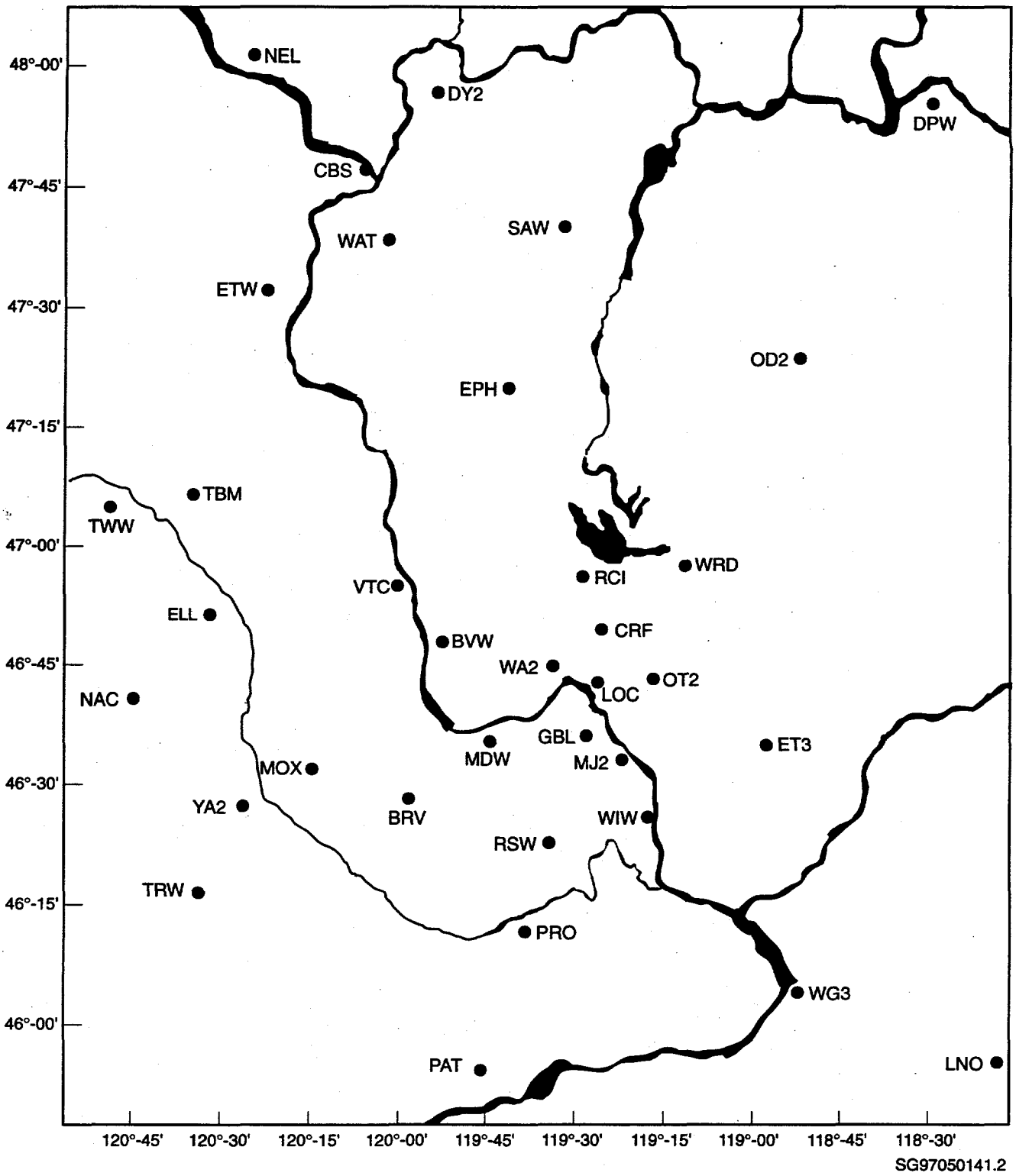

Figure 2. Location of Eastern Washington Regional Network Seismometer Sites.

Table 2. Stations Comprising 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 Positioning Satellite system (GPS).

Station	LatitudeDeg. MinN.	Longitude Deg.Min.W.	Elevation in Meters	Seismometer[a]	Station Name
BRV	46-29.12	119-59.47	920	L-4C	Black Rock Valley
BVW	46-48.66	119-52.99	670	SS-1	Beverly
CBS	47-48.26	120-02.50	1,067	SS-1	Chelan Butte, South
CRF	46-49.50	119-23.22	189	SS-1	Corfu
DPW	47-52.25	118-12.17	892	S-13	Davenport
DY2	47-59.11	119-46.28	890	SS-1	Dyer Hill Two
Ell	46-54.58	120-33.98	789	SS-1	Ellensburg
EPH	47-21.38	119-35.76	661	L-4	Ephrata
ET3	46-34.64	118-56.25	286	S-13	Eltopia Three
ETW	47-36.26	120-19.94	1,477	S-13	Entiat
GBL	46-35.92	119-27.58	330	S-13	Gable Mountain
LNO	45-52.31	118-17.11	771	SS-1	Lincton Mt. Oregon
LOC	46-43.02	119-25.85	210	SS-1	Locke Island
MDW	46-36.79	119-45.66	330	S-13	Midway
MJ2	46-33.45	119-21.54	146	SS-1	May Junction Two
MOX	46-34.64	120-17.89	501	SS-1	Moxee City
NAC	46-43.99	120-49.42	728	S-13	Naches
NEL	48-04.21	120-20.41	1,500	S-13	Nelson Butte
OD2	47-23.26	118-42.58	553	SS-1	Odessa Two
OT3	46-40.14	119-13.98	322	S-13	Othello Three
PAT	45-52.92	119-45.14	262	L-4C	Paterson
PRO	46-12.73	119-41.15	550	S-13	Prosser
*RC1	46-56.71	119-26.66	485	S-13	Royal City One
RSW	46-23.67	119-35.48	1,045	S-13	Rattlesnake Mt.
SAW	47-42.10	119-24.03	701	SS-1	St. Andrews
SNI	46-27.85	119-39.60	312	S-13	Snively Ranch
TBM	47-10.20	120-35.88	1,006	SS-1	Table Mountain
TRW	47-17.32	120 32.31	723	L-4C	Toppenish Ridge
TWW	47-08.29	120-52.10	1,027	L-4C	Teanaway
VT2	46-58.04	119-58.95	1,270	S-13	Vantage Two
WA2	46-45.32	119-33.94	244	S-13	Wahluke Slope Two
WAT	47-41.92	119-57.24	821	SS-1	Waterville
WG4	46-01.85	118-51.34	511	L-4C	Wallula Gap Four
WIW	46-25.76	119-17.26	128	S-13	Wooded Island WA
WRD	46-58.20	119-08.69	375	S-13	Warden
YA2	46-31.60	120-31.80	652	L-4C	Yakima Two

Manufacturers: SS-1--Kinemetrics. S-13--Geotech. L-4C--Mark Inc.

Seismometer stations are located in buried vaults to provide security and protect equipment from the elements. Each site consists of a seismometer, electronic signal conditioning units, solar power subsystem, and radio transmitters. Regional sites are linked by radio relay stations consisting of solar power subsystem, signal conditioning units, and radio transmitters and receivers. The seismometer is located in an enclosed, water-tight vault buried about one foot underground; the vault consists of a concrete pad with a PVC housing set in the concrete. The instrument package is housed in a double galvanized, water-tight 30-gallon drum. Radio transmitters and receivers are in water-tight boxes and mounted on posts set in the ground. These instruments and their housings meet the requirements of DOE Order 5480.28.

All seismometer sites are vertical component stations except Royal City and Gable Butte, which are three-component stations consisting of one vertical, one north-south horizontal, and one east-west horizontal data channel.

Data from seismic stations are transmitted by radio to the Hanford Recording Center in the 337 Building. Data from seismic events are automatically recorded on a computer system. Data are processed initially by an automated processing system that is used to calculate a preliminary hypocenter location and magnitude for those seismic events originating on or very near the Hanford Site. Refined locations are later determined by seismic analysis staff using a computer aided seismic analysis and display program. All seismic events detected at or near the Hanford Site are recorded on magnetic tape and archived. These data are used to make an annual earthquake catalog. The catalog consists of the final earthquake locations and magnitudes on or near Hanford accompanied by maps and a geologic and tectonic interpretation of the seismic events.

The Eastern Washington Regional Network (Figure 2; Table 2) is operated by the Geophysics Program, University of Washington but is maintained by PNNL. The sites were installed prior to 1986, but between 1986 and 1996 all sites were upgraded to the specifications described above. All sites are continuously monitored and routinely checked for operational problems. Any operational problem is corrected within 1-2 working days by a site visit unless weather conditions prevent access to a site.

Operation of the Hanford Site network is governed by two procedures:

1) Installation and Maintenance of Seismic Arrays (Rev. 1, 4/29/94);

2) Seismic Data Analysis and Record Processing (Rev. 1, 4/29/94).

Both procedures were developed under Rockwell Hanford Operations and Westinghouse Hanford Company. With the transfer of Seismic Monitoring to Pacific Northwest National Laboratory (PNNL) on October 1, 1996, these procedures are currently being incorporated into PNNL procedures.

2.2 Strong Motion Accelerometer Sites

There are five free-field SMA Sites (Figure 1) and one SMA housed in the 337 Building (Table 3). The SMA instruments are three-component units consisting of one vertical, one north-south horizontal, and one east-west horizontal data channel. Instrument specifications are summarized in Table 4. SMA systems consist of strong-motion accelerometers, electronic signal conditioning units, solar power subsystems with battery backup for free-field sites, and modems with cellular

telephones. The SMAs also have an internal timing circuit that is linked to the Global Positioning Satellites (GPS) and the National Bureau of Standards timing system. The system includes a recording system that records each accelerometer channel at the site. The accelerographs digitize the analog signal as part of the recording process.

The free-field SMAs are housed in a buried vault to provide security and ensure that the equipment is protected from the elements. This design ensures high-quality operating conditions and minimal maintenance costs. Each site consists of two doubly galvanized 30-gallon drums buried in the ground. The SMA is housed in one drum that is set in a pad of concrete 1 m x 1 m x 20 cm. This vault is designed to withstand ground acceleration in excess of 2 g. The cellular telephone, batteries, and voltage regulator are set in the second drum. The two drums are connected by water-tight conduit that contains the electrical wiring.

The SMA network for the Hanford Site uses instruments that electronically store and transmit the data to a central recording station in the Hanford Seismic Recording Center. Analysis of the data consists of measurement of peak ground accelerations and spectral response for comparison to facility design bases. All data can be processed at one field location immediately or at the RL Site Emergency Response Facility in the Federal Building. If a seismic event should occur during off-shift hours, the SMA sites are programmed to notify the Seismic Monitoring office via preprogrammed telephone pagers. This allows the SMA notification system to operate on a 24-hour-a-day, 7-day-a-week basis. Procedures are currently being developed for this strong motion accelerometer system.

Table 3. Free-Field SMA Sites.

Site	Location	Design
100 K Area	South of K Basins outside 100 Area fence.	One free-field Kinemetrics ETNA Model SMA housed in a ground vault.
200 East Area	East of B Plant; north of 7th street and east of Baltimore Ave.	One free-field Kinemetrics ETNA Model SMA housed in ground vault.
200 West Area	Northeast of Plutonium Finishing Plant (PFP); north of 19th street and east of Camden Ave.	One free-field Kinemetrics ETNA Model SMA housed in ground vault.
300 Area	South end of 300 Area inside fence line. (NE 1/4, SW 1/4, Sec. 11, T10N, R28E).	One free-field Kinemetrics ETNA Model SMA housed in ground vault.
400 Area	500 feet from fence line on east side of facility and north of parking area).	One free-field Kinemetrics ETNA Model SMA house in ground vault.
337 Building	Office of Seismic Monitoring, Room 176	One Kinemetrics ETNA Model SMA attached to concrete floor

3.0 Operations of the Hanford Seismic Monitoring Network

The combined operations, data recording and interpretation, and maintenance facility is located in the 337 Building and is operated by the PNNL Seismic Monitoring team. This organization provides an area and point of contact for facility Emergency Response and Safety Personnel and facility managers to receive information from the network. After a large-magnitude seismic event, the Seismic Monitoring Center provides Hanford facility managers with key emergency response data so that emergency response plans could be implemented.

Table 4. Instrument Specifications for Kinemetrics ETNA System.

Parameter	Value or range
Sensor	
Type	Triaxial Force Balance Accelerometer, orthogonally oriented with internal standard.
Full-Scale Range	$\pm$ 2 g
Natural Frequency	50 Hz range
Damping	70% critical
Dynamic Range	Greater than 135 db 0.01 Hz to 50 Hz Greater than 145 db 0.01 Hz to 20 Hz
Data Acquisition	
Number of Channels	3
Dynamic Range	>110 db @ 200 sps
Frequency Response	DC to 80 Hz @ 200 sps
Resolution	18-bit resolution @ 200sps
Digital Output	Real-time, RS-232 Output Stream
Seismic Trigger	
Type	IIR Bandwidth filter
Trigger level	0.01 g
Pre-event Memory	60 sec
Post-event Time	Up to 65,000 sec

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