First Quarter Hanford Seismic Report for Fiscal Year 2012 (October-December 2011)

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[Including much material prepared and presented by Alan Rohay and others at Pacific Northwest National Labs]

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Notice

This quarterly report of seismic monitoring for public safety and resource protection at the Hanford site in Washington State was prepared by the Pacific Northwest Seismic Network (PNSN) at the University of Washington (UW). PNSN are sub-contractors to the Mission Support Alliance (MSA), and these reports are part of the contractual obligations. The PNSN/MSA team has taken over operations of the seismic monitoring network from years of operation by the Pacific Northwest National Laboratory (PNNL). This report diverges somewhat from previous reports, as the PNSN/MSA team's familiarity with both the network and our clients' needs and wishes evolve. While background information in this report will use much wording quoted directly from earlier reports (*e.g.,* Rohay *et al.,* 2009a, 2009b, 2010a, 2010b, *etc*.), we have rearranged the format somewhat, to achieve what we believe to be better clarity. Chiefly, the Quarterly catalog of earthquakes has been moved from Section 4 (which section remains, however, a description of the catalog production) to Section 5. Section 5 thus becomes a more unified discussion of the quarterly seismicity. Also, a new table has been introduced (Table 5.2), which presents summary statistics for the regional earthquake and blast events in a slightly different format than previous reports have used. This table clearly divides the numbers of events into those on, or immediately adjacent to, the Hanford site, and those in the surrounding 100 km or so surrounding the site. We hope it will make the data more easily digestible, as well as provide a view of quarterly fluctuations throughout the year.

Summary

The PNSN/MSA team continues to provide uninterrupted collection of high-quality raw and processed seismic data from the Eastern Washington Regional Sub-Network (EWRSN) for the U.S. Department of Energy and its contractors. The team is responsible for identifying and locating sources of seismic activity that might affect the Hanford site, monitoring changes in the historical pattern of seismic activity surrounding the Hanford Site, and monitoring ground motion to provide data to constrain studies of earthquake effects on the Hanford site. Seismic data are compiled, archived, and published for use by the Hanford Site for waste management, natural phenomena hazards assessments, and engineering design and construction. In addition, the team works with the Hanford Site Emergency Services Organization to provide assistance in the event of a significant earthquake on the Hanford Site. The Hanford Seismic Network and the Eastern Washington Regional Network consist of 49 individual sensor sites and 15 radio relay sites maintained by the PNSN.

The EWRSN recorded 57 eastern Washington earthquakes during the first quarter of FY 2012, 29 local to the Hanford site (local), and 28 off of the site (regional). Of the local earthquakes, 26 were located at shallow depths (less than 4 km), 2 at intermediate depths (between 4 and 9 km), most likely in the pre-basalt sediments, and 1 deeper than 9 km, within the basement. Geographically, all 26 shallow local earthquakes were located in the Wye swarm area. The three non-swarm local earthquakes were classified as random events. Of the regional earthquakes 11 were shallow, 5 intermediate, and 12 deep.

The largest regional event (4.6 M_c) took place on November 18, 2011 at depth of 11.92 km with epicenter located in the vicinity of Okanogan, about 200 km north of the Hanford site. The largest earthquake near the Hanford site (3.4 M_c) was located in the Wye swarm area in the vicinity of Wooded Island, a few miles north of Richland, on October 15, 2011 at depth of 1.43 km. Wooded Island events recorded this quarter were a continuation of the swarm events observed during the 2009 and 2010 fiscal years and reported in previous reports (Rohay *et al.,* 2009a, 2009b, 2009c, 2010a, and 2010b).

Abbreviations and Acronyms

ANSS Advanced National Seismic System
AQMS ANSS Quake Management System
BPA Bonneville Power Administration
BWIP Basalt Waste Isolation Project
CRBG Columbia River Basalt Group
DOE U.S. Department of Energy
ETNA strong motion accelerometer manufactured by Kinemetrics
EWRSN Eastern Washington Regional Sub-Network
FY fiscal year
GPRS General Packet Radio Service
GPS Global Positioning System
HLSMP Hanford Lifecycle Seismic Monitoring Program
HSN Hanford Site Network
IRIS Incorporated Research Institutions in Seismology
MSA Mission Support Alliance
M_c coda-length magnitude
M_L local magnitude
PNNL Pacific Northwest National Laboratory
PNSN Pacific Northwest Seismic Network
PSRP Public Safety and Resource Protection
SMA strong motion accelerometer
TA Transportable Array (part of USArray experiment)
USGS U.S. Geological Survey
UTC Coordinated Universal Time
UW University of Washington
WHC Westinghouse Hanford Company

1.0 Introduction

This quarterly report documents the locations, magnitudes, and seismic interpretations of earthquakes recorded for the Hanford monitoring region of south-central Washington during the first quarter of government fiscal year (FY) 2012 (October 2011 through December 2011). Since April 1st, 2011, seismic monitoring for Public Safety and Resource Protection (PSRP) at the Hanford site has been carried out by the Hanford Lifecycle Seismic Monitoring Program (HLSMP). HLSMP is managed by Mission Support Alliance (MSA) with the monitoring work being performed under a sub-contract to the Pacific Northwest Seismic Network (PNSN).

1.1 Mission

The mission of the HLSMP is to maintain seismic stations, report data from measured events, and provide assistance in the event of an earthquake. This mission supports the U.S. Department of Energy (DOE) and the other Hanford Site contractors in their compliance with DOE Order 420.1B, Chapter IV, Section 3.d "Seismic Detection" and DOE Order G 420.1-1, Section 4.7, "Emergency Preparedness and Emergency Communications." DOE Order 420.1B requires facilities or sites with hazardous materials to maintain instrumentation or other means to detect and record the occurrence and severity of the seismic event. The HLSMP maintains the seismic network located on and around the Hanford Site. The data collected from the seismic network can be used to support facility or site operations to protect the public, workers, and the environment from the impact of seismic events.

In addition, the HLSMP provides an uninterrupted collection of high-quality raw seismic data from the Hanford Site Network (HSN) and the Eastern Washington Regional Sub-Network (EWRSN) and provides interpretations of seismic events from the Hanford Site and the vicinity. The program locates and identifies sources of seismic activity, monitors changes in the historical pattern of seismic activity, and builds a "local" earthquake database (processed data) that is permanently archived. The focus of this report is the precise location of earthquakes proximal to or on the Hanford Site, specifically, between 46-47° north latitude and between 119-120° west longitude. Data from the EWRSN and other seismic networks in the Northwest provide the HLSMP with necessary regional input for the seismic hazards analysis at the Hanford Site. These seismic data are used to support Hanford Site contractors for waste management activities, natural phenomena hazards assessments, and engineering design and construction.

1.2 History of Monitoring Seismic Activity at Hanford

Monitoring seismic activity at the Hanford Site was initiated in 1969 by the U.S. Geological Survey (USGS) under a contract with the U.S. Atomic Energy Commission. In 1975, the University of Washington (UW) assumed responsibility for the network and subsequently expanded it. In 1979, the Basalt Waste Isolation Project (BWIP) became responsible for collecting seismic data for the Hanford Site as part of site characterization activities. Rockwell Hanford Operations, followed by Westinghouse Hanford Company (WHC), operated the local network and were the contract technical advisors for the EWRSN operated and maintained by UW. Funding ended for BWIP in December 1988; the seismic program (including the UW contract) was transferred to the WHC Environmental Division. Maintenance responsibilities for the EWRSN also were assigned to WHC, who made major upgrades to EWRSN sites. Effective October 1, 1996, all seismic assessment activities were transferred to the Pacific Northwest National Laboratory (PNNL).[1]

The Hanford SMA network was constructed during 1997, becoming operational in May 1997. It was shut down in FY 1998 due to lack of funding but became operational again in FY 1999 and has operated continuously since that time.

During the third quarter of FY2011, operations of the seismic monitoring network were assumed by HLSMP. As of the writing of this quarterly report the PNSN/MSA team is operating the network, assessing the state of the network and planning long term monitoring strategy.

1.3 Documentation and Reports

The HLSMP issues quarterly reports of local seismic activity, an annual catalog of earthquake activity in southeastern Washington, and special-interest bulletins on local seismic events. This includes information and special reports as requested by DOE and Hanford Site contractors. Earthquake information provided in these reports is subject to revision as new information becomes available. An archive of all seismic data from the HLSMP is maintained by PNSN on computer servers at the UW. PNSN is in the process of documenting the metadata from stations taken over from PNNL so that all data can also be archived at the Incorporated Research Institutions in Seismology (IRIS) seismic data archive in Seattle, Washington.

2.0 Network Operations

2.1 Seismic Stations

The seismic network consists of two types of earthquake sensors—seismometers and strong motion accelerometers (SMAs). Seismometers are very sensitive sensors designed primarily to detect micro earthquakes near Hanford. They record seismograms that are used to determine the magnitudes and locations of seismic events. SMA stations are designed to measure ground motion from larger earthquakes, and are discussed separately in Section 2.2. We further divide the seismic stations supported by MSA into two geographic sub-networks for discussion: the Hanford Site Network (HSN), which are sites located on the Hanford site itself, and the Eastern Washington Regional Sub-Network (EWRSN), which includes sites that surround the Hanford site.

Combined, the HSN and the EWRSN include 49 stations. Figure 2.1 shows the location of these stations. The figure also shows the locations of some stations operated by other entities, but that most contribute to the EWSRN's seismic monitoring capabilities. Most stations reside in remote locations and require solar panels and batteries for power. The HSN includes 16 stations (Table 2.1) and the EWRSN consists of 33 stations (Table 2.2).

The EWRSN is used by the HLSMP for two major reasons. A large earthquake located in the Pacific Northwest outside of Hanford could produce significant ground motion and damage to structures at the Hanford Site. For example, the magnitude 7.0 earthquake that occurred in 1872 near Chelan/Entiat or other earthquakes located in the region (*e.g.,* eastern Cascade mountain range) could have such an effect. The EWRSN would provide valuable information to help determine the impacts of such an event. Additionally, the characterization of seismicity throughout the surrounding areas, as required for the Probabilistic Seismic Hazard Analysis, supports facility safety assessments at the Hanford Site. Both the HSN and the EWRSN are fully integrated within the Pacific Northwest Seismic Network managed by the University of Washington.

The HSN and EWRSN networks have a total of 69 combined data channels because the 5 three-component seismometer sites (GBB, FHE, CCRK, DDRF, and PHIN), and the 5 SMA sites in the HSN (H1K, H2E, H2W, H3A, and H4A) require two additional data channels per station. The tri-axial stations record motion in the vertical, north-south horizontal, and east-west horizontal directions. Stations CCRK, DDRF, and PHIN were acquired from the National Science Foundation funded USArray, Transportable Arrays (TA) experiment that are broad-band seismometers with digital telemetry via cellular telephone. GBB and FHE are tri-axial sites with 1-Hz seismometers and analog radio telemetry. The other 39 stations are single vertical component seismometers. Fifteen radio telemetry relay sites are used by both networks to continuously transmit seismogram data to the PNSN in Seattle, Washington, for processing and archiving.

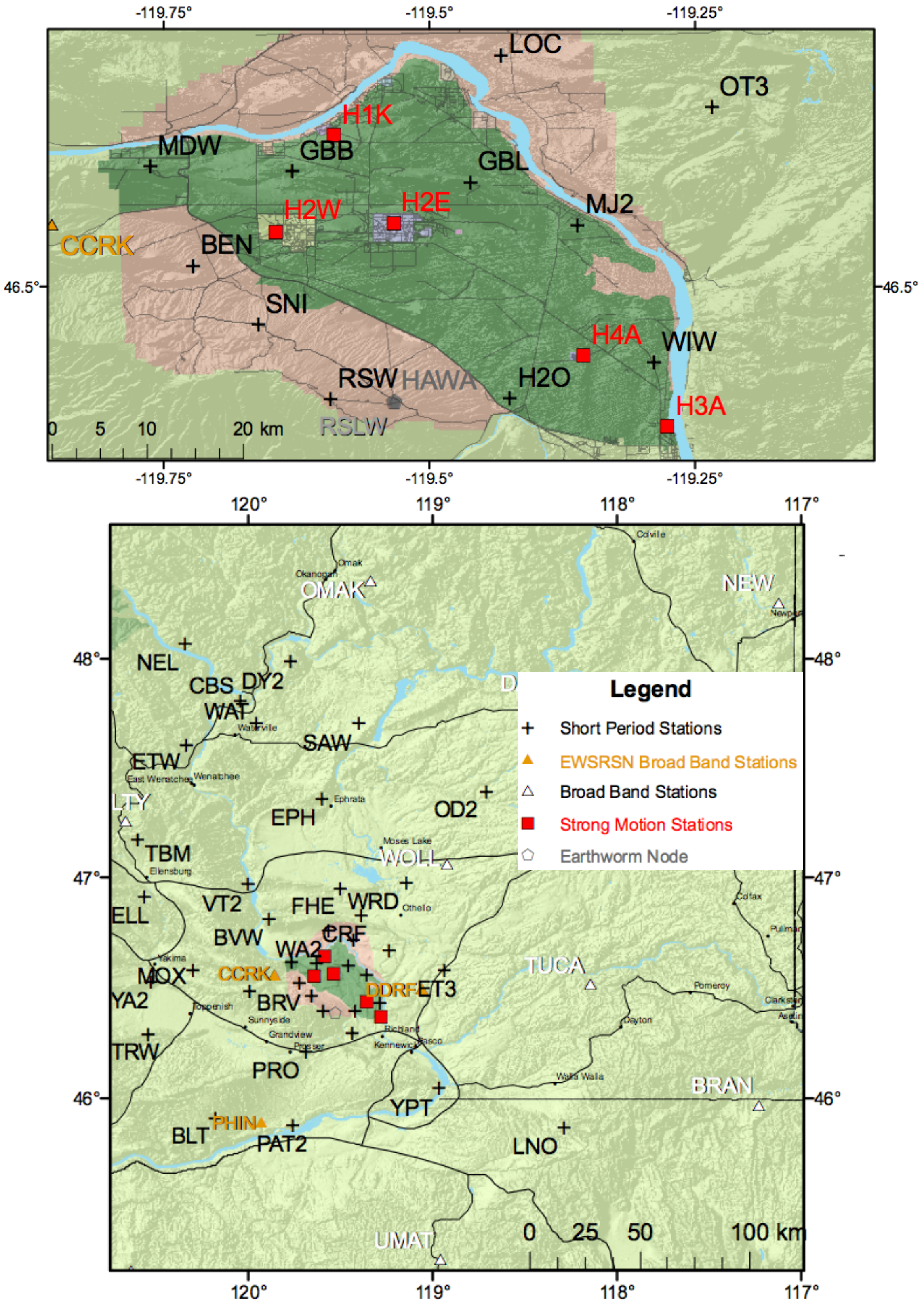


Figure 2.1 SMAs and seismometer stations HSN and the EWRSN on, and immediately adjacent to, the Hanford site (top), and in the wider region surrounding the site (bottom). Black crosses and station codes in black font are short period stations. Red squares and red font are strong motion stations. Yellow triangles are HSN/EWRSN broadbands. The grey pentagon is the Lower Rattlesnake installation earthworm data acquisition node, RSLW, and the grey triangle and station HAWA contribute broadband data to HLSMP, as do the regional broadband stations shown as white triangles and in white font.

Table 2.1 Hanford Site Network (HSN) Stations. *Italic font* indicates a 3-channel station, **bold font** indicates a Strong Motion Accelerometer.

Station	Latitude	Longitude	Elevation (m)	Station Name
BEN	46.52	-119.72167	335	Benson Ranch
GBB	*46.60814*	*-119.62898*	*185*	*Gable Butte*
GBL	46.59819	-119.46097	33	Gable Mountain
H1K	***46.64468***	***-119.59287***	***152***	***100 K Area (SMA)***
H2E	***45.55780***	***-119.53450***	***187***	***200 East Area (SMA)***
H2O	46.39555	-119.42411	175	Water Station
H2W	***46.5517***	***-119.64532***	***129***	***200 West Area (SMA)***
H3A	***46.36322***	***-119.27747***	***99***	***300 Area (SMA)***
H4A	***46.46835***	***-119.35441***	***147***	***400 Area (SMA)***
LOC	46.71686	-119.43197	21	Locke Island
MDW	46.61302	-119.76215	33	Midway
MJ2	46.55736	-119.36013	146	May Junction Two
RSW	46.39436	-119.59247	1045	Rattlesnake Mountain
SNI	46.46386	-119.66089	323	Snively Ranch
WA2	46.75519	-119.56681	244	Wahluke Slope
WIW	46.42919	-119.2888	128	Wooded Island

Table 2.2 Eastern Washington Regional Sub-Network (EWRSN) Stations. *Italic font* indicates a 3-channel station.

Station	Latitude	Longitude	Elevation (m)	Station Name
BLT	45.915	-120.177	659	Bickleton
BRV	46.48519	-119.992	920	Black Rock Valley
BVW	46.81083	-119.883	670	Beverly
CBS	47.80469	-120.043	1067	Chelan Butte South
CCRK	*46.5585*	*-119.855*	*561*	*Cold Creek*
CRF	46.82486	-119.388	189	Corfu
DDRF	*46.4911*	*-119.06*	*233*	*Didier Farms*
DPW	47.87052	-118.204	892	Davenport
DY2	47.98503	-119.773	890	Dyer Hill Two
ELL	46.90951	-120.568	789	Ellensburg
EPH	47.35619	-119.597	661	Ephrata
ET3	46.57719	-118.939	286	Eltopia Three
ETW	47.60418	-120.334	1477	Entiat
FHE	*46.95178*	*-119.498*	*455*	*Frenchman Hills East*
LNO	45.87169	-118.286	771	Lincton Mountain Oregon
MOX	46.57718	-120.299	501	Moxee City
NAC	46.73301	-120.825	728	Naches

NEL	48.07003	-120.341	1500	Nelson Butte
OD2	47.38754	-118.711	553	Odessa Two
OT3	46.66886	-119.234	322	Othello Three
PAT2	45.88362	-119.75775	262	Paterson Two
PHIN	*45.8951*	*-119.928*	*227*	*Phinney Hill*
PRO	46.21252	-119.687	553	Prosser
RED	46.29736	-119.43880	330	Red Mountain
SAW	47.70153	-119.402	701	St. Andrews
TBM	47.16985	-120.599	1006	Table Mountain
TRW	46.29207	-120.543	723	Toppenish Ridge
TWW	47.13801	-120.87	1027	Teanaway
VT2	46.96719	-120	385	Vantage Two
WAT	47.69852	-119.955	821	Waterville
WRD	46.96986	-119.146	375	Warden
YA2	46.52652	-120.531	652	Yakima Two
YPT	46.04869	-118.963	325	Yellepit

2.1.1 Station Maintenance

In the 1st quarter of FY2012 site visits were made to the Waterville BPA and the Chelan Butte South (CBS) relay sites to balance analog telemetry lines. Site visits to H2W, and H2E replaced batteries at these strong motion sites. Also the field datalogger at the Lower Rattlesnake installation (RSLW in Figure 2.1), that acquires data from 7 on-site analog stations, was visited and a second GPS timing antenna was added.

2.1.2 Data Acquisition

The signals from the seismometers are monitored for changes in signal amplitude that are expected from earthquakes. The seismic network is subdivided into spatial groupings of stations that are monitored for nearly simultaneous amplitude changes, resulting in triggering a permanent recording of the events. The groupings and associated weighting schemes are designed to allow very small seismic events to be recorded and to minimize false triggers. Events are classified as local (south-central Washington near the Hanford Site), regional (western United States and Canada), and teleseisms (from farther distances around the world). Local and regional events are usually earthquakes, but quarry and mining explosions also are recorded. Quarry and mining explosions usually can be identified from wave characteristics and the time of occurrence and may be confirmed with local government agencies and industries. Frequently, military exercises at the U.S. Army Yakima Training Center produce a series of acoustic shocks that trigger the recording system. Sonic booms and thunder also produce acoustic signals that may trigger the recording system.

The HLSMP uses Earthworm, an automated computer-based software system developed by the USGS and used throughout the region by the Pacific Northwest Seismic Network at the UW, to record triggered events. We currently run Earthworm Version 7.4. Two Earthworm systems run continuously at the PNSN. If one fails, the second one serves as a "backup". The two systems are located in different buildings on separate computer servers with redundant power supplies, backed up by different uninterruptable power supplies and a diesel-powered electric generator capable of powering the network for 14 days until refueling is needed. Seismic data from triggered events are collected on a SUN workstation (Sun Microsystems, Santa Clara, California) for assessment by HLSMP staff. This information is evaluated to determine if the event is "false" (for example, due to a sonic boom) or is an earthquake or ground-surface or underground blast. Earthquake events are evaluated to determine epicenter locations, focal depths, and magnitudes (Section 4).

2.2 Strong Motion Accelerometer Stations

2.2.1 Location

The Hanford SMA network consists of five free-field SMA stations (see Figure 2.1; Table 2.1). SMAs are located in the 200 East and 200 West Areas, in the 100-K Area adjacent to the K Basins, in the 400 Area near the former Fast Flux Test Facility, and at the south end of the 300 Area.

The locations of SMA stations were chosen based on two criteria: 1) density of workers and 2) sites of hazardous facilities (Moore and Reidel 1996). The 200 East and 200 West Areas contain single-shell and double-shell tanks in which high-level radioactive wastes from past processing of fuel rods are stored. In addition, the Canister Storage Facility (holding encapsulated spent fuel rods) and the new Waste Treatment and Immobilization Plant being constructed are both located in the 200 East Area. The 100-K Area contained the K Basins, where spent fuel rods from the N Reactor were stored prior to encapsulation and relocation to Hanford's central plateau. The now inactive Fast Flux Test Facility is located in the 400 Area.

2.2.2 Station Design

All free-field SMA stations consist of a four-panel solar array and two 30-gallon galvanized drums that contain equipment. Each panel has a maximum 42 watt output. The two drums are set in the ground such that the base of each drum is about 1 m below the ground surface. One drum houses only the SMA; the other drum, which is connected via a sealed conduit to the SMA drum, contains the batteries. In 2011, data communication from all five stations was revised to be provided by cellular modem. The enclosure serves as a junction box for all cabling that is routed through conduit inside and outside the equipment drums. The antenna for the cell modem is mounted on top of the enclosure. The enclosure permits quick access to check battery conditions and a connection directly to the RS-232 port of the SMA without removing the drum lids. However, with continuous data telemetry via cell modem, most interrogation of the system is accomplished remotely.

The SMA stations are three-component units consisting of vertical, north-south horizontal, and east-west horizontal accelerometers manufactured by Kinemetrics, Inc., Pasadena, California, and known as the ETNA system. In addition to the 3-component accelerometer, each ETNA unit contains a digital recorder, a data storage unit, and a Global Positioning System (GPS) receiver with the equipment housed in a watertight box.

The cell modem system provides the Internet address connection to access the system. Stations can be monitored from any computer with appropriate access, and data can be downloaded to a dedicated computer in the Seismic Assessment Laboratory. The data also can be downloaded directly at each site via a built-in cable connection at the enclosure in case of communication failure. The GPS receiver is used principally to access the National Bureau of Standards timing system. The GPS receiver antenna is mounted on the enclosure at the rear of the solar array. The GPS receiver is activated internally approximately every 4 hr and checks the "location of the instrument" and the time. Any differences between the internal clock and the GPS time are recorded by the SMA. Any corrections to the internal timing are made automatically. Typically, the greatest correction recorded is approximately 4 milliseconds (ms).

2.2.3 Strong Motion Accelerometer Operations Center

The combined operations, data recording, data interpretation, and maintenance facility is located in the PNSN offices at the UW in Seattle.

2.2.4 Strong Motion Operational Characteristics

At each SMA site, signals from the three accelerometer channels use an 18-bit digitizer with data temporarily stored in a memory buffer. The digital sampling rate is 200 samples/s. Data are sent continuously in real-time to the PNSN offices at the UW in Seattle. The three channels are monitored for signals that exceed a programmable trigger threshold. Through April, 2011, the SMA data recording was triggered by strong motion, stored on the data logger and downloaded by dial-up telephone, or retrieved manually by a site visit. The nominal ground motion trigger threshold used from 1998 to 2006 was 0.1% g (0.05% of the full-scale range of 2.0 g; g is the acceleration of gravity, 9.8 m/s^2 or 32 ft/s^2). In the event of telemetry outage, triggered data are still recorded on site, as a back-up. Threshold trigger levels are set to trigger infrequently on noise sources (e.g., vehicles, sonic booms) near each site. In 2006, larger data storage capacities were installed that allowed the trigger thresholds to be reduced to 0.02% g.

When one of the accelerometer channels exceeds the trigger threshold, the recorders save information within the data buffers. Data recording begins 10 s before the actual trigger time, continues until the trigger threshold is no longer exceeded, and ends with an additional 40 s of data. The saved files created by a triggered event are stored on memory cards to be retrieved and examined by HLSMP staff.

3.0 Geology and Tectonic Analysis

The Hanford Site lies within the Columbia Basin, an intermontane basin between the Cascade Range and the Rocky Mountains filled with Cenozoic volcanic rocks and sediments. This basin forms the northern part of the Columbia Plateau physiographic province (Fenneman 1931) and the Columbia River flood-basalt province (Reidel et al. 1989). In the central and western parts of the Columbia Basin, the Columbia River Basalt Group (CRBG) overlies Tertiary continental sedimentary rocks and is overlain by late Tertiary and Quaternary fluvial and glaciofluvial deposits (Campbell 1989; Reidel et al. 1989, 1994; DOE 1988). In the eastern part, little or no sediment separates the basalt and underlying crystalline basement, and a thin (<10-m) veneer of eolian sediments overlies the basalt (Reidel et al. 1989, 1994).

The Columbia Basin has two structural subdivisions or subprovinces—the Yakima Fold Belt and the Palouse Slope. The Yakima Fold Belt includes the western and central parts of the Columbia Basin and is a series of anticlinal ridges and synclinal valleys with major thrust faults typically along the northern flanks (Figure 3.1) (Reidel and Fecht 1994a, 1994b). The Palouse Slope is the eastern part of the basin and is less deformed than the Yakima Fold Belt, with only a few faults and low-amplitude long-wavelength folds on an otherwise gently westward dipping paleoslope. Figure 3.2 shows north-south (B-B′) and east-west (A-A′) cross sections through the Columbia Basin based on surface mapping (Reidel and Fecht 1994a, 1994b), deep boreholes (Reidel et al. 1994), geophysical data (Rohay *et al.,* 1985; DOE 1988), and magnetotelluric data obtained as part of BWIP (DOE 1988).

3.1 Earthquake Stratigraphy

Seismic studies at the Hanford Site have shown that the earthquake activity is related to crustal stratigraphy (large groupings of rock types) (Rohay et al. 1985; DOE 1988). The main geologic units important to earthquakes at the Hanford Site and the surrounding area are

- Miocene Columbia River Basalt Group
- Sub-basalt sediments of Paleocene, Eocene, Oligocene, and Early Miocene age
- Precambrian and Paleozoic cratonic basement
- Mesozoic accreted terranes forming the basement west of the craton margin.

3.2 Geologic Structure Beneath the Monitored Area

Between the late 1950s and the mid 1980s, deep boreholes were drilled for hydrocarbon exploration in the Columbia Basin. These boreholes provided accurate measurements of the physical properties of the CRBG and the pre-basalt sediments (Reidel et al. 1989, 1994), but the thickness of the sub-basalt sediments and nature of the basement are still poorly understood. Table 3.1, derived from Reidel et al. (1994), was developed for the geologic interpretation in this report. The thicknesses of these units are variable across the monitored area. Table 3.1 summarizes the approximate thickness at the borders of the monitored area.

Table 3.1 Thicknesses of Stratigraphic Units in the Monitoring Area (from Reidel *et al.,* 1994)

Stratigraphy	North	South	East	West
Columbia River Basalt Group (includes suprabasalt sediments)	3.0 km	4.5 km	2.2 km	4.2 km
Pre-basalt sediments	3.0 km	>4.5 km	0	>6.0 km

The thickness of the basalt and the sub-basalt sediments varies as a result of different tectonic environments. The western edge of the North American craton (late Precambrian/Paleozoic continental margin and Precambrian craton) is located in the eastern portion of the monitored area (Reidel et al. 1994). The stratigraphy on the craton consists of CRBG overlying basement; the basement is continental crustal rock that underlies much of western North America. The stratigraphy west of the craton consists of 4 to 5 km of CRBG overlying up to 6 km of pre-basalt sediments. This in turn overlies accreted terranes of Mesozoic age. The area west of the craton was subsiding during the Eocene and Oligocene, accumulating great thickness of pre-CRBG sediments. Continued subsidence in this area during the Miocene resulted in thicker CRBG compared to that on the craton. Subsidence continues today but at a greatly reduced rate (Reidel *et al.,* 1994).

3.3 Tectonic Pattern

Studies have concluded that earthquakes can occur in the following six different tectonic environments (earthquake sources) at the Hanford Site (Geomatrix 1996):

- **Major Geologic Structures**. Reverse/thrust faults in the CRBG associated with major anticlinal ridges such as Rattlesnake Mountain, Yakima Ridge, and Umtanum Ridge could produce some of the largest earthquakes.
- **Secondary Faults**. These faults are typically smaller (1 to 20 km in length) than the main reverse/ thrust faults that occur along the major anticlinal ridges (up to 100 km in length). Secondary faults can be segment boundaries (tear faults) and small faults of any orientation that formed along with the main structure.
- **Swarm Areas**. Small geographic areas not known to contain any geologic structures produce clusters of events (swarms), usually located in synclinal valleys. These clusters consist of a series of small shocks with no outstanding principal 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. In the past, swarms were thought to occur only in the CRBG. Most swarm areas are in the basalt, but swarm events also appear to occur in all geologic layers. However, typically a swarm event at a specific time is usually restricted to one layer. Seven earthquake swarm areas are recognized in the HSN area, but this list will be updated as new swarm areas develop. The Saddle Mountains, Wooded Island, Wahluke, Coyote Rapids, and Horse Heaven Hills swarm areas are typically active at one time or another during the year (see Figure 5.1 for a map of these swarm areas). The other earthquake swarm areas are active less frequently.

- **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. Seismic interpretation classifies it as a random event for purposes of seismic design and vibratory ground motion studies.

- **Basement Source Structures**. Studies (Geomatrix 1996) suggest that major earthquakes can originate in tectonic structures in the basement. Because little is known about geologic structures in the basement beneath the Hanford Site, earthquakes cannot be directly tied to a mapped fault. Earthquakes occurring in the basement without known sources are treated as random events.

- **Cascadia Subduction Zone**. This source has been postulated to be capable of producing a magnitude 9 earthquake. Because this source is along the western boundary of Washington State and outside the HSN, 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 or can be felt like the February 2001 Nisqually earthquake, UW monitors and reports on this earthquake source for the DOE. Ground motion from any moderate or larger Cascadia subduction zone earthquake is detected by Hanford SMAs and reported (see Section 5).

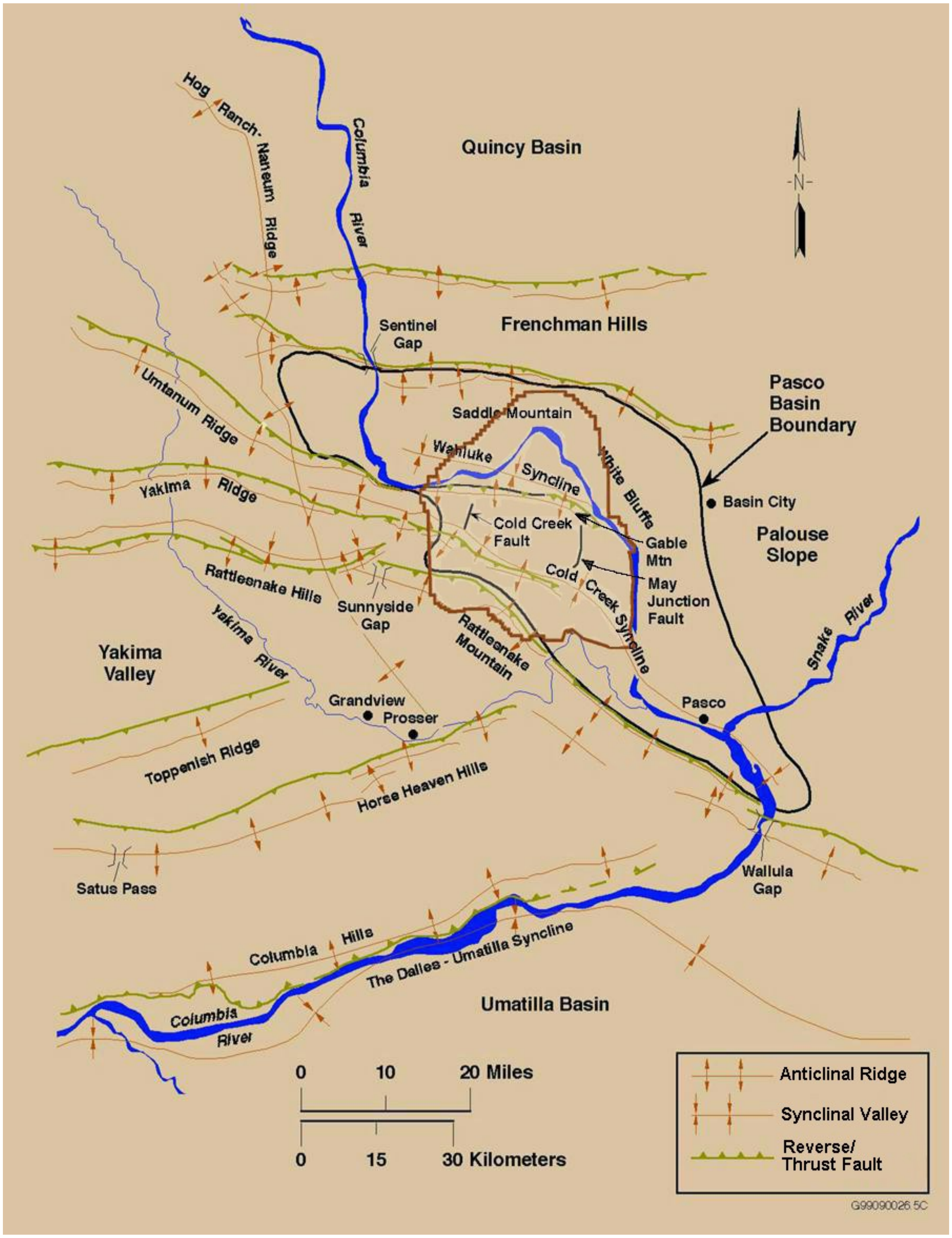


Figure 3.1 Tectonic features of the Hanford site within eastern Washington. (from Rohay et al., 2010b).

4.0 Earthquake Catalog Description

An interactive program called Jiggle is used to manually review and revise automatic pick arrival times and signal durations and their uncertainties. Arrival and duration times and uncertainties are used as input to the hypocenter locating routine (called Hypoinverse) to estimate locations and magnitudes of the seismic events. Hypoinverse results for local earthquakes (46-47° north latitude, 119-120° west longitude) are reported in Table 5.1. Other seismic events located in southeastern Washington, the Pacific Northwest, or outside the region also are evaluated, with results stored on the computer system; these results are not reported in this document. These other results sometimes are used as a check to confirm that the HSN is functioning properly (*e.g.,* quality checks on data recording).

4.1 Coda-Length Magnitude

Coda-duration magnitude (M_c), an estimate of local magnitude (M_L) (Richter 1958), is calculated using a relationship developed for Washington State by Crosson (1972):

$$M_c = 2.82 \log (D) - 2.46$$

where D is the duration of the observed event. Many earthquakes yield magnitude determinations that are very small ($M_c < 0$) and highly uncertain. We define earthquakes with magnitudes (M_c) smaller than 1.0 as “minor”. Coda-duration magnitudes for events classified as explosions are reported although they may be biased by a prominent surface wave that extends the apparent duration in a way inconsistent with coda-length measurement.

4.2 Velocity Model

Hypoinverse uses the crustal velocity model for eastern Washington given in Table 4.1. The model does not include a surface layer for the Hanford or Ringold formations because most seismometer stations are sited on basalt. The crustal velocity model extends 38 km deep (to the mantle) and consists of six layers, each with uniform seismic velocity. The crustal velocity model was developed using available geologic information and calibrated from seismic data recorded from accurately located earthquake and blast events in eastern Washington. Time corrections (delays) are incorporated into the velocity model to account for significant deviations in station elevations or stations situated on sedimentary layers. Station delays also are determined empirically from accurately located earthquakes and blast events in the region.

4.3 Quality Factors (Q)

Hypoinverse assigns a two-letter **Quality factor** (Table 5.1) that indicates the general reliability of the solution (**A** is best quality, **D** is worst). The first letter of the quality code is a measure of the hypocenter quality based primarily on arrival time residuals. For example: Quality **A** requires a root-mean-square residual (**RMS**) less than 0.15 s, while a **RMS** of 0.5 s or more is **D** quality (other estimates of the location uncertainty also affect this quality parameter). The second letter of the quality code is related to the spatial distribution of stations that contribute to the event location, including the number of stations (**NS**), the number of p-wave and s-wave phases (**NP**), the largest gap in event-station azimuth distribution (**GAP**), and the closest distance from the epicenter to a station (**DMIN**). Quality **A** requires a solution with **NP** >8, **GAP** <90°, and **DMIN** <5 km (or the hypocenter depth if it is greater than 5 km). If **NP** ≤5, **GAP** >180°, or **DMIN** >50 km, the solution is assigned Quality **D**. Uncertainties associated with estimated depths depend upon the number of stations and number of phase measurements (**NS/NP**) utilized in the XPED calculation. Generally speaking, if the number of phases exceeds 10 measurements, the depth estimate is considered to be reliable. In this case, the second letter in the quality evaluation is either "A" or "B" (*cf.* Table 5.1). For example, the number of phase measurements from earthquakes ultimately classified as "deep" events typically falls within the 10-20 measurement range; these depth estimates are considered reliable. However, the number of phase measurements from earthquakes classified as "shallow" or "intermediate" may be less than 10 readings; in this case the depth estimate is less certain and the event could be classified as occurring in the CRBG or pre-basalt layers.

***Table 4.1**. Crustal Velocity Model for Eastern Washington (from Rohay et al. 1985)*

Depth to Top of Layer (km)	Layer	Velocity (km/s)
0.0	Saddle Mountains and Wanapum Basalts and intercalated Ellensburg Formation	3.7
0.4	Grande Ronde Basalt and pre-basalt sediments	5.2
8.5	Basement, Layer 1	6.1
13.0	Basement, layer 2	6.4
23.0	Sub-basement	7.1
38.0	Mantle	7.9

5.0 Seismic Activity – First Quarter FY 2012

5.1 Catalog of Seismic Events

Table 5.1 Local Seismic Data, October 1 – December 31, 2011

Oct. 2011

DAY	TIME	LAT	LON	DEPTH	M	NS/NP	GAP	RMS	Q	MOD	TYPE
5	20:45:56	46.6220	-120.6535	0.67	1.9	5/005	146	0.14	AD	E3	P
6	15:42:58	46.6150	-120.6772	0.42	1.2	5/005	155	0.13	AD	E3	
8	7:49:26	46.6962	-120.9520	7.98	1.9	21/022	82	0.11	AB	C3	
9	8:42:19	46.3935	-119.2643	0.41	0.7	8/009	214	0.15	AD	E3	
9	18:49:42	47.6818	-120.2258	0.50	1.5	5/007	125	0.22	BD	N3	
10	18:51:47	47.6823	-120.2297	4.56	1.2	3/005	183	0.04	AD	N3	
11	4:21:05	47.6783	-120.2250	8.21	0.8	3/005	140	0.06	AD	N3	
14	4:29:12	46.1703	-120.4678	16.54	1.9	11/014	95	0.35	CB	E3	
14	4:35:34	46.1597	-120.4505	16.52$	1.9	12/012	83	0.49	CA	E3	
14	19:40:23	48.1757	-121.3197	10.20$	1.7	10/011	140	0.27	BC	C3	
15	6:11:29	46.4082	-119.2623	1.43	3.4	38/038	68	0.24	BA	E3	F
15	7:38:38	46.4797	-119.2690	0.48	0.8	3/005	310	0.11	BD	E3	
15	7:47:52	46.4598	-119.2880	0.05*	0.0	4/005	190	0.02	AD	E3	
15	8:37:08	46.4047	-119.2602	0.41	0.8	9/010	137	0.10	AC	E3	
15	11:24:07	46.4760	-119.2902	0.47	0.4	5/006	201	0.16	BD	E3	
15	11:55:25	46.3962	-119.2623	0.46	0.4	4/005	212	0.05	AD	E3	
15	13:05:54	46.3973	-119.2602	0.42	0.6	7/008	212	0.15	BD	E3	
15	18:53:43	46.3982	-119.2568	0.02*	0.9	6/008	212	0.11	AD	E3	
15	23:30:08	46.4055	-119.2590	0.45	1.3	10/011	138	0.07	AC	E3	
16	1:15:33	46.4017	-119.2525	0.13	1.7	14/018	94	0.20	BB	E3	
17	0:26:55	46.4090	-119.2590	0.60	2.0	30/031	91	0.23	BB	E3	
17	1:22:32	46.7728	-120.7092	9.66	1.4	10/010	95	0.17	BB	C3	
18	4:05:07	45.1272	-120.9278	9.56*	1.5	4/004	199	0.00	AD	P3	
18	4:49:18	45.1240	-120.9312	17.61	1.7	12/012	118	0.15	BB	O0	
18	7:24:54	46.3973	-119.2578	2.05	0.6	9/011	145	0.12	AC	E3	

18	12:08:42	46.3945	-119.2527	0.03*	0.4	6/007	215	0.15	AD	E3	
18	12:25:31	45.1230	-120.9387	20.85	2.9	26/029	103	0.20	BB	O0	
19	8:58:18	46.3887	-120.9798	1.78	2.2	17/017	79	0.28	BC	C3	
21	18:54:55	46.4022	-119.2645	0.81*	0.8	7/007	208	0.05	AD	E3	
23	6:16:50	46.3855	-119.1983	2.37	0.2	3/004	306	0.00	AD	E3	
25	17:24:41	46.6247	-120.6385	0.05*	1.6	7/008	141	0.19	BC	E3	P
27	20:29:41	45.8827	-119.7235	0.04*	2.3	7/007	176	0.43	CC	E3	P
29	5:49:43	46.4447	-119.2828	2.47	0.4	6/006	180	0.03	BC	E3	
29	7:25:22	46.4560	-119.2785	0.76	0.0	3/004	187	0.01	AD	E3	
29	15:09:24	46.3783	-119.2753	5.46	1.3	10/011	131	0.18	BB	E3	

Nov. 2011

DAY	TIME	LAT	LON	DEPTH	M	NS/NP	GAP	RMS	Q	MOD	TYPE
1	20:34:50	46.9500	-119.1040	0.03*	1.1	4/004	148	0.04	AD	E3	P
2	21:35:11	46.5718	-120.4737	0.02*	2.2	5/005	133	0.00	AD	E3	P
4	1:29:59	47.6763	-120.4155	0.85*	1.3	7/008	110	0.09	AC	N3	
4	9:58:24	46.7277	-121.1220	1.63	2.4	46/047	31	0.20	BC	C3	
4	15:40:39	47.3708	-120.0567	0.03*	0.0	4/004	162	0.11	AD	P3	
12	11:28:47	46.5982	-119.8602	7.39$	1.0	10/011	181	0.09	AD	E3	
16	14:56:41	48.5212	-119.9110	0.03*	2.5	10/010	107	0.12	AC	N3	
18	13:09:01	48.4693	-119.6073	11.92	4.6	18/018	121	0.26	BB	N3	F
18	15:16:36	48.5162	-120.6790	10.25	1.7	5/005	224	0.30	CD	C3	
26	21:22:25	46.4118	-119.2612	0.03*	0.6	5/006	201	0.03	AD	E3	
30	1:02:01	46.4473	-119.2765	0.35$	0.4	4/005	181	0.10	DD	E3	
30	3:20:26	46.4512	-119.2793	0.22	0.2	4/004	183	0.00	AD	E3	

Dec. 2011

DAY	TIME	LAT	LON	DEPTH	M	NS/NP	GAP	RMS	Q	MOD	TYPE
1	1:45:59	46.4183	-119.2642	2.22	0.8	7/008	126	0.09	AB	E3	
1	18:53:48	46.2717	-117.9650	16.80	1.7	17/018	160	0.35	CD	E3	
2	18:36:54	46.4097	-119.2642	1.57	0.9	11/012	130	0.08	AB	E3	
3	15:56:15	47.7317	-120.2457	6.68	1.1	8/011	105	0.11	AC	N3	
7	0:10:43	45.0798	-121.3197	0.034	2.3	9/009	139	0.16	BC	O0	P
7	5:32:44	44.9688	-121.4963	12.80	1.1	8/008	144	0.08	AC	O0	
7	11:49:04	46.6838	-119.7257	12.17$	0.6	11/012	104	0.94	DB	E3	

9	3:21:06	47.6708	-120.2182	0.03*	1.5	7/009	126	0.06	AC	N3	
14	19:30:21	45.7965	-120.8522	0.02*	1.5	11/011	83	0.45	CC	C3	P
14	22:09:48	46.6462	-120.4908	0.82	1.6	8/008	122	0.21	BC	E3	P
15	7:43:05	47.6338	-120.3855	0.53	1.0	7/008	129	0.10	AC	N3	
16	20:16:13	45.0772	-121.3120	0.45	2.2	9/009	140	0.22	BC	O0	P
17	3:29:43	46.7367	-121.1265	5.08$	1.1	14/015	118	0.49	CC	C3	
17	3:30:13	46.7040	-121.1450	2.56	1.8	24/024	111	0.14	AC	C3	
17	3:51:50	46.7247	-121.1362	9.14$	0.6	10/011	155	0.09	CC	C3	
17	4:23:41	46.7248	-121.1132	1.72$	1.2	14/015	156	0.27	CC	C3	
22	14:06:59	46.4155	-119.2723	0.42	0.7	6/006	120	0.16	BC	E3	
22	19:59:53	46.6408	-120.4918	0.64	2.1	10/010	104	0.28	BC	E3	P
23	3:16:04	46.3993	-119.2647	1.04$	0.3	6/006	210	0.06	CD	E3	
25	17:15:52	46.4248	-119.2987	1.62	0.2	9/010	190	0.09	AD	E3	

Explanation of Table 5.1 – also see section 4.3 of this report

Type:	P is Probable Blast; X is Confirmed Blast; blank is local earthquake, F was reported as being felt.
Date:	The year and date in Universal Time Coordinated (UTC). UTC is used throughout this report unless otherwise indicated.
Time:	The origin time of the earthquake given in Coordinated Universal Time (UTC). To covert UTC to Pacific Standard Time, subtract eight hours; to Pacific Daylight Time, subtract seven hours.
Lat:	North latitude, in decimal degrees, of the earthquake epicenter.
Lon:	West longitude, in decimal degrees, of the earthquake epicenter.
Depth:	The depth of the earthquake in kilometers (km). * = Depth constrained by location program, $ = location program had trouble converging and constrained both location and depth.
Mag:	The magnitude is expressed as coda-length magnitude M_c, an estimate of local magnitude M_L (Richter 1958). If magnitude is blank, a determination was not made.
NS/NP:	Number of stations/number of phases used in the solutions.
Gap:	Azimuthal gap; the largest angle (relative to the epicenter) containing no stations.
DMIN:	The distance from the earthquake epicenter to the closest station.
RMS:	The summed root-mean-square residual (observed arrival times minus the predicted arrival times) of all phases used from all stations used to locate the earthquake. It is a measure of quality of the solution only 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 s.
Q:	Quality factors; indicate the general reliability of the solution/location (A is best quality, D is worst). See Section 4.3 of this report, "Quality Factors."

5.2 Summary

In terms of the number of earthquakes recorded, October through December of 2011 was seismically relatively quiet in eastern Washington. Notwithstanding the relatively low seismicity rate, one local earthquake caused nearly 1.5% g horizontal accelerations. Another earthquake, 200 km north of the Hanford site but well-recorded on the HSN accelerographs, was one of the larger regional earthquakes recorded by the network in recent times.

5.3 First Quarter FY 2012 Earthquakes

The EWRSN recorded 57 eastern Washington earthquakes during the first quarter of FY 2012, 29 local to the Hanford site (local), and 28 off of the site (regional). Of the local earthquakes, 26 were located at shallow depths (less than 4 km), 2 at intermediate depths (between 4 and 9 km), most likely in the pre-basalt sediments, and 1 deeper than 9 km, within the basement. Geographically, all 26 shallow local earthquakes were located in the Wye swarm area. The three non-swarm local earthquakes were classified as random events. Of the regional earthquakes 11 were shallow, 5 intermediate, and 12 deep.

The largest regional event (4.6 M_c) took place on November 18, 2011 at depth of 11.92 km with epicenter located in the vicinity of Okanogan, about 200 km north of the Hanford site. The largest earthquake near the Hanford site (3.4 M_c) was located in the Wye swarm area in the vicinity of Wooded Island, a few miles north of Richland, on October 15, 2011 at depth of 1.43 km. A further 5 earthquake-like signals were categorized as probable surface explosions (Table 5.1).

Epicenters of the earthquakes tabulated in Table 5.1 are plotted in Figures 5.1 and 5.2. The depth distribution and geographic pattern of the tabulated earthquakes. Epicenters of earthquakes in the immediate vicinity of the Hanford site, and their relationship to known faults and swarm areas are shown on Figure 5.2. Figure 5.3 is a perspective plot showing the hypocenters in the vicinity of the Hanford site and their location at depth and their relationship to the surface topography. Table 5.2 tabulates the earthquake types and locations discussed above.

5.3.1 Location and Depth of Local Earthquakes

During the first quarter of FY 2012, 26 local events occurred in swarm areas, 3 events were classified as random, and no events located near geologic structures.

5.3.2 Major Anticlinal Ridges

No notable or unusual seismicity was clearly or unambiguously associated with the region's major anticlines or their underlying faults.

5.3.3 Earthquake Swarm Areas

Twenty-six earthquakes were characterized as swarm events in the first quarter of FY 2012. Small geographic areas not known to contain any geologic structures produce clusters of events (swarms), usually located in synclinal valleys. Swarms were generally thought to occur only at relatively shallow depths within the CRBG, however, in recent years swarms have also been recorded at deeper locations, for example, within the Horse Heaven Hills (Rohay *et al.,* 2008). Swarm activity may wax and wane over time, but generally do not follow a typical mainshock-aftershock temporal pattern.

5.3.3.1 Wye Swarm Area

During the first quarter FY 2012, 26 Wye Swarm events were recorded (Table 5.1). The majority of these were in a small area about eight miles north of Richland, west of the Columbia River about halfway between Hanford’s 300 Area and Energy Northwest. With the exception of the October 15, 2011, earthquake discussed above, all events were considered minor (coda-length magnitude [M_c] less than 2.0) with the maximum estimated depth at ~2 km. This placed the Wooded Island events within the CRBG. The Wooded Island events recorded this quarter were a continuation of the swarm events observed during the 2009 and 2010 fiscal years and reported in previous quarterly and annual reports (Rohay et al. 2009a, 2009b, 2009c, 2010a, and 2010b)

5.3.4 Random or Floating Events

The earthquakes occurring during the quarter, and not discussed above, may be considered Random, or Floating earthquakes.

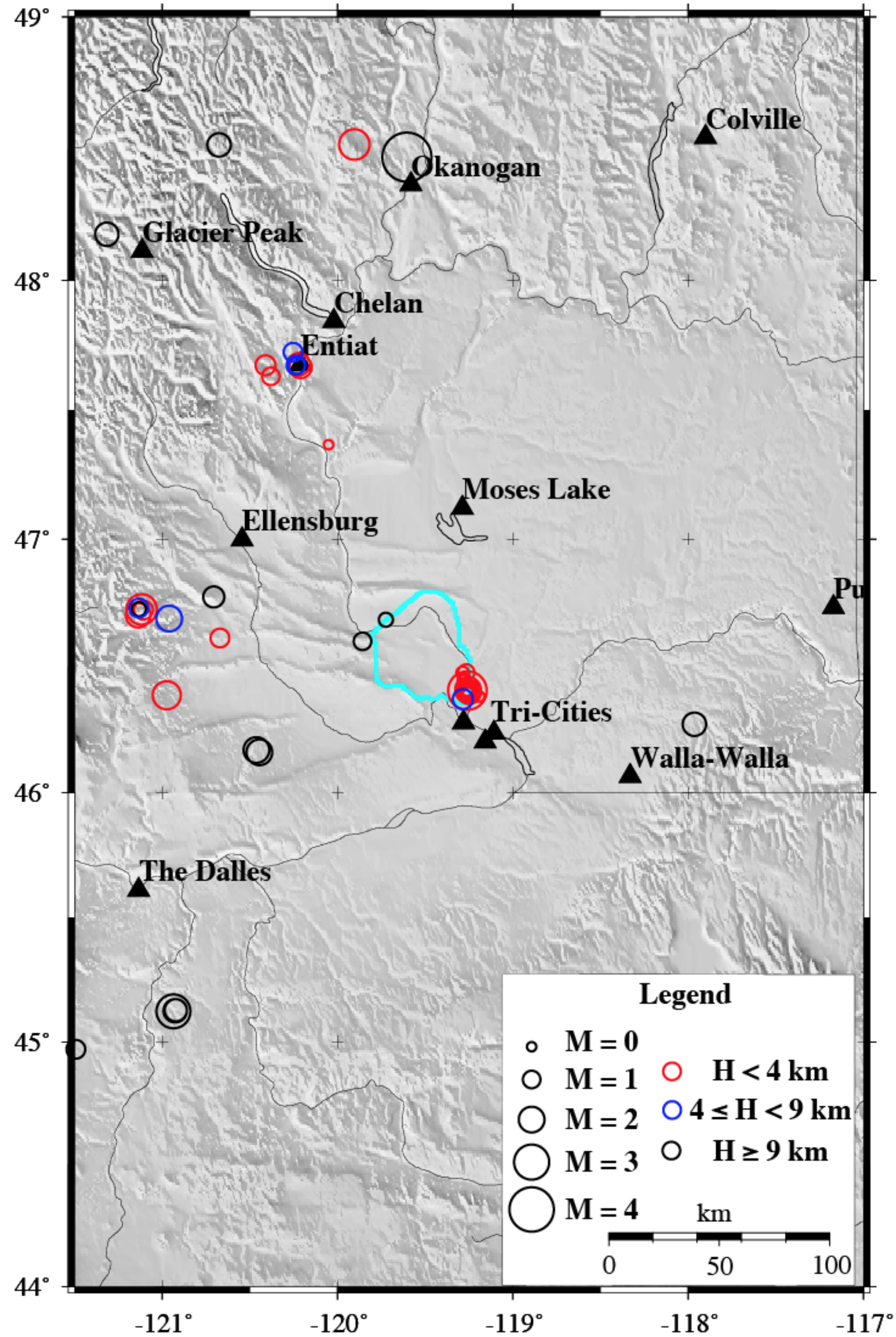


Figure 5.1 Epicenters of earthquakes recorded in the Eastern Washington region during the 1st Quarter of FY2012.

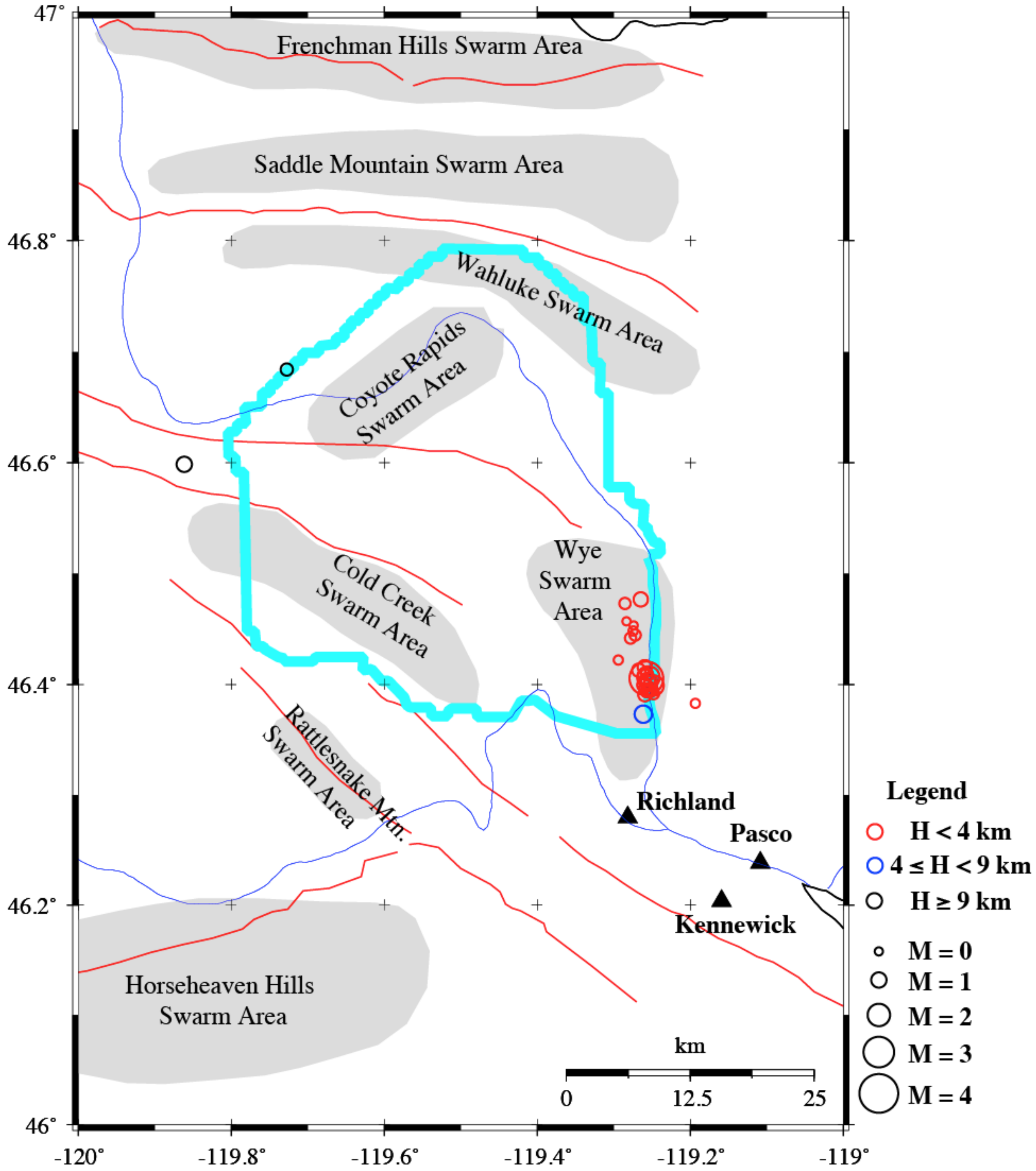


Figure 5.2 Epicenters of earthquakes occurring during the1st Quarter of FY2012 in the vicinity of the Hanford site (blue outline), and their relationship to known structures (red lines), swarm areas (shaded bits), and cultural features.

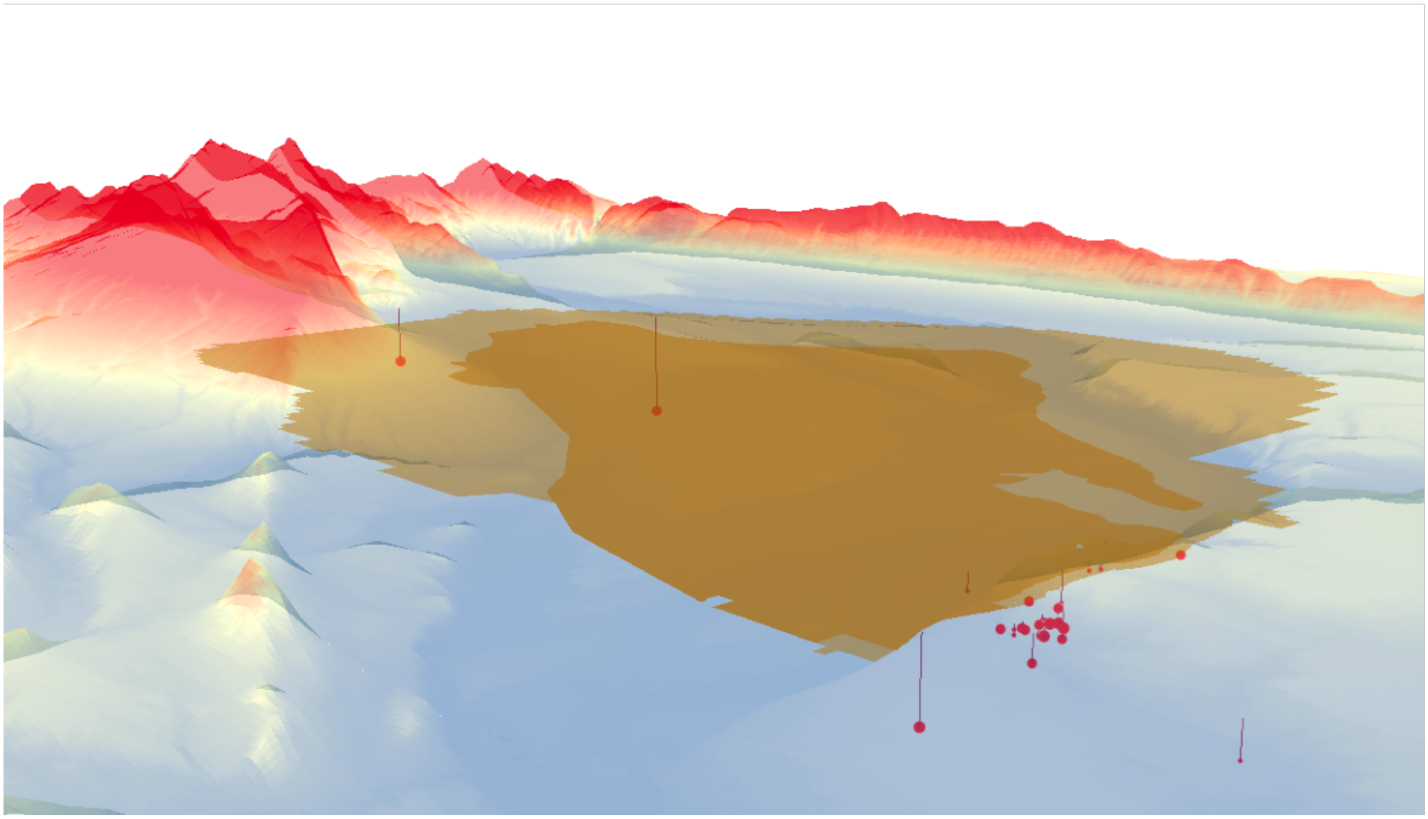


Figure 5.3 Perspective plot showing topography (exaggerated) and hypocenters (red dots, connected to epicenter with fine vertical line) of earthquakes occurring during the1st Quarter of FY2012 in the vicinity of the Hanford site, both overall (lightly shaded region), and inner (darker shading).

Table 5.2. Summary Table of the Distribution of Earthquakes for 1st Quarter, FY 2012

Event Category		1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		FY 2012	
		Hanford	Region	Hanford	Region	Hanford	Region	Hanford	Region	Hanford	Region
Depth	< 4 km	26	11								
	4-9 km	2	5								
	>9 km	1	12								
Sub-total		29	28								
Total		57									
Geographic Area	FHS	0	-								
	SMS	0	-								
	WAHS	0	-								
	CRS	0	-								
	CCS	0	-								
	WYES	26	-								
	RMS	0	-								
	HHS	0	-								
	Structure	0	-								
Random Event		3	-								
Sub-total		29	-								
Total		29	-								
Felt		1	1								
Probable Blast		-	10								

6.0 Strong Motion Accelerometer Operations

6.1 First Quarter FY 2012 Performance of the Hanford SMA Network

The SMA stations performed well over the quarter. Because of low light conditions, a battery change was needed to keep the stations operating. All of the SMA stations on the Hanford site have been converted to telemeter data continuously, so continuous data are now available in near real time from the PNSN data archive. But they are also automatically included with the “snippets” of all data from all seismic stations triggered and analyzed automatically, and reviewed by PNSN seismic analysts. Figure 6.1 shows the analyst’s screen view of the M_C 3.4, 15 October, 2011, Wooded Island swarm event (Table 5.1, Figures 5.1, 5.2, and 5.3). This earthquake produced peak accelerations on the North-South component of 1.386 cm/s^2. Undoubtedly this is because of the proximity of the station to the very shallow earthquake.

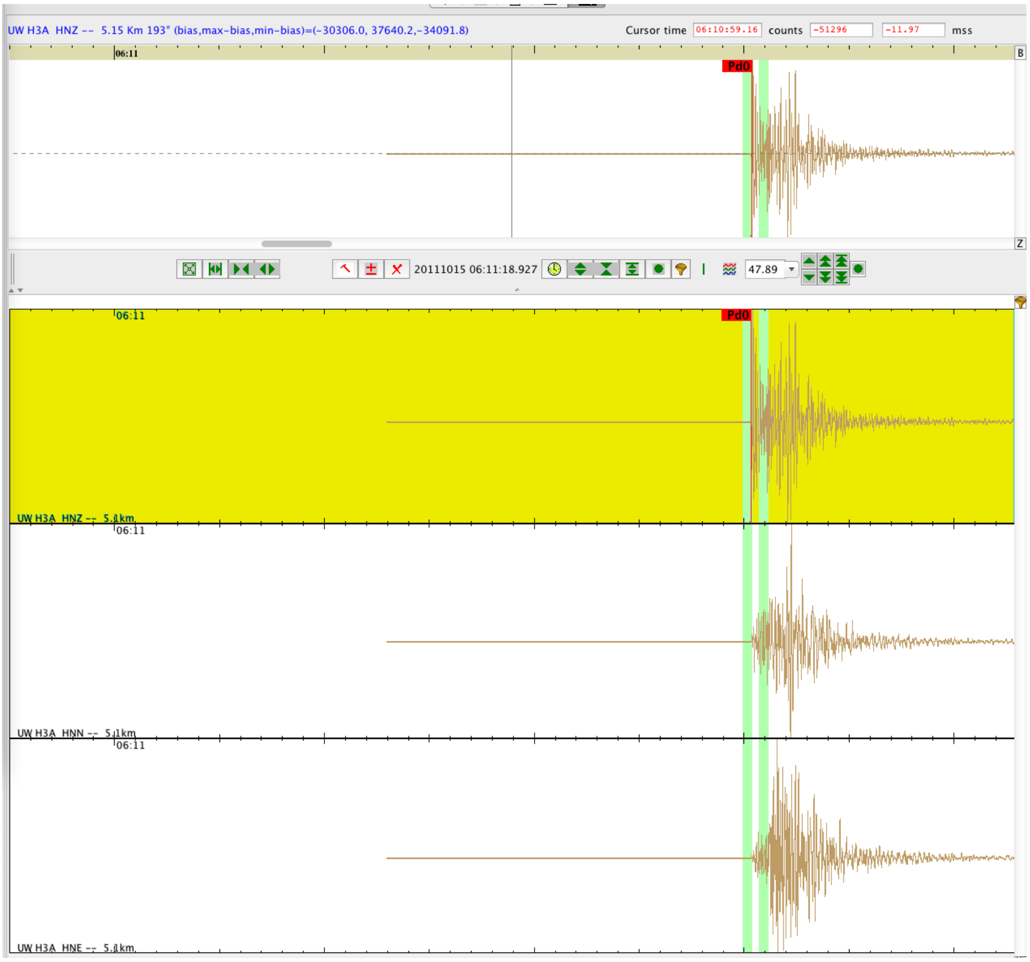
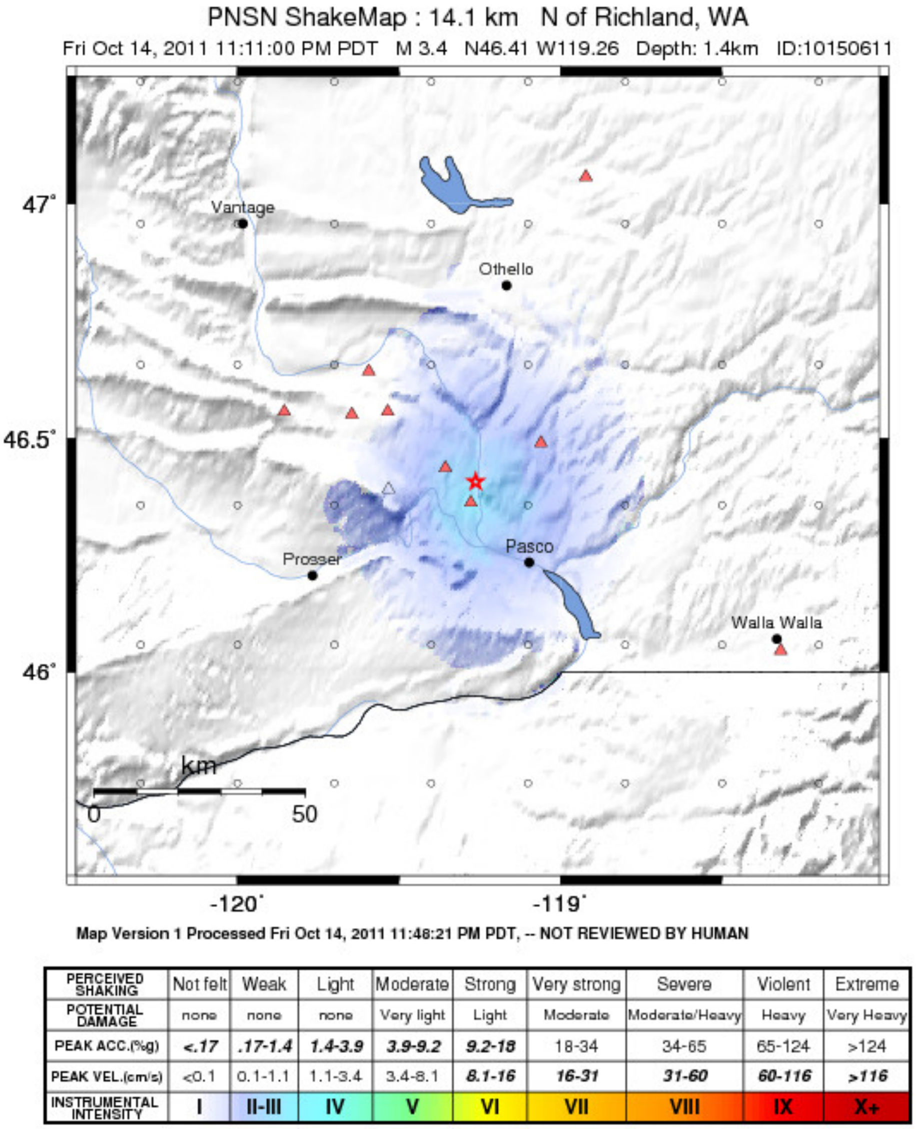


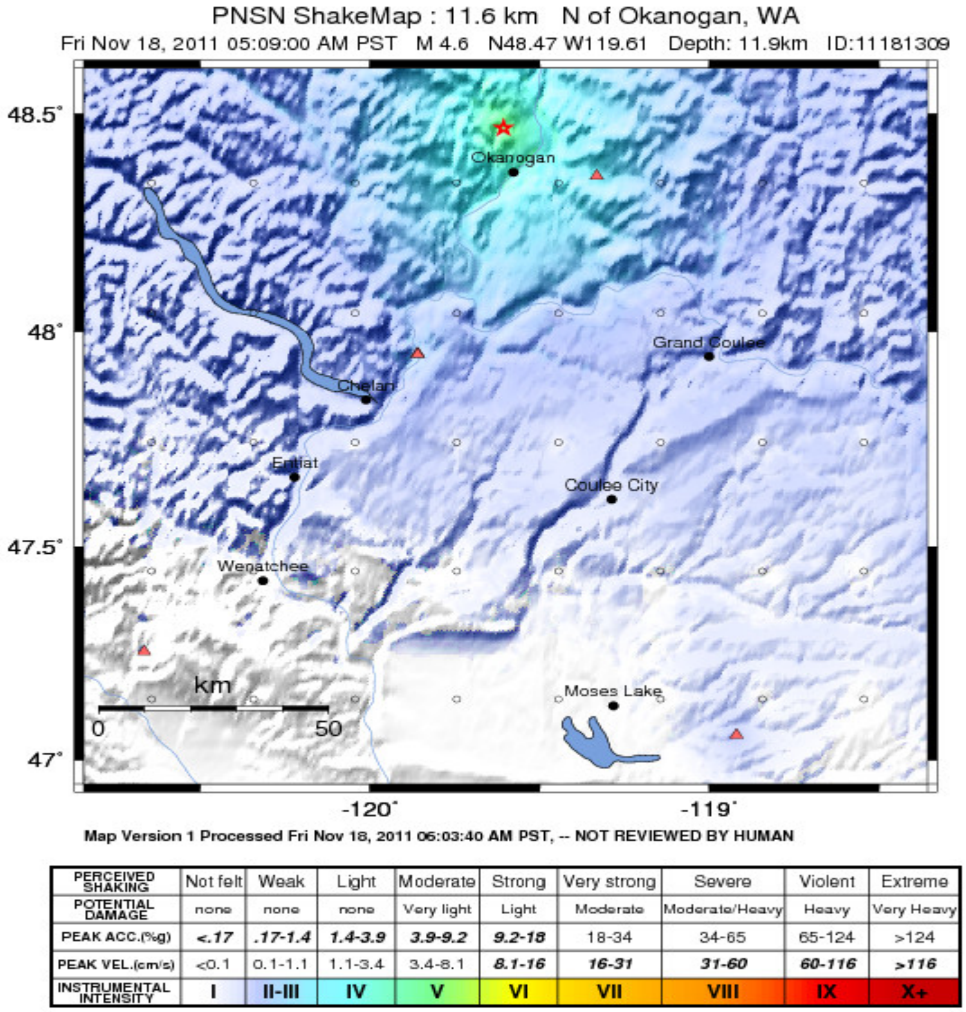
Figure 6.1 Screen shot of analyst’s view of the data from the 15 October, 2011 M_c 3.4 Wooded Island swarm earthquake recorded at HSN station H3A. Red label “flags” attached to thin red bars reveal time of analyst-reviewed phase picks, labeled with pick type and weight. These records verify that shaking levels were not close to levels that might be expected to cause damage, but of a level sufficient to be felt rather sharply.



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Figure 6.2. Shakemap of the 15 October, 2011 M_c 3.4 Wooded Island swarm earthquake. The contours are estimates of the shaking intensities experienced in the area as computed from the data at the HSA stations shown as red triangles and from a model of regional seismic wave propagation including the amplifying effect of near surface geology.

The 18 November, 2011, M_c 4.6 Okanagan earthquake produced ground motions felt over a wide area (Figure 6.3). However the sparse population and relatively sparse infrastructure in the region meant that the earthquake's impact was relatively muted.



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Figure 6.3 Shakemap of the 18 November, 2011 M_c 4.6 Okanagan earthquake.

7.0 Capabilities in the Event of a Significant Earthquake

The SMA network was designed to provide ground motion data in areas at the Hanford Site that have high densities of people and/or facilities containing hazardous materials, to ensure that the Hanford Site is in compliance with DOE Order 420.1B, Chapter IV, Section 3.d, "Seismic Detection." The network also allows the HLSMP to support Hanford Site emergency services organizations in complying with DOE Order G 420.1-1, Section 4.7, "Emergency Preparedness and Emergency Communications," by providing area ground motion data in the event of an earthquake on the Hanford Site. This section summarizes the capabilities of the PNSN network in the event of an earthquake at Hanford.

Historically, only a few facilities at the Hanford Site had instruments to provide data on peak ground accelerations or any type of ground motion. The current SMA instruments were located so that if an earthquake occurred, ground motion data would be readily available to assess the damage at the 100-K Area, the 200 East and West Areas, and the 300 and 400 Area facilities, which have the greatest concentration of people and also contain hazardous materials (Moore and Reidel 1996).

Many facilities at the Hanford Site have undergone various degrees of seismic analysis, either during design or during requalification. Although the seismic design of a building may be known, when an earthquake is "felt" in a facility on the Hanford Site, a determination must be made as to the extent of damage before it can be reoccupied and the systems restarted. A "felt" earthquake may not cause any significant damage to a building but, without adequate characterization of the ground motion, initial determination of the building's possibility of having damage may be impossible.

We now automatically produce "ShakeMaps" for any earthquake that might be widely felt at the Hanford site.

In the event of a major regional earthquake such as the 2001 Nisqually event, building managers, emergency directors, and engineers can obtain ground motion data recorded by the SMA network from the PNSN website within minutes of the event. This information is also passed on to Hanford Site Emergency Services personnel where the facility engineers can use the data to determine if the ground motion exceeded, is equal to, or is less than the building design. This, along with assessments from trained engineers, allows the facility manager to make a rapid and cost-effective determination on whether a building is safe to re-occupy or should not be used until it has been inspected in more detail. Buildings that have designs exceeding the recorded ground motion could be put back into service very quickly; buildings with designs that are very close to or less than measured ground motion could be given priority for onsite damage inspections.

8.0 References

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