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HANFORD SEISMIC REPORT FOR FISCAL YEAR 2023 (OCTOBER 2022 - SEPTEMBER 2023)

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Hanford Seismic Report for Fiscal Year 2023 (October 2022 – September 2023)

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management
Contractor for the U.S. Department of Energy
under Contract 89303320DEM000031

P.O. Box 943

Richland, Washington 99352

Hanford Seismic Report for Fiscal Year 2023 (October 2022 – September 2023)

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Executive Summary

The Pacific Northwest Seismic Network (PNSN) and Hanford Mission Integration Solutions (HMIS) provide uninterrupted collection of high-quality raw and processed seismic data from the Hanford Seismic Network (HSN). The HSN includes both onsite and offsite [Eastern Washington Regional Sub-Network (EWRSN)] stations that are operated for the U.S. Department of Energy (DOE) 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 HSN and the EWRSN together consist of 40 individual sensor sites and 14 radio relay sites maintained by the PNSN.

During FY2023, seismic activity increased slightly throughout eastern Washington. 426 earthquakes were cataloged in the region, of which about 32% (136) took place on or in the immediate vicinity of the Hanford Site. This is an increase from 316 earthquakes in the previous year. Several earthquakes took place in the historically active area of Entiat and Chelan. Within the vicinity of the Hanford Site, there was low to typical swarm-type activity, most strongly observed near the Horse Heaven and Cold Creek Swarm Areas.

Abbreviations and Acronyms

ANSS	Advanced National Seismic System
AQMS	ANSS Quake Management System
BB	Broadband (type of seismic station)
BPA	Bonneville Power Administration
BWIP	Basalt Waste Isolation Project
CRBG	Columbia River Basalt Group
Dmin	Minimum distance (closest distance from an earthquake epicenter to a station)
DOE	U.S. Department of Energy
EEW	Earthquake early warnings
Etyp	Event type
EWRSN	Eastern Washington Regional Sub-Network
FY	Fiscal Year
g	typical value of gravitational acceleration at Earth's surface (~978 cm/sec/sec)
GPS	Global Positioning System
HLSMP	Hanford Lifecycle Seismic Monitoring Program
HMIS	Hanford Mission Integrated Solutions, LLC
HNF	Hanford Nuclear Facility
HSN	Hanford Seismic Network
IRIS	Incorporated Research Institutions in Seismology
LAT	Latitude
LON	Longitude
Km	kilometer
M_d	Coda-duration magnitude
M_L	Local magnitude
Mag	Magnitude of earthquake
MMI	Modified Mercalli Intensity
MOD	Wavespeed model
MSA	Mission Support Alliance
Mtyp	Magnitude type
NS/NP	Number of stations/number of phases
PNNL	Pacific Northwest National Laboratory
PNSN	Pacific Northwest Seismic Network
Q	Quality factor (of earthquake location)
RMS	Root Mean Square (error of earthquake location)
RSLW	Lower Rattlesnake (Mountain) data acquisition/telemetry site
SHPS	Safety and Health Programs Support
SMA	Strong Motion Accelerometer (type of seismic station)
USGS	U.S. Geological Survey
UTC	Coordinated Universal Time
UW	University of Washington
WHC	Westinghouse Hanford Company
WSUR	Washington State University Richland

Table of Contents

Executive Summary i
Abbreviations and Acronyms ii
1.0 Introduction 5
1.1 Mission 5
1.2 History of Monitoring Seismic Activity at Hanford 5
1.3 Documentation and Reports 6
2.0 Geology and Tectonic Analysis 7
2.1 Earthquake Stratigraphy 7
2.2 Geologic Structure Beneath the Monitored Area 7
2.3 Tectonic Pattern 8
3.0 Network Operations 11
3.1 Seismic Station Overview 11
3.2 Strong Motion Accelerometer Stations 16
3.2.1 Strong Motion Station Location 16
3.2.2 Strong Motion Station Design 16
3.2.3 Strong Motion Operational Characteristics 17
3.3 Data Analysis 18
4.0 Earthquake Catalog 19
4.1 Wavespeed Models 19
4.2 Earthquake Magnitudes 19
4.3 Quality Factors 20
4.4 FY 2023 Earthquake Catalog for Eastern Washington 22
5.0 Discussion of Seismic Activity – FY 2023 22
5.1 Summary 33
6.0 Status of Monitoring 35
7.0 References 36

Figures

Figure 2.1. Tectonic Features of the Hanford Site within Eastern Washington..........................10
Figure 5.1. Hanford and Regional Epicenters of Earthquakes Recorded during FY 2023. Background color indicates elevation. Red circles stand for shallow earthquakes (0-4 km). Blue circles for intermediate-depth earthquakes (4-9 km). Black circles denote earthquakes deeper than 9 km....................................34

Tables

Table 2.1. Thicknesses of Stratigraphic Units in the Monitoring Area 8
Table 3.1. Hanford Seismic Network Onsite Stations 12
Table 3.2. Hanford Seismic Network Offsite Stations 14
Table 4.1. Wavespeed Model for Eastern Washington...19
Table 4.2. Seismicity in the region 44° to 49° N latitude, -121.5° to -117° E longitude.............22
Table 5.1. Depth Distribution of Eastern Washington Earthquakes for FY 2023.......................33
Table 5.2. Earthquake Counts for FY 2023 for Earthquakes near the Hanford Site...................33

1.0 Introduction

This annual report documents the locations, magnitudes, and seismic interpretations of earthquakes recorded for the Hanford monitoring region of south-central Washington during the fiscal year (FY) 2023 (October 2022 through September 2023). Hanford Mission Integrated Solutions, LLC manages seismic monitoring for the Hanford Site with the monitoring work being performed by the PNSN under a sub-contract with the University of Washington (UW).

1.1 Mission

The mission of the Hanford Lifecycle Seismic Monitoring Program (HLSMP) is to maintain seismic stations, report data from measured events, and to provide assistance in the event of an earthquake. This mission supports DOE and the other Hanford Site contractors in their compliance with DOE Order 420.1C, Chapter IV, Section 3.e, "Seismic Detection," and DOE Order G 420.1-1A, Section 5.4.8, "Design for Emergency Preparedness and Emergency Communications." DOE Order 420.1C requires facilities or sites with hazardous materials to maintain instrumentation or other means to detect and record the occurrence and severity of seismic events. 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 HSN and the 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 and explosions proximal to or on the Hanford Site, specifically, between 46°-47° north latitudes (LAT) and between 119°-120° west longitudes (LON). 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

The U.S. Geological Survey (USGS) under a contract with the U.S. Atomic Energy Commission initiated monitoring seismic activity at the Hanford Site in 1969. In 1975, the 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).

The Hanford Strong Motion Accelerometer (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, administration of the seismic monitoring networks was assumed by HLSMP and contracted to be operated by the PNSN, University of Washington.

1.3 Documentation and Reports

The HLSMP issues annual reports of local and regional 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 cataloged seismic event locations and magnitudes and related waveform data from the HLSMP is maintained by PNSN on computer servers at the UW. Continuous waveform data and associated station metadata from all available seismic stations are permanently archived and made available by EarthScope Consortium's Data Services, previously known as the Incorporated Research Institutions in Seismology (IRIS).

2.0 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, 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 sub-provinces—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 2.1) (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-wave-length folds on an otherwise gently westward dipping paleoslope.

2.1 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.

2.2 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 2.1, 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 2.1 summarizes the approximate thickness at the borders of the monitored area.

Table 2.1. 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 because 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).

2.3 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 form along with the main structure.

Swarm Areas. Small geographic areas produce clusters of events (swarms); usually located in synclinal valleys not known to contain any mapped geologic faults. 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 later. 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. It is traditional to regard swarms as occurring within one of seven earthquake swarm areas in the HSN area. 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. The other earthquake swarm areas are active less frequently. There is, however, no compelling theory to suggest a generative mechanism active within these swarm areas. They are deduced purely empirically, are rather conjectural, and will likely be updated or reconfigured as new swarm areas develop.

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.

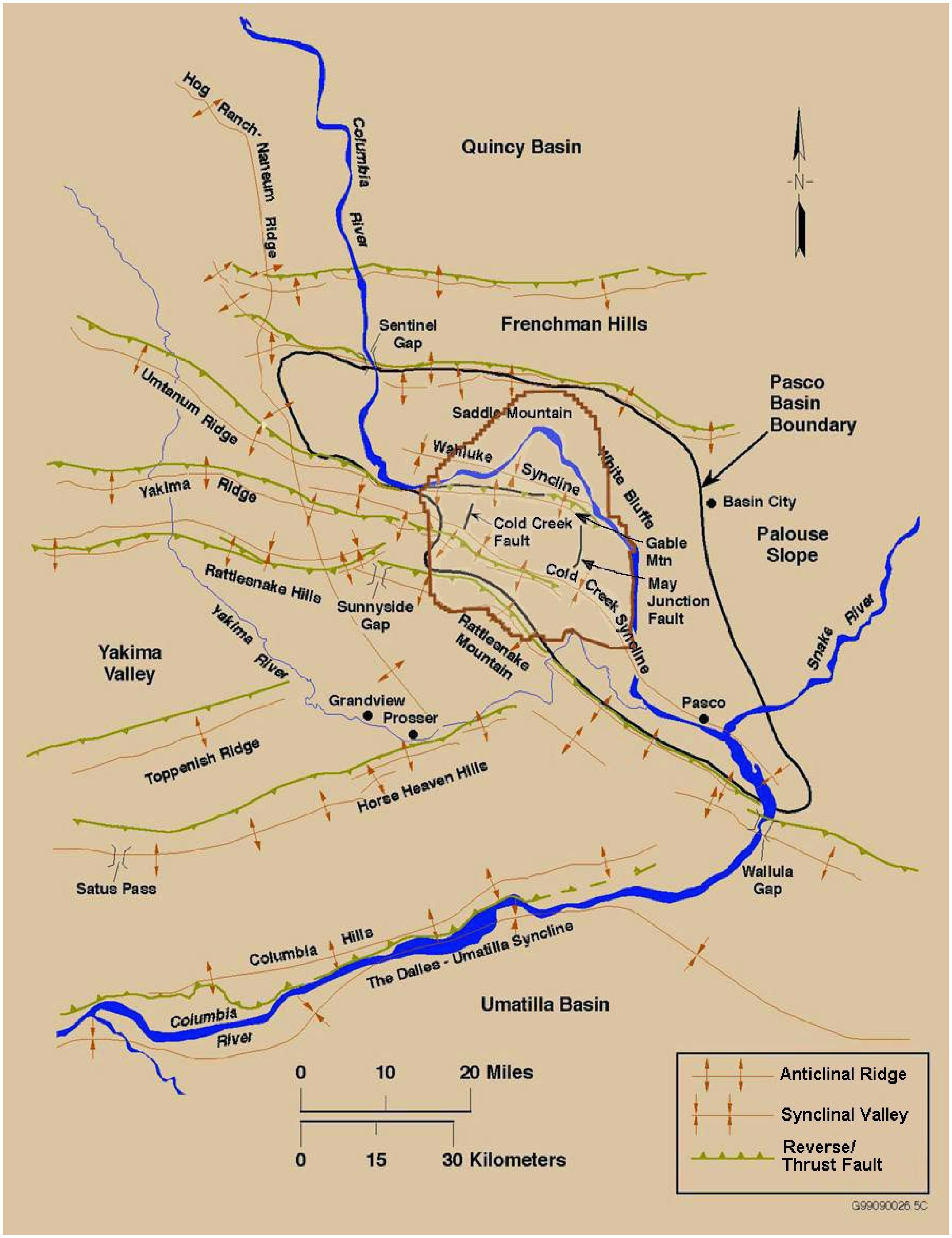

Figure 2.1. **Tectonic Features of the Hanford Site within Eastern Washington**

(from Rohay et al., 2010b)

3.0 Network Operations

3.1 Seismic Station Overview

The seismic network consists of three types of earthquake sensors—short-period seismometers, broadband seismometers, and strong motion accelerometers (SMAs).

Short-period seismometers are very sensitive passive sensors (they do not use external electric power) designed primarily to detect micro-earthquakes. While most short-period stations have a single component, sensitive only to the vertical motion of the ground, one HLSMP short-period station records the ground in three orthogonal directions. In a regional network like the HLSMP networks, the time of arrival of waves, and the signal duration derived from short-period stations are used to determine the locations and magnitudes of seismic events; the polarities of ground motions may be used to constrain estimates of the geometry of fault that ruptured in an earthquake.

Broadband seismometers are active sensors (they use electricity to power advanced electronic circuitry that is integral to the sensor) that faithfully record ground motions over a wide frequency range. The data they produce are acquired digitally with 24-bit dynamic range; a broadband system will therefore stay "on-scale" over a much broader range of ground motions than a short-period sensor. In addition to locations and magnitudes derived from signal durations, details of the observed waveforms are used to reveal the source processes of small to moderately large earthquakes. HLSMP broadband stations are all 3-component.

Both short-period and broad-band sensors will ultimately "clip", or fail to record properly, if subjected to more than moderate levels of shaking (well below damaging levels). SMA stations, however, are designed to measure even the damaging ground motions from larger earthquakes. They are 3-component stations and must be carefully and strongly anchored to the ground so that the details of ground shaking up to 2g (twice the vertical acceleration of gravity) are accurately recorded. In addition to helping to characterize the earthquake source, they are critically important in measuring the ground motions that impact a particular site. They aid in determining what the built environment has been exposed to for earthquake response activities and engineers and others use them in designing appropriate structures. Because of their importance to seismic monitoring on the Hanford Site, the distribution, design, and operations of SMA stations within the HLSMP is discussed separately in Section 3.2.

Five HLSMP stations are now capable of recording 4 channels of seismic data. These sites will record 3 orthogonal components of strong motion and a vertical component of high-gain short-period motion. An additional 16 sites record 6 channels of seismic data, three components of strong motion accelerometer data and three components of high-gain broadband data. The high-gain data is used to detect and locate earthquakes too small to generate ground motions above the strong-motion channels' noise level.

The seismic stations supported by HMIS are further divided into two geographic sub-networks for discussion: HSN, which are sites located on the Hanford Site itself, and the EWRSN, which includes sites that surround the Hanford Site.

Combined, the HSN and the EWRSN include 40 stations. Most stations reside in remote locations and require solar panels and batteries for power. The HSN includes 18 stations (Table 3.1 and Figure 3.1), and the EWRSN consists of 22 stations (Table 3.2 and Figure 3.2).

Table 3.1. Hanford Seismic Network Onsite Stations

Station	Latitude	Longitude	Elevation (m)	Station Name
Strong Motion Accelerometer, 3-Channel Station				
H2E	46.5578	-119.5345	210	200 East Area (SMA)
H2W	46.5517	-119.6453	201	200 West Area (SMA)
H3A	46.3632	-119.2775	119	300 Area (SMA)
H4A	46.4377	-119.3557	171	400 Area (SMA)
Strong motion and Broadband, 6-Channel Station				
GBB	46.6087	-119.6290	185	Gable Butte
H2O	46.3956	-119.4241	175	Water Station
MDW	46.6130	-119.7622	330	Midway
NIKE	46.3919	-119.5327	369	Nike Missile Silo
SNI2	46.4648	-119.6552	267	Snively Ranch
WA2	46.7552	-119.5668	244	Wahluke Slope
Strong motion and Short Period, 4-Channel Station				
H1K	46.6447	-119.5929	152	100 K Area (SMA)
HGBL	46.5980	-119.4613	330	Gable Mountain
HWIW	46.4292	-119.2888	128	Wooded Island
GRUT	46.5512	-119.5102	219	Wet-Grout Plant
MJ2	46.5574	-119.3601	146	May Junction Two
Broadband, 3-Channel Station				
LIGO	46.4617	-119.4177	158	LIGO Observatory
Short Period, Single Channel Analog				
BEN	46.5186	-119.7185	335	Benson Ranch
LOC	46.7169	-119.4320	210	Locke Island
RSW	46.3944	-119.5925	1045	Rattlesnake Mountain

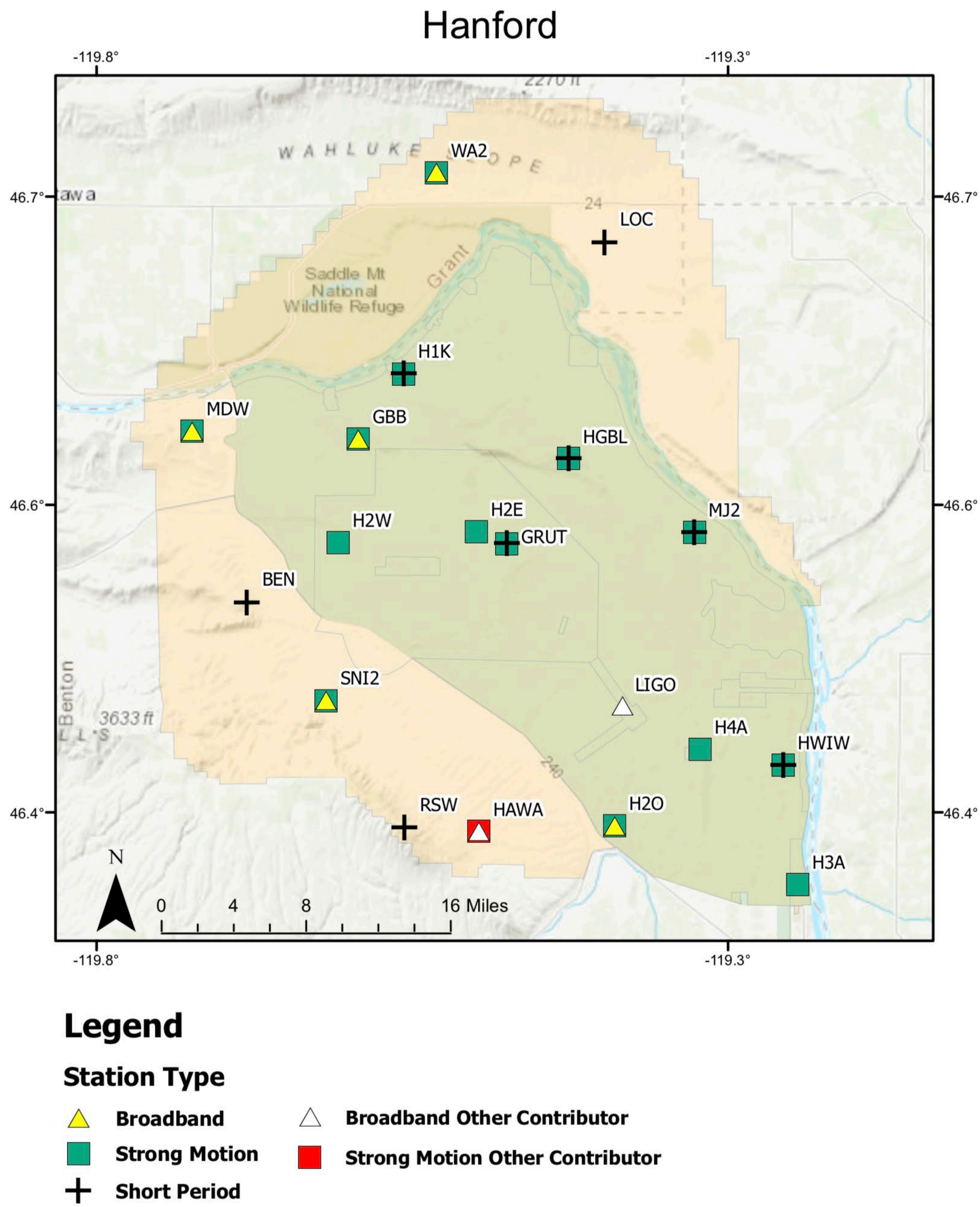

Figure 3.1. Hanford Seismic Network Onsite Stations

Table 3.2. Hanford Seismic Network Offsite Stations

Figure 3.2. Hanford Seismic Network Stations of the Eastern Washington Region Sub-Network

Station	Latitude	Longitude	Elevation (m)	Station Name
Strong Motion and Broadband, 6-Channel Station				
CCRK	46.5585	-119.8548	561	Cold Creek
DDRF	46.4911	-119.0595	233	Didier Farms
EPH2	47.3562	-119.5972	661	Ephrata
LNO	45.8717	-118.2862	771	Lincton Mountain Oregon
MANO	46.9511	-120.7247	1200	Manatash Ridge Observatory
MOX	46.5772	-120.2993	501	Moxee City
OD2	47.388	-118.7108	553	Odessa 2
OT3	46.6689	-119.2341	322	Othello 3
PHIN	45.8950	-119.9280	227	Phinney Hill
PRO	46.2125	-119.6868	553	Prosser
YPT	46.0487	-118.9634	325	Yellepit
Short Period, Single-Channel Analog				
BRV	46.4852	-119.9923	920	Black Rock Valley
BVW	46.8108	-119.8835	670	Beverly
CRF	46.8249	-119.3881	189	Corfu
ELL	46.9095	-120.5675	789	Ellensburg
NAC	46.7330	-120.8249	728	Naches
PAT2	45.8836	-119.7578	259	Paterson 2
RED2	46.3053	-119.4526	330	Red Mountain 2
TRW	46.2921	-120.5431	723	Toppenish Ridge
VT2	46.9672	-120.0003	385	Vantage 2
WRD	46.9699	-119.1460	375	Warden
Short Period, 3-Channel Analog				
FHE	46.9518	-119.4981	455	Frenchman Hills East

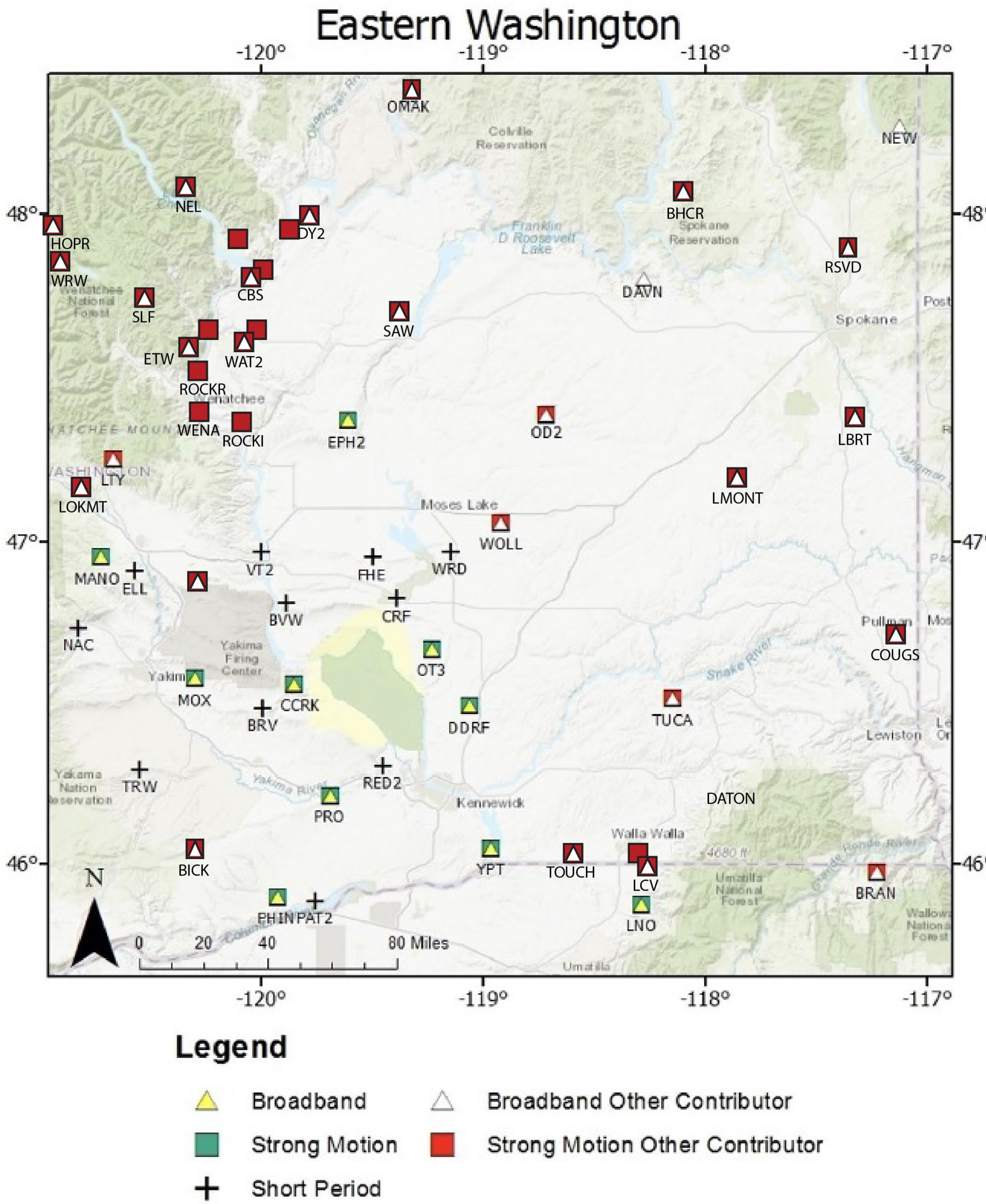

Figure 3.2. Hanford Seismic Network Stations of the Eastern Washington Region Sub-Network

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 145 combined data channels from: 14 single channel sites, 2 three-component seismometer sites (FHE and LIGO), 17 six-component sites (CCRK, DDRF, EPH2, GBB, H2O, LNO, MANO, MDW, MOX, NIKE, OD2, OT3, PHIN, PRO, SNI2, WA2, and YPT) and 9 other sites in the HSN (H1K, H2E, H2W, H3A, H4A, MJ2, GRUT, HGBL, and HWIW) that acquire additional data channels at each station. The three component sensors record motion in the vertical, north-south horizontal, and east-west horizontal directions. Fourteen radio telemetry relay sites are used by both sub-networks to transmit seismogram data continuously to the PNSN in Seattle, Washington, for processing and archiving.

3.2 Strong Motion Accelerometer Stations

3.2.1 Strong Motion Station Location

SMAs provided ground motion observations critical to understand the impacts of strong ground shaking that affect the Hanford Site itself. The Hanford SMA network consists of 15 free-field SMA stations (see Figure 3.1; Table 3.1). 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. The now inactive Fast Flux Test Facility is located in the 400 Area.

3.2.2 Strong Motion 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. Cellular modems provide communication from all five SMAs. The enclosure serves as a junction box for all cabling that is routed through conduits 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.

Four of the SMA stations (H3A, H4A, H2E, H2W) are three-component units consisting of vertical, north-south horizontal, and east-west horizontal seismometers manufactured by Nanometrics, Inc., and known as the Titan system. Each Titan unit contains a digital recorder, a data storage unit, and a Global Positioning System (GPS) receiver with the equipment housed in a watertight box. Five sites (H1K, HWIW, HGBL, GRUT, and MJ2) have Kinemetrics Basalts with 3 SMA channels that are supplemented by a high-gain vertical short-period sensor. Five sites have a broadband and strong-motion sensor packaged in a single casing that is deployed in a shallow posthole, Nanometrics Trillium Cascadia and a Centaur datalogger (GBB, H2O, MDW, SNI2, WA2).

A cell modem or digital radio system provides the Internet address connection to access the system. Stations can be monitored from any computer with appropriate access, and data are continuously telemetered to UW. 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 provides timing of the ground motions accurate to several microseconds, coordinated to Universal Coordinated Time (UTC). 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 hours and checks the "location of the instrument" and the time. The SMA records any differences between the internal clock and the GPS time. Any corrections to the internal timing are made automatically. Typically, the greatest correction recorded is approximately 4 milliseconds.

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

3.2.3 Strong Motion Operational Characteristics

Signals from the three-channel SMA stations use an 18-bit digitizer with data sampled at 200 samples/s. Data are sent continuously in real-time to the PNSN offices at the UW in Seattle. This permits the recording of ground motion data for smaller, non-damaging earthquakes that can be useful in estimating impacts of larger earthquakes. It also helps confirm the correct operation of the instruments.

For security and robustness, the Titan also stores triggered event files. When one of the accelerometer channels exceeds the trigger threshold (0.02%g), the recorders save information within the data buffers on memory cards within the Titan. 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 files created by a triggered event can be retrieved and examined by HLSMP staff, in the event of telemetry failure. The retrieval can be accomplished either remotely when telemetry is re-established, or manually by a technician traveling to the site.

Data from the SMA channels of the 4-channel and 6-channel stations are treated in a similar fashion. The primary difference is that the data from these channels (as well as the vertical high-gain channel) are digitized with 24-bit resolution.

3.3 Data Analysis

Signals from the seismometers are monitored in real time for changes in signal amplitudes and frequency that are expected from earthquakes. The seismic network is subdivided into spatial groupings of stations that are monitored for nearly simultaneous amplitude changes, 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. Acoustic signals are identified by their slower propagation across the network (soundwave speed) compared to seismic signals (elastic wave speed in rocks). All data are continuously telemetered, recorded, and saved in a permanent seismic data archive operated by the EarthScope Consortium's Data Services, previously known as the IRIS data management center, and is available for download and analysis.

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 acquire seismic data and automatically detect and locate events (Hartog et al., 2020). We currently run Earthworm version 7.10 on a variety of computer servers. Redundant Earthworm systems run continuously at the PNSN. If one fails, a second one serves as a "backup." Two complete 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 until refueling is needed. Seismic data from triggered events are collected 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).

Data from HLSMP-operated seismic stations are combined at the UW analysis center with seismic data from regional seismic stations operated by other entities and contributed in real-time to PNSN. The earthquake locations and ground motion we report in this catalog include these valuable contributed data. This contributed data improves the accuracy of the seismic products we provide at Hanford, and adds to the robustness of the entire network in the event that any particular portion of the network suffers temporary data loss from environmental or other causes.

4.0 Earthquake Catalog

Within the Advanced National Seismic System (ANSS) Quake Management System (AQMS) seismic network processing software, an interactive program called Jiggle is used to manually review and revise automatic phase arrival picks and signal durations, as well as their polarities, uncertainties and quality factors (Hartog et al., 2020). Arrival and duration times and uncertainties are used as input to an earthquake location program (Klein, 2002) to compute locations and magnitudes of the seismic events. Resulting locations for local earthquakes (44°-49° north latitude, 117°-121.5° west longitude) are reported in Table 4.2. Additional seismic events located outside the reporting region for this report are also evaluated. These surrounding events are not reported in this document, but are used as a check to confirm that the HSN and EWRSN are functioning properly (*e.g.,* quality checks on data recording). All processing results are available through the PNSN at www.pnsn.org.

4.1 Wavespeed Models

Earthquake location uses the arrival times of seismic phases at seismic stations and a model of the seismic wave speeds of crustal rocks of eastern Washington called a "wave speed model" (MOD), to solve for the most likely location for the earthquake source. AQMS divides the eastern Washington and Oregon region into 3 sub-regions. The wave speed models for each sub-region were 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 wave speed models to account for significant deviations in station elevations or stations situated on sedimentary layers. Station delays are determined empirically from accurately located earthquakes and blast events in the region.

Table 4.1. Wave speed Model for Eastern Washington
(from Rohay et al. 1985)

Depth to Top of Layer (km)	Layer	Wave speed (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

4.2 Earthquake Magnitudes

AQMS computes several different magnitude estimates (Mtyp) for earthquakes. Table 4.1 shows the analyst-preferred value of either: 1) the coda-duration magnitude (M_d), or 2) the local magnitude (M_L)

(Richter 1958). We report the median magnitude provided by all stations contributing estimates for an event.

The coda duration magnitude is based on a relationship developed for Washington State by Crosson (1972), modified for application within the AQMS software. The formula we use for M_d is:

$$M_d = -1.61 + 2.82 \log(D) - 2.46$$

Where *D* is the duration of the observed event (in seconds), starting from the P-wave arrival. Many earthquakes yield magnitude determinations that are very small ($M_d < 0$) and highly uncertain. Earthquakes with magnitudes (M_d) smaller than 3.0 are defined 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.

M_L is computed from the maximum amplitudes of the signals on the horizontal components recording an event, filtered to mimic the instrument response of a Wood-Anderson torsion seismograph. The formula is:

$$M_L = \log(A) - \log(A_0) + S$$

Where *A* is the average zero-to-peak amplitude of the two horizontal components at a station after they have been converted to pseudo-Wood-Anderson traces. Log (A_0) is a distance correction, for which we use the Jennings and Kanamori (1983) values, and *S* is a site correction term that accounts for differences in local geological conditions amongst stations.

The choice of preferred magnitude type involves some subjectivity, as the relative strength of each depends on conditions that differ from event to event. In general, M_L is preferred for an event that is well-recorded on a sufficient number of suitable channels. [This is because there may be subjectivity in determining the durations used by the M_d algorithm (although AQMS does this in a largely automatic, and hence objective, way), and because the determination of the duration is biased by background noise levels.] In practice, this usually means that M_L is preferred for earthquakes sufficiently large to be observed at several three-component broadband stations. Although occasionally smaller earthquakes yield robust M_L estimates, depending on the background noise level at the time of the earthquake. M_d, on the other hand can be obtained from smaller earthquakes, even if the recording should "clip." For earthquakes larger than about M4.5, only the M_L should be used. The two magnitude scales are defined to be consistent for the events for which they overlap.

4.3 Quality Factors

Table 4.1 tabulates a two-letter **Quality factor** (Q) for each event 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 – not shown**). 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 by the Hypoinverse location program. If the number of phases exceeds 10 measurements, the depth estimate is considered reliable. In this case, the second letter in the quality evaluation is either "A" or "B" (cf. Table 4.1). 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.

4.4 FY 2023 Earthquake Catalog for Eastern Washington

Table 4.2. Seismicity in the region 44° to 49° N latitude, -121.5° to -117° E longitude. (10 pages)

Day	Time	Lat	Lon	Depth	Mag	Mtype	NS/NP	Gap	Rms	Q	Mod	Type
October 2022												
01	20:09:27	46.7327	-121.0392	4.6	2.1	Ml	039/058	86	0.27	BC	C3	eq
03	22:14:27	47.7090	-117.5442	-0.7*	1.6	Md	007/008	129	0.12	CC	N3	px
05	08:50:07	47.6687	-120.3228	-0.4*	0.5	Ml	008/014	94	0.07	CB	N3	eq
05	16:13:06	47.6137	-117.3755	-0.7*	1.5	Md	006/004	211	0.03	CD	N3	px
05	18:17:55	46.2048	-121.4835	0.2*	1.0	Ml	015/020	317	0.17	CD	C3	eq
05	22:29:03	48.0470	-120.7125	-0.0*	0.7	Ml	008/015	118	0.25	CC	C3	eq
05	23:58:59	47.6865	-120.3307	5.5	0.2	Ml	005/009	119	0.04	AB	N3	eq
06	21:11:53	44.5573	-117.4190	-1.1*	1.9	Ml	006/008	79	0.44	CC	N3	px
07	02:22:59	46.0270	-118.6978	14.8	2.1	Ml	017/025	82	0.24	BA	E3	eq
07	05:47:24	47.6680	-120.0928	6.8	0.2	Ml	010/015	72	0.07	AA	N3	eq
07	09:16:21	46.1783	-120.4012	7.4	1.0	Ml	007/007	158	0.06	BC	E3	eq
08	04:47:56	46.8538	-120.6588	8.8	1.0	Ml	016/022	60	0.29	BB	E3	eq
09	17:47:18	48.3515	-120.2868	2.8*	0.6	Ml	005/006	209	0.16	CD	N3	eq
10	05:08:30	47.6685	-120.2260	1.1	0.5	Ml	011/016	65	0.07	AA	N3	eq
11	21:09:04	46.0133	-119.7052	3.9	0.9	Md	005/006	179	0.04	AC	E3	eq
12	00:50:47	44.0208	-121.2472	-1.7*	1.9	Ml	011/011	146	0.05	CC	E3	px
12	09:40:35	46.0612	-119.7898	3.9	0.6	Ml	010/013	168	0.29	BC	E3	eq
12	09:59:32	46.0337	-119.7295	7.1	0.9	Ml	014/017	153	0.07	AC	E3	eq
13	22:40:46	47.7090	-117.5392	-0.7*	2.9	Md	006/008	129	0.10	CC	N3	px
14	19:34:22	46.2087	-119.2030	-0.3*	0.7	Md	009/012	172	0.30	CC	E3	px
16	14:04:29	48.4180	-118.8340	1.7*	1.1	Ml	006/008	103	0.07	CC	N3	eq
19	15:16:51	47.9987	-119.8847	-0.8*	1.0	Ml	010/010	63	0.09	CB	N3	px
19	23:26:17	47.8200	-119.9722	2.2	0.4	Ml	007/012	162	0.10	AC	N3	eq
20	00:33:42	47.3225	-117.8950	-0.7*	2.4	Ml	007/010	101	0.41	CC	N3	px
22	00:59:40	46.6010	-119.8825	6.5	1.5	Ml	013/019	91	0.08	AB	E3	eq
22	05:12:10	46.7445	-121.0418	0.1*	1.1	Ml	012/016	122	0.27	CC	C3	eq
22	08:08:55	47.6823	-120.3170	1.6	1.7	Ml	010/017	107	0.08	AB	N3	eq
22	18:04:32	47.6860	-120.3185	-0.3*	1.4	Ml	015/021	86	0.08	CB	N3	eq
23	00:36:57	47.7663	-120.1445	4.4	0.6	Ml	007/011	119	0.05	AB	N3	eq
23	07:31:21	47.6658	-120.1813	2.5	0.4	Ml	005/010	105	0.06	AB	N3	eq
24	14:48:30	46.7402	-121.0445	0.0*	1.0	Ml	024/033	102	0.29	CC	C3	eq
24	20:51:48	47.7985	-117.3800	-0.8*	1.9	Ml	008/013	154	0.30	CC	N3	px
25	18:00:00	46.1708	-119.2478	-0.2*	1.1	Ml	009/011	284	0.26	CD	E3	px
26	06:19:01	48.7403	-119.4320	6.0	1.1	Ml	008/012	109	0.16	BB	N3	eq
27	00:20:04	47.6787	-120.2512	2.0	0.6	Ml	004/008	191	0.07	AD	N3	eq
28	20:26:43	47.6930	-120.3472	5.3	0.7	Ml	007/012	122	0.08	AB	N3	eq
29	13:44:33	47.7202	-120.2685	3.2	0.0	Ml	007/010	88	0.04	AB	N3	eq
30	13:13:15	47.6748	-120.1213	5.0	1.0	Ml	008/013	108	0.04	AB	N3	eq
November 2022												
01	01:53:37	47.6773	-120.3153	-0.5*	0.3	Ml	005/009	115	0.06	CB	N3	eq
01	07:05:43	48.5378	-119.4930	2.2	1.3	Ml	010/012	94	0.07	BC	N3	eq
01	08:10:03	45.8023	-120.3697	16.9	1.5	Ml	020/020	120	0.21	BB	E3	eq
01	17:22:01	45.9137	-119.2903	-0.3*	1.4	Ml	008/012	206	0.30	CD	E3	px
02	22:51:39	46.5957	-119.8550	6.7	1.3	Ml	013/020	232	0.06	AD	E3	eq
02	23:22:19	47.9947	-119.8870	-0.8*	1.2	Ml	010/009	112	0.08	CB	N3	px

03	17:56:35	46.5982	-119.8602	6.9	1.3	Ml	014/021	93	0.09	AB	E3	eq
03	18:49:51	46.3050	-119.4322	-0.4*	0.9	Ml	007/007	269	0.31	DD	E3	px
03	19:44:24	45.9795	-120.1170	7.7	1.2	Ml	014/016	91	0.11	AB	E3	eq
04	17:37:16	45.9172	-119.3622	-0.5*	1.6	Ml	007/006	269	0.07	CD	E3	px
05	05:51:10	47.1380	-121.3268	8.5*	1.7	Ml	023/027	98	0.17	CC	C3	eq
08	14:27:11	47.9365	-120.9268	5.7	0.3	Md	003/005	164	0.02	CD	C3	eq
12	13:58:13	47.7108	-120.3348	1.4	0.2	Ml	007/012	112	0.06	BB	N3	eq
14	13:33:55	46.1817	-120.6442	16.1	1.4	Ml	008/009	181	0.22	BD	E3	eq
15	19:49:34	45.8033	-120.8168	-0.7*	1.8	Ml	012/015	86	0.27	CC	C3	px
16	21:32:19	46.2623	-120.5967	5.0	1.6	Ml	014/018	120	0.14	AB	E3	eq
17	19:54:16	47.1400	-119.5537	15.2	0.9	Ml	012/015	116	0.12	AB	N3	eq
17	21:51:23	44.2533	-120.8720	2.3	2.3	Ml	013/011	178	0.04	AC	N3	eq
18	10:41:03	47.6165	-120.2650	4.1	0.4	Ml	004/006	169	0.02	BC	N3	eq
19	21:57:57	47.7202	-120.0503	5.9	0.1	Ml	007/010	112	0.08	AB	N3	eq
21	20:24:40	44.1050	-121.3653	-1.4*	2.2	Ml	013/012	163	0.06	CC	N3	px
23	08:13:56	47.6692	-120.1227	4.0	1.0	Ml	010/015	88	0.06	AA	N3	eq
25	00:10:26	48.6082	-119.6043	1.0*	0.7	Ml	006/010	156	0.09	CC	N3	eq
25	04:28:18	47.6870	-120.3157	0.1	1.1	Ml	008/013	107	0.09	CB	N3	eq
25	10:46:33	46.4707	-119.7282	14.3	0.4	Ml	012/020	222	0.11	AD	E3	eq
25	11:05:27	48.6178	-119.5960	6.8	1.3	Ml	008/015	113	0.22	BC	N3	eq
27	02:19:02	48.7113	-119.6482	13.4	1.1	Ml	006/009	129	0.32	CB	N3	eq
27	05:35:19	48.6967	-119.6460	8.6	1.3	Ml	007/009	127	0.13	AB	N3	eq
27	07:38:08	48.7175	-119.6605	8.5	2.4	Ml	009/013	131	0.25	BB	N3	eq
28	00:45:53	46.5795	-119.2995	15.7	1.1	Ml	022/032	65	0.12	AA	E3	eq
28	14:40:12	46.7070	-121.0347	6.5	1.1	Ml	020/032	118	0.23	BC	C3	eq
28	20:24:08	47.0448	-120.7572	-0.9*	1.8	Ml	021/026	82	0.59	DC	C3	px
29	11:11:51	46.7973	-119.4983	13.2	0.5	Ml	012/015	131	0.06	AB	E3	eq
29	11:39:48	47.6870	-120.3307	2.0	0.5	Ml	008/014	114	0.05	AB	N3	eq
29	16:34:33	46.6717	-120.4958	5.6	0.9	Ml	009/013	96	0.16	BC	E3	eq
29	16:37:22	46.5523	-120.5397	25.6	0.7	Ml	007/012	132	0.99	DB	E3	eq
29	17:15:48	46.6463	-120.4785	14.8	0.7	Ml	010/013	89	0.21	BA	E3	eq
29	17:24:53	46.6603	-120.4937	9.8	1.6	Ml	015/018	97	0.17	BB	E3	eq
29	17:29:53	46.6585	-120.5027	7.7	1.2	Ml	018/022	88	0.20	BB	E3	eq
29	23:07:25	47.5615	-120.3088	-1.3*	0.6	Md	005/004	243	0.08	CD	N3	px
30	02:10:21	48.6203	-119.5907	7.3	1.2	Ml	007/011	113	0.17	BC	N3	eq
December 2022												
01	05:09:19	46.7580	-120.9945	0.3*	0.8	Ml	018/028	118	0.48	CC	C3	eq
01	11:06:44	47.7352	-120.0433	3.6	0.1	Ml	007/011	167	0.06	AC	N3	eq
01	22:00:42	46.3795	-119.9153	-0.5*	1.7	Ml	011/012	140	0.11	CC	E3	px
02	04:47:35	48.6137	-119.6027	0.2*	1.3	Ml	007/009	157	0.08	CC	N3	eq
02	05:07:52	46.6627	-120.4887	8.1	1.9	Ml	026/027	73	0.15	BB	E3	eq
02	14:40:39	47.0327	-120.9160	18.5	1.2	Ml	017/021	115	0.18	BB	C3	eq
03	13:20:05	48.3660	-120.5480	12.8	1.4	Ml	014/025	119	0.37	CC	C3	eq
04	14:07:16	48.6642	-120.8478	10.5*	2.1	Ml	008/014	120	0.35	CD	C3	eq
04	22:30:50	48.0893	-120.7488	3.1	0.4	Ml	009/013	131	0.07	AC	C3	eq
05	06:51:40	48.6163	-119.5917	6.6	1.2	Ml	008/012	112	0.15	BC	N3	eq
05	09:49:56	46.1293	-120.4913	12.3	1.4	Ml	015/017	117	0.13	AB	E3	eq
05	12:31:22	45.8413	-120.1667	16.3	1.5	Ml	018/025	128	0.18	BB	E3	eq
05	20:42:36	46.6722	-117.1437	-0.7*	2.2	Ml	013/018	220	0.87	DD	E3	px
07	00:52:24	46.7653	-121.0375	-0.0*	0.7	Ml	020/026	132	0.19	CC	C3	eq
07	13:25:34	46.1978	-119.2707	8.2*	0.7	Ml	011/014	286	0.07	CD	E3	eq

07	20:42:53	45.4220	-117.5998	8.8	2.0	Ml	008/013	104	0.29	CD	E3	eq
09	10:25:25	47.6830	-120.3237	2.9	0.7	Ml	008/014	110	0.05	AB	N3	eq
10	20:59:44	47.6563	-120.2062	1.6	0.4	Ml	004/008	119	0.06	AB	N3	eq
13	13:05:00	47.6478	-120.1485	3.2	0.9	Ml	008/015	111	0.05	AB	N3	eq
13	22:39:27	47.5483	-120.2728	-1.1*	1.1	Md	005/007	210	0.23	CD	N3	px
14	11:21:47	46.7138	-120.7587	9.2	1.7	Ml	023/039	98	0.18	BB	C3	eq
15	19:46:37	47.1353	-120.4085	-0.9*	1.6	Ml	008/009	158	0.08	CC	N3	px
15	20:26:30	45.9343	-119.9423	-0.6*	1.8	Ml	010/011	99	0.12	CB	E3	px
16	10:04:36	48.1838	-120.8020	4.2	0.5	Ml	008/015	164	0.16	BC	C3	eq
16	12:23:13	47.6647	-120.2750	2.4	0.1	Ml	005/010	108	0.06	AB	N3	eq
16	16:15:44	46.9537	-120.3282	-0.9*	1.7	Ml	016/017	149	0.47	CC	E3	px
17	06:17:14	47.5820	-120.2995	6.1	0.5	Ml	007/011	192	0.07	AD	N3	eq
19	21:57:03	48.1808	-119.5817	9.3	1.0	Ml	008/014	123	0.20	BC	N3	eq
20	00:59:59	47.6323	-120.3995	3.1	0.7	Ml	006/008	184	0.08	AD	N3	eq
20	08:29:43	48.7508	-119.5137	8.8	1.7	Ml	013/018	118	0.26	BB	N3	eq
20	15:39:06	47.1280	-120.7903	-1.0*	1.3	Ml	012/012	80	0.27	CA	C3	px
23	00:34:50	46.3823	-119.6077	17.3	0.5	Ml	009/016	138	0.06	AC	E3	eq
23	03:55:40	46.7837	-120.6602	8.7	1.6	Ml	027/039	76	0.21	BB	E3	eq
23	16:07:32	47.9048	-120.3942	19.0	0.7	Md	005/007	225	0.32	CD	N3	eq
28	22:46:50	46.2048	-120.5762	12.2	0.7	Md	005/007	209	0.14	BD	E3	eq
29	03:40:47	46.5003	-119.6843	13.3	0.1	Ml	011/016	180	0.10	AC	E3	eq
30	07:11:19	46.6838	-121.0875	14.1	2.4	Ml	012/019	141	0.17	BC	C3	eq
30	07:12:32	46.6865	-121.0892	15.0	1.2	Ml	007/011	140	0.16	BC	C3	eq
30	08:15:27	46.7173	-121.0758	6.2	0.9	Ml	011/015	130	0.22	BC	C3	eq
January 2023												
02	11:52:06	47.6925	-120.3330	1.6	0.1	Ml	009/011	119	0.07	BB	N3	eq
05	22:23:40	46.2533	-119.4742	-0.3*	1.6	Ml	010/010	173	0.04	CC	E3	px
07	19:53:49	47.6688	-120.2590	3.4	1.1	Ml	007/012	102	0.05	AB	N3	eq
12	04:16:37	48.4408	-120.3393	3.8*	1.4	Ml	011/016	202	0.26	CD	C3	eq
14	17:45:55	47.7497	-120.2065	3.5	0.8	Ml	012/021	62	0.11	AB	N3	eq
18	16:10:19	47.7005	-120.3260	-1.3*	0.7	Ml	005/010	111	0.05	CC	N3	eq
19	20:10:34	48.2642	-117.1227	-0.8*	-5.0	Mh	001/000	0	0.00	AD	N3	eq
21	02:36:32	46.1925	-119.5587	5.6	0.7	Ml	011/018	172	0.09	AC	E3	eq
21	07:25:57	46.1963	-119.5507	6.0	0.5	Ml	008/012	249	0.10	AD	E3	eq
22	08:21:12	46.1948	-119.5640	4.4	0.5	Ml	008/010	248	0.04	AD	E3	eq
23	04:58:47	46.1933	-119.5630	5.1	0.8	Ml	010/016	249	0.07	AD	E3	eq
23	13:45:25	46.3728	-119.2387	4.4*	0.3	Ml	005/008	318	0.36	DD	E3	eq
23	20:32:18	46.1465	-119.5612	12.6	0.6	Ml	006/007	283	0.02	BD	E3	eq
24	22:04:14	46.2690	-119.3903	-0.3*	2.2	Ml	020/019	203	0.07	CD	E3	px
25	00:33:36	46.6548	-119.8470	-0.4*	0.7	Ml	012/019	156	0.15	CC	E3	px
27	03:14:45	46.4640	-119.7733	17.0	0.1	Ml	008/013	217	0.07	AD	E3	eq
29	06:45:23	45.2057	-120.8332	17.5	1.6	Ml	010/013	130	0.15	BB	E3	eq
30	03:32:10	46.5443	-119.8450	6.1	0.5	Ml	013/018	115	0.11	AB	E3	eq
30	14:43:21	47.7552	-120.1773	6.5	0.3	Ml	010/014	67	0.09	AB	N3	eq
30	22:28:58	47.3640	-117.8685	-0.6*	2.0	Ml	008/009	149	0.45	CC	N3	px
31	11:27:26	47.2328	-121.0163	13.5	1.1	Ml	021/031	53	0.32	CB	C3	eq
February 2023												
01	07:09:24	46.7060	-119.6383	15.0	0.6	Ml	017/021	79	0.11	AA	E3	eq
01	23:32:52	46.8528	-120.7065	19.1	0.6	Ml	016/021	79	0.32	CA	C3	eq
02	08:16:02	47.6472	-120.1998	6.1	-0.0	Ml	006/010	130	0.02	AB	N3	eq
02	20:16:31	47.7505	-120.0477	4.5	0.4	Ml	010/015	104	0.07	AB	N3	eq

02	22:05:03	46.2053	-120.2527	-0.4	0.4	Md	004/006	235	0.22	BD	E3	eq
02	22:31:48	47.7053	-120.3352	4.2	0.3	Ml	004/008	115	0.07	BC	N3	eq
03	00:59:27	47.6720	-120.3047	2.1	0.8	Ml	006/010	105	0.04	AB	N3	eq
04	23:34:17	47.5400	-120.6340	6.5	1.1	Ml	012/019	94	0.26	BC	C3	eq
05	04:07:30	47.7003	-120.1352	-0.3*	0.9	Ml	015/026	53	0.13	CB	N3	eq
08	02:51:07	47.8153	-119.1152	0.6*	0.7	Ml	007/011	105	0.20	CC	N3	eq
10	09:08:34	47.7488	-120.2718	2.3	0.0	Md	008/012	78	0.05	BC	N3	eq
11	20:24:44	46.5647	-119.4768	15.6	0.4	Ml	015/023	63	0.08	AA	E3	eq
13	14:47:56	46.2248	-119.6293	16.1	0.7	Ml	009/011	197	0.04	AD	E3	eq
13	20:01:15	47.4525	-120.1797	-1.0*	1.1	Ml	006/005	139	0.03	CD	N3	px
13	22:52:57	46.3147	-119.4933	17.4	0.3	Ml	007/009	125	0.31	CB	E3	eq
15	11:26:44	47.8193	-119.1080	0.6*	1.2	Ml	012/016	93	0.16	CC	N3	eq
15	20:04:19	44.3892	-121.0248	-1.6*	1.7	Ml	007/008	291	0.10	CD	N3	px
15	21:55:00	48.7473	-119.4355	6.2	1.4	Ml	008/012	110	0.20	BB	N3	eq
17	11:20:24	48.4683	-121.3378	6.9	1.9	Ml	018/024	120	0.25	BC	C3	eq
18	06:33:06	46.4852	-119.7182	7.3	0.1	Ml	009/015	172	0.06	AC	E3	eq
18	06:33:19	46.4853	-119.7200	6.7	0.0	Md	009/015	174	0.08	AC	E3	eq
22	19:57:52	47.5687	-117.5190	-0.7*	1.6	Md	004/005	151	0.12	CD	N3	px
23	20:32:24	46.2553	-120.5787	13.0	1.2	Ml	008/009	199	0.19	BD	E3	eq
24	19:39:56	46.1693	-119.8567	13.2	0.9	Ml	009/012	181	0.09	AD	E3	eq
24	19:47:12	46.1833	-119.8695	10.2	1.4	Ml	017/021	89	0.08	AB	E3	eq
24	19:50:56	46.1763	-119.8685	11.1	1.0	Ml	011/016	116	0.12	AB	E3	eq
25	00:32:33	48.3083	-117.7697	0.5*	1.3	Ml	006/009	131	0.20	CC	N3	px
25	01:41:38	46.1813	-119.8628	11.5	1.0	Ml	013/017	115	0.08	AB	E3	eq
25	12:04:55	47.6327	-120.1925	4.4	0.2	Ml	008/011	151	0.05	AC	N3	eq
26	07:19:54	47.5058	-120.5347	5.3	0.8	Ml	010/015	129	0.16	BC	N3	eq
27	21:15:52	44.3527	-121.0400	-1.6*	1.9	Ml	009/013	265	0.26	CD	N3	px
28	00:15:51	47.3280	-117.8473	-0.7*	2.0	Ml	007/008	116	0.36	CC	N3	px
March 2023												
01	17:23:51	45.9868	-119.4692	-0.3*	1.8	Ml	008/009	239	0.06	CD	E3	px
03	19:41:08	47.6533	-120.1813	2.2	0.9	Ml	010/015	94	0.06	AB	N3	eq
05	01:18:50	44.7570	-117.3197	6.8	2.2	Ml	008/011	84	0.27	BB	N3	eq
06	17:58:26	46.0522	-119.9328	8.1*	1.2	Ml	012/019	116	0.17	CC	E3	eq
08	09:33:33	44.7403	-117.2828	4.9	3.1	Ml	014/023	73	0.43	CC	E3	eq
10	03:09:13	46.2485	-119.4362	10.5	0.2	Ml	008/011	203	0.06	BD	E3	eq
10	04:32:10	46.2390	-119.4687	7.5	1.1	Ml	017/026	228	0.08	AD	E3	eq
10	04:41:52	46.2377	-119.4720	7.1	0.9	Ml	016/024	228	0.09	AD	E3	eq
11	01:41:07	46.2397	-119.4775	8.3	0.6	Ml	015/020	226	0.10	AD	E3	eq
12	13:30:37	46.7338	-119.6988	11.0	0.6	Ml	010/014	102	0.08	AB	E3	eq
13	18:05:14	48.5942	-121.4317	3.1	1.2	Ml	008/011	189	0.24	CD	C3	eq
13	21:03:16	48.8218	-121.3977	16.2	0.8	Md	004/007	273	0.05	AD	C3	eq
14	14:20:25	48.7555	-119.4957	8.3	1.2	Ml	008/014	117	0.28	BB	N3	eq
16	11:48:06	48.1917	-119.3300	0.0*	1.0	Ml	011/017	55	0.21	CC	N3	eq
17	00:38:20	46.2925	-118.0483	3.2	1.7	Ml	009/010	124	0.06	AB	E3	eq
18	10:30:03	46.4848	-119.7027	6.4	-0.0	Ml	007/009	204	0.06	AD	E3	eq
18	10:52:57	47.6545	-120.1893	5.5	0.7	Ml	009/013	119	0.03	AB	N3	eq
20	19:04:03	46.2710	-119.6473	-0.5*	1.9	Ml	008/011	283	0.12	CD	E3	px
21	04:43:19	47.6735	-120.3888	-0.4*	0.4	Ml	010/014	148	0.05	CC	N3	eq
21	05:50:39	46.1280	-120.4542	11.5	1.1	Ml	008/009	170	0.07	AC	E3	eq
22	06:15:38	47.8542	-120.1467	7.0	0.4	Ml	008/012	135	0.09	AB	N3	eq
22	22:08:28	47.7908	-120.8405	5.5	2.6	Ml	026/038	64	0.18	BB	C3	eq

22	22:19:59	47.8095	-120.8342	4.5	0.7	Ml	005/010	223	0.11	AD	C3	eq
22	22:20:58	47.7650	-120.8775	0.1*	-0.0	Md	003/006	266	0.04	CD	C3	eq
22	22:22:04	47.7862	-120.8628	5.0	0.9	Ml	011/014	96	0.07	AB	C3	eq
22	22:50:05	47.7850	-120.8610	4.9	0.8	Ml	009/012	108	0.07	AB	C3	eq
22	23:22:26	47.7693	-120.8712	2.1	0.5	Ml	004/007	241	0.07	BD	C3	eq
22	23:25:58	47.6415	-120.2842	4.6	-0.1	Ml	007/011	102	0.07	AB	N3	eq
23	00:57:05	47.7820	-120.8643	2.5	0.4	Ml	005/008	237	0.06	BD	C3	eq
23	01:45:53	47.7785	-120.8458	2.2	2.2	Ml	021/030	65	0.21	BB	C3	eq
23	01:46:24	47.7800	-120.8667	4.5	1.9	Md	006/009	187	0.07	AD	C3	eq
23	01:54:19	47.8033	-120.8287	4.5	1.6	Ml	016/024	69	0.27	BB	C3	eq
23	02:07:37	48.0380	-120.7167	-0.2*	0.5	Ml	009/014	117	0.24	CC	C3	eq
23	02:51:00	47.8008	-120.8377	3.8	1.1	Ml	013/015	94	0.13	AB	C3	eq
23	08:47:05	47.7930	-120.8398	5.3	0.6	Ml	010/014	211	0.22	BD	C3	eq
23	21:44:39	44.5293	-117.4797	0.5	1.6	Ml	006/012	95	0.67	DC	C3	eq
24	18:45:09	47.3685	-117.8797	-0.7*	2.2	Ml	013/015	58	0.96	DC	N3	px
24	20:17:03	47.1778	-118.3195	-0.5*	2.0	Ml	008/007	149	0.15	CC	N3	px
27	02:56:27	46.3523	-119.5868	16.3	0.4	Ml	013/018	216	0.06	AD	E3	eq
27	07:27:46	47.7392	-120.2957	3.9	2.0	Ml	008/013	87	0.06	AB	N3	eq
28	01:04:42	46.1490	-119.1917	-0.2*	2.0	Ml	020/026	144	0.16	CC	E3	px
28	15:08:30	46.7188	-119.5420	0.2*	0.8	Ml	012/017	167	0.09	CC	E3	eq
29	05:52:04	46.2453	-119.4603	8.5	0.2	Ml	012/017	311	0.08	AD	E3	eq
29	05:56:12	47.4918	-120.6453	0.5*	0.9	Ml	008/013	140	0.12	CC	C3	eq
29	05:57:38	46.2393	-119.4677	7.4	0.5	Ml	015/019	248	0.09	AD	E3	eq
29	14:08:38	47.8112	-120.8328	4.8	1.1	Ml	009/014	93	0.12	AB	C3	eq
29	19:13:23	47.1400	-118.8388	-0.4*	1.5	Ml	015/017	136	0.46	CC	N3	px
31	09:50:16	46.6020	-119.7887	7.5	0.7	Ml	012/017	116	0.08	AB	E3	eq
31	15:36:10	47.2933	-119.9393	-0.8*	1.3	Ml	009/012	110	0.23	CC	N3	px
31	20:36:09	44.6248	-117.5560	-1.1*	2.2	Md	003/004	331	0.12	CD	N3	px
April 2023												
01	00:21:40	47.7823	-120.8532	3.3	0.8	Ml	010/014	161	0.11	AC	C3	eq
03	20:45:36	47.7492	-120.0957	4.1	1.0	Ml	011/017	63	0.07	AB	N3	eq
04	01:28:51	47.6572	-120.3333	4.1	0.5	Ml	003/006	233	0.06	AD	N3	eq
04	02:11:26	47.7557	-120.8722	-0.3	0.9	Ml	009/011	163	0.21	BC	C3	eq
04	03:25:21	47.3695	-120.5892	5.4	1.3	Ml	015/021	122	0.18	BC	N3	eq
04	18:36:18	47.6488	-120.1947	4.1	0.4	Ml	006/012	128	0.08	AB	N3	eq
05	18:04:12	46.1752	-121.4123	9.7	1.1	Ml	017/025	255	0.17	BD	C3	eq
05	18:28:52	47.1658	-119.3120	-0.4*	1.1	Md	003/004	272	0.02	CD	N3	px
06	19:08:11	46.1438	-119.2713	-0.3*	1.9	Ml	013/015	171	0.11	CC	E3	px
07	12:34:00	47.6755	-120.1570	2.0	0.5	Ml	008/013	68	0.07	AA	N3	eq
08	08:55:09	48.2203	-120.6108	4.8	0.6	Ml	007/010	233	0.10	AD	C3	eq
09	00:29:23	47.6528	-120.1783	2.6	0.7	Ml	009/014	119	0.06	AB	N3	eq
10	16:13:28	46.9183	-120.5877	-0.9*	1.4	Ml	016/020	56	1.14	DA	E3	px
11	12:27:08	46.6318	-120.6387	0.3	1.2	Ml	008/009	141	0.19	BC	E3	eq
12	14:09:51	47.7015	-120.2897	3.4	0.3	Ml	006/011	94	0.08	AB	N3	eq
12	21:28:25	46.3603	-120.6777	13.0	0.8	Ml	005/009	202	0.55	DD	E3	eq
13	21:16:38	46.9620	-119.1103	3.6	1.4	Ml	012/012	144	0.08	AC	E3	eq
16	00:56:40	48.5738	-119.3648	10.1	1.4	Ml	009/015	98	0.24	BB	N3	eq
17	20:03:15	47.5533	-120.2787	-1.1*	1.0	Ml	008/008	111	0.09	CB	N3	px
19	22:07:22	47.3430	-117.8865	-0.7*	2.1	Ml	007/007	101	0.07	CC	N3	px
20	01:13:47	48.5730	-119.3725	12.7	1.4	Ml	011/017	97	0.25	BB	N3	eq
22	04:22:25	48.5850	-119.3768	14.2	1.2	Ml	009/018	95	0.38	CB	N3	eq

23	16:44:32	48.5745	-119.3628	12.8	1.3	Ml	010/018	88	0.29	BB	N3	eq
25	16:48:53	47.7920	-117.3927	0.2*	1.0	Md	006/010	153	0.15	CC	N3	eq
25	19:28:08	47.7902	-117.3798	-0.7*	1.0	Md	008/013	94	0.29	CC	N3	px
27	18:59:47	46.1682	-119.1185	-0.2*	2.0	Ml	013/016	135	0.17	CC	E3	px
27	19:12:51	47.6713	-120.1333	2.9	0.5	Ml	007/012	97	0.08	AB	N3	eq
27	19:49:53	44.3412	-121.4163	11.1	1.4	Ml	018/023	99	0.13	AB	N3	eq
28	09:07:45	47.7005	-120.2692	2.2	-0.0	Ml	005/010	126	0.06	AB	N3	eq
29	11:00:01	47.1138	-119.3363	20.0	0.8	Ml	016/019	81	0.15	BB	N3	eq
29	21:18:25	47.7507	-120.1050	4.8	0.4	Ml	007/013	140	0.06	AC	N3	eq
30	02:05:34	46.1230	-120.4255	12.1	1.3	Ml	012/017	226	0.08	AD	E3	eq
May 2023												
01	07:17:37	47.7092	-120.1592	4.7	1.2	Ml	014/022	57	0.08	AB	N3	eq
02	01:41:48	47.6900	-120.0428	4.1	1.4	Ml	013/019	66	0.08	AA	N3	eq
02	16:27:15	45.9138	-118.3620	-0.7*	2.1	Ml	005/005	96	0.08	CD	E3	px
02	21:14:21	47.8308	-119.8050	-1.0*	1.5	Ml	008/012	107	0.17	CC	N3	px
02	23:11:30	48.7517	-120.9857	3.8	2.5	Ml	017/023	140	0.37	CD	C3	eq
03	02:41:32	48.7130	-121.0257	17.4	0.8	Ml	008/014	183	0.81	DD	C3	eq
03	07:27:37	48.7502	-120.9932	9.5*	1.2	Ml	008/013	192	0.37	CD	C3	eq
03	07:55:11	47.7908	-120.1618	5.3	0.3	Ml	006/012	126	0.09	AB	N3	eq
03	12:02:29	48.6660	-120.2910	16.8	0.4	Md	005/007	252	0.07	BD	C3	eq
03	22:28:12	47.7890	-117.3807	-0.7*	1.9	Md	005/006	155	0.02	CC	N3	px
04	01:43:03	47.7065	-120.0310	2.2	0.8	Ml	008/012	108	0.04	AB	N3	eq
07	23:48:22	47.6823	-120.3385	0.2*	0.1	Md	004/006	242	0.02	CD	N3	eq
08	07:59:25	47.6113	-120.2345	1.4	0.3	Ml	006/010	182	0.11	AD	N3	eq
08	12:55:35	47.7045	-120.3340	3.0	1.7	Ml	017/022	86	0.07	AB	N3	eq
09	14:59:13	46.6098	-119.8453	6.4	1.2	Ml	015/025	103	0.08	AB	E3	eq
10	14:22:04	46.6098	-119.8448	6.6	0.8	Ml	013/016	88	0.06	AA	E3	eq
11	21:58:21	45.4855	-120.7137	-0.9*	1.6	Ml	012/014	114	0.51	DB	E3	px
11	22:34:11	45.5417	-118.0318	3.8*	2.7	Md	003/006	307	3.73	DD	E3	eq
12	18:13:23	45.6065	-121.0932	-1.3*	1.7	Ml	005/006	286	0.09	CD	C3	px
17	21:16:49	47.3017	-119.9400	-0.9*	1.3	Ml	013/014	86	0.17	CC	N3	px
18	21:21:58	44.5222	-117.4355	-1.1*	1.8	Ml	008/007	81	0.31	CD	N3	px
19	10:26:37	47.7078	-120.0293	4.4	0.6	Ml	006/009	124	0.04	AC	N3	eq
19	14:05:14	47.6573	-120.1360	6.1	1.6	Ml	018/033	48	0.14	AA	N3	eq
19	17:01:06	44.1322	-121.3358	-1.5*	1.0	Md	009/010	139	0.25	CC	N3	px
19	17:54:08	47.1632	-119.1760	-0.5*	0.8	Md	006/007	108	0.49	CC	N3	px
21	16:28:07	48.9962	-119.1188	0.5*	1.7	Ml	009/015	186	0.37	CD	N3	eq
22	23:16:02	48.6042	-117.9710	-0.8*	1.7	Ml	008/007	201	0.07	CD	N3	px
23	19:28:39	45.6498	-118.8987	-0.6*	1.0	Md	005/004	167	0.03	CD	E3	px
25	19:41:08	46.7327	-117.1908	-0.8*	2.3	Ml	010/011	88	0.60	DA	E3	px
26	04:16:49	46.4582	-120.7618	8.0	0.9	Ml	008/013	146	0.29	BC	C3	eq
26	18:35:59	47.1020	-119.1070	-0.5*	1.4	Ml	011/008	116	0.63	DC	N3	px
June 2023												
01	22:28:03	47.7380	-120.6563	5.7	0.7	Ml	006/009	187	0.14	AD	C3	eq
02	00:15:18	47.7445	-120.1890	2.0	0.4	Ml	005/010	134	0.07	BC	N3	eq
08	01:45:34	46.5945	-119.8608	6.8	0.7	Ml	012/017	94	0.06	AB	E3	eq
08	03:54:02	47.4758	-120.6768	-1.0*	1.0	Ml	009/009	117	0.03	CC	C3	px
08	05:30:45	47.6845	-120.3388	3.5	1.0	Ml	010/013	125	0.04	AB	N3	eq
08	20:08:55	46.9100	-119.1143	-0.3*	1.1	Ml	022/014	162	0.08	CC	E3	px
09	18:02:38	47.1135	-119.1850	-0.5*	1.1	Ml	010/011	78	0.19	CC	N3	px
10	08:33:27	47.6063	-120.2990	5.8	0.5	Ml	009/016	100	0.06	AB	N3	eq

10	09:06:09	46.9818	-120.6658	5.9	0.7	Ml	003/004	263	0.00	BD	E3	eq
14	15:51:45	46.2460	-119.5440	8.5	0.5	Ml	008/013	206	0.08	AD	E3	eq
14	15:58:41	46.2058	-119.6148	9.6	0.3	Md	007/011	230	0.07	AD	E3	eq
14	16:00:14	46.2200	-119.6003	6.8	0.2	Md	007/011	213	0.08	AD	E3	eq
14	16:03:18	46.2143	-119.5942	7.4	0.6	Ml	009/012	222	0.08	AD	E3	eq
14	18:09:28	46.2068	-119.6047	8.4	0.6	Ml	007/010	250	0.05	BD	E3	eq
14	22:15:20	46.2187	-119.5972	7.0	0.7	Ml	009/010	238	0.05	BD	E3	eq
14	22:19:17	46.2220	-119.6047	7.2	0.5	Ml	010/013	233	0.04	AD	E3	eq
14	22:28:09	46.2232	-119.5990	6.8	1.1	Ml	014/020	211	0.07	AD	E3	eq
14	22:51:51	46.2203	-119.5995	7.0	0.6	Ml	008/011	213	0.07	AD	E3	eq
14	23:15:02	46.2192	-119.6015	7.1	0.5	Ml	010/013	149	0.06	AC	E3	eq
15	02:40:39	46.2252	-119.6017	7.2	1.0	Ml	012/015	146	0.05	AC	E3	eq
15	05:12:52	46.5608	-119.5465	15.5	0.8	Ml	017/024	87	0.08	AA	E3	eq
15	07:27:20	46.2240	-119.6023	7.0	1.3	Ml	014/020	164	0.08	AC	E3	eq
15	07:47:17	46.2220	-119.6028	7.3	0.8	Ml	013/017	210	0.05	AD	E3	eq
15	08:04:07	46.2163	-119.5965	7.3	2.2	Ml	028/036	143	0.08	AC	E3	eq
15	18:50:54	47.3548	-117.8687	-0.7*	2.2	Ml	007/010	103	0.32	CC	N3	px
16	01:17:34	44.9688	-117.9643	-1.0*	1.6	Ml	005/009	192	0.42	CD	N3	px
16	02:08:33	46.2212	-119.5977	7.0	1.3	Ml	014/021	213	0.08	AD	E3	eq
16	06:56:57	47.7103	-120.0833	3.9	1.0	Ml	015/021	55	0.08	AB	N3	eq
17	16:05:14	47.6358	-120.1635	3.7	0.2	Ml	004/008	140	0.02	AC	N3	eq
18	08:54:04	47.7080	-120.0425	3.8	1.2	Ml	012/019	107	0.10	AB	N3	eq
18	12:17:31	48.2298	-121.3268	13.2	0.9	Md	006/008	162	0.10	AC	C3	eq
18	16:22:28	46.2137	-119.5905	6.9	1.3	Ml	011/017	224	0.14	AD	E3	eq
19	06:59:31	46.2018	-119.5818	7.3	0.2	Ml	007/009	269	0.02	AD	E3	eq
19	07:38:33	46.2252	-119.6047	7.5	1.2	Ml	008/012	206	0.08	AD	E3	eq
19	07:49:24	46.2230	-119.5975	7.0	1.0	Ml	009/015	211	0.06	AD	E3	eq
19	08:02:26	46.2195	-119.5953	7.2	0.4	Ml	007/009	250	0.04	BD	E3	eq
19	14:20:23	46.2260	-119.6042	6.8	0.9	Ml	012/018	205	0.07	AD	E3	eq
19	18:23:34	46.2240	-119.6008	6.8	0.6	Ml	010/017	209	0.05	AD	E3	eq
20	03:47:14	46.2100	-119.5973	8.0	0.6	Ml	011/016	153	0.06	AC	E3	eq
20	09:44:10	46.2013	-119.5862	7.8	0.6	Ml	010/016	239	0.13	AD	E3	eq
20	12:54:22	46.2258	-119.6010	7.0	0.8	Ml	010/017	206	0.07	AD	E3	eq
20	13:35:12	46.2027	-119.5795	7.2	0.6	Md	007/010	269	0.06	AD	E3	eq
21	07:57:46	44.0660	-117.5323	0.7	1.7	Ml	005/006	179	0.03	AD	E3	eq
22	05:30:37	46.9167	-120.5547	-0.8*	1.2	Ml	009/011	164	0.71	DC	E3	px
22	05:44:18	46.9050	-120.5600	-0.8*	0.5	Ml	005/005	156	0.44	CD	E3	px
22	06:55:41	46.9095	-120.5632	-0.9*	1.4	Ml	010/014	106	1.20	DB	E3	px
22	12:57:03	46.8688	-120.7002	8.9	0.7	Ml	007/010	136	0.26	BC	C3	eq
23	10:05:54	47.7288	-120.2777	-0.4*	0.7	Ml	009/014	84	0.08	CB	N3	eq
23	17:59:44	45.9702	-121.3520	0.2*	1.9	Ml	009/013	239	0.40	CD	C3	eq
23	19:28:56	47.1700	-119.2173	-0.5*	0.7	Md	005/005	110	0.15	CD	N3	px
24	02:33:56	47.8415	-120.8517	-1.4*	1.1	Ml	007/007	144	0.09	CC	C3	px
24	10:28:39	46.2290	-120.5625	9.1	0.7	Ml	006/007	220	0.08	AD	E3	eq
24	10:29:45	46.2313	-120.5812	10.8	1.1	Ml	008/011	204	0.21	BD	E3	eq
24	15:25:32	46.2047	-119.5930	7.9	0.2	Ml	007/010	234	0.04	BD	E3	eq
24	23:23:55	46.4355	-119.5945	2.0	0.7	Ml	009/011	124	0.04	AB	E3	eq
25	17:43:37	46.2302	-119.6080	6.8	0.2	Md	006/009	198	0.07	AD	E3	eq
26	01:03:47	47.7087	-120.3070	2.6	0.8	Ml	009/016	81	0.05	AB	N3	eq
26	20:06:34	46.8397	-120.8988	6.3	1.4	Ml	015/016	100	0.22	BC	C3	eq
26	21:19:33	44.9827	-117.4113	-1.1*	1.3	Ml	004/006	156	1.13	DC	C3	px

27	16:15:58	48.5792	-117.9730	-0.9*	1.3	Md	004/004	188	0.04	CD	N3	px
27	23:03:23	46.6002	-120.9523	4.2	1.4	Ml	011/014	131	0.23	BC	C3	eq
28	00:12:24	46.6107	-120.9555	6.4	1.8	Ml	055/068	49	0.36	CC	C3	eq
28	00:26:30	46.5965	-120.9700	6.6	1.0	Ml	011/017	133	0.25	BC	C3	eq
28	00:47:44	46.6048	-120.9618	7.8	1.3	Ml	022/036	130	0.31	CC	C3	eq
28	02:05:35	46.6048	-120.9602	7.5	1.4	Ml	012/020	130	0.27	BC	C3	eq
28	10:55:57	47.6513	-120.2928	3.1	0.1	Ml	004/008	128	0.07	AB	N3	eq
28	21:51:34	47.6588	-120.1670	3.0	0.3	Ml	004/008	111	0.05	AB	N3	eq
28	23:42:54	45.9117	-119.3068	-0.3*	1.9	Ml	016/018	108	0.11	CC	E3	px
29	17:59:22	47.1440	-118.5023	-0.5*	1.6	Ml	014/016	138	0.59	DC	N3	px
30	15:43:56	45.0715	-121.0315	15.5	1.3	Ml	010/016	108	0.23	BB	N3	eq
30	19:09:17	47.5435	-120.2815	6.1	1.4	Ml	014/022	85	0.11	AB	N3	eq
July 2023												
01	05:17:59	48.0920	-119.4898	0.8*	0.9	Ml	008/009	121	0.09	CC	N3	eq
01	13:20:13	46.6127	-119.8962	6.0	0.5	Ml	011/017	111	0.06	AB	E3	eq
01	16:23:36	47.7120	-120.3137	4.0	1.6	Ml	016/026	81	0.10	AB	N3	eq
02	00:57:59	46.2188	-119.5643	12.0	0.4	Ml	007/011	225	0.10	AD	E3	eq
03	23:36:19	48.6298	-119.6793	0.1*	1.1	Ml	008/008	121	0.10	CC	N3	eq
05	05:00:15	47.7588	-120.3033	5.5	0.6	Ml	009/013	83	0.08	AC	N3	eq
05	16:30:00	46.0370	-120.5658	15.9	1.4	Ml	007/010	162	0.12	AC	E3	eq
05	23:30:01	46.4810	-119.5413	14.6	0.5	Ml	011/017	118	0.06	AB	E3	eq
06	07:51:18	47.6443	-120.3215	-0.3*	0.7	Ml	009/012	109	0.07	CB	N3	eq
07	00:20:29	46.9168	-120.5483	-0.9*	1.3	Ml	012/012	115	0.72	DB	E3	px
07	00:22:16	46.9098	-120.5703	-0.8*	1.0	Ml	007/007	169	0.89	DC	E3	px
08	01:27:10	46.7265	-119.3763	12.6	0.6	Ml	009/016	197	0.07	AD	E3	eq
08	16:50:44	46.7298	-121.0458	13.0	1.0	Ml	014/022	139	0.11	AC	C3	eq
09	20:29:49	46.5535	-119.9218	8.2	0.9	Ml	007/012	290	0.28	BD	E3	eq
11	21:55:53	46.5022	-119.7688	18.0	1.0	Ml	011/018	183	0.09	AD	E3	eq
11	23:15:49	44.8252	-120.4850	2.7	1.5	Ml	012/012	132	0.18	BC	E3	eq
12	05:18:58	47.6507	-120.2272	5.4	-0.4	Md	005/008	127	0.05	AB	N3	eq
12	10:40:52	47.7153	-120.2298	-0.4*	1.6	Ml	018/025	70	0.08	CB	N3	eq
12	13:19:36	47.7115	-120.2448	-0.6	0.1	Ml	006/012	81	0.09	AA	N3	eq
12	15:04:45	46.6302	-120.5358	-0.6*	1.7	Ml	014/018	103	0.36	CC	E3	px
12	15:21:25	48.2142	-121.2218	9.1	0.9	Md	009/014	143	0.23	BC	C3	eq
14	13:54:15	46.1512	-120.2707	-0.2	1.0	Ml	006/010	103	0.37	CC	E3	eq
14	22:01:31	45.7175	-119.1908	7.7	1.6	Ml	016/021	152	0.20	BC	E3	eq
15	00:02:26	47.2877	-121.2337	0.9*	0.8	Ml	015/016	128	0.15	CC	C3	eq
16	08:50:04	47.7262	-120.3140	3.8	1.0	Ml	011/017	98	0.08	AB	N3	eq
16	13:11:50	46.2178	-119.6058	7.5	2.1	Ml	024/027	148	0.09	AC	E3	eq
16	13:18:51	46.2423	-119.6302	7.0	0.1	Ml	007/012	171	0.10	AC	E3	eq
16	13:33:32	46.2258	-119.6027	7.4	0.5	Ml	010/016	206	0.05	AD	E3	eq
16	14:45:40	46.2123	-119.5858	6.9	0.4	Ml	006/009	260	0.04	AD	E3	eq
16	17:22:06	46.2207	-119.5973	7.3	0.9	Ml	014/021	214	0.05	AD	E3	eq
16	17:48:06	48.6463	-121.0227	8.7*	1.5	Ml	009/015	170	0.32	CC	C3	eq
16	18:10:12	46.2245	-119.6013	7.0	0.3	Ml	009/013	208	0.06	AD	E3	eq
16	19:08:15	47.9080	-120.8615	6.7	1.1	Ml	005/008	164	0.10	AC	C3	eq
16	21:15:45	46.2215	-119.5963	6.7	1.2	Ml	009/016	213	0.08	AD	E3	eq
16	21:48:55	47.9110	-120.8438	6.2	0.8	Md	003/005	143	0.01	AD	C3	eq
16	22:23:32	46.2227	-119.6052	7.2	0.3	Ml	011/015	209	0.06	AD	E3	eq
17	02:35:15	46.2085	-119.6007	8.0	0.0	Ml	008/013	228	0.08	AD	E3	eq
17	20:58:22	46.4957	-119.5555	17.6	0.2	Md	005/007	195	0.06	BD	E3	eq

18	04:09:41	46.4535	-119.5777	18.0	0.5	Ml	011/017	95	0.17	BB	E3	eq
18	08:38:31	46.9193	-120.5545	-0.9	1.5	Ml	017/022	88	0.65	DA	E3	eq
18	13:47:56	46.9440	-120.5652	-0.7	1.4	Ml	013/017	98	0.33	CC	E3	eq
18	15:26:21	44.5490	-117.3997	6.6	1.8	Ml	005/006	202	0.19	BD	E3	eq
18	17:02:04	46.9673	-120.5595	-0.9	0.9	Ml	010/015	128	1.61	DB	E3	eq
19	16:23:56	46.2157	-119.5872	7.0	0.3	Ml	007/011	222	0.05	AD	E3	eq
19	17:16:49	46.2247	-119.6032	6.8	0.4	Ml	010/015	207	0.04	AD	E3	eq
20	05:34:47	47.6882	-120.3615	2.5	0.1	Ml	005/009	137	0.04	BC	N3	eq
20	16:19:07	46.2715	-120.6047	11.3	0.6	Ml	006/010	201	0.21	BD	E3	eq
20	19:14:55	46.7685	-119.7652	-0.3*	1.6	Ml	016/018	106	0.12	CB	E3	px
21	10:37:23	47.6435	-121.4500	6.5	1.0	Ml	008/013	254	0.22	BD	C3	eq
21	17:37:31	46.3042	-119.4873	9.2	0.2	Ml	008/013	235	0.09	AD	E3	eq
22	00:49:52	46.2203	-119.5982	7.3	0.8	Ml	012/018	214	0.06	AD	E3	eq
22	08:01:26	48.6250	-119.6620	7.6	1.1	Ml	009/012	119	0.16	BC	N3	eq
23	17:24:19	46.4557	-121.3013	8.2	1.7	Ml	043/056	103	0.17	BC	C3	eq
24	19:04:38	46.2258	-119.6033	7.1	1.5	Ml	011/018	206	0.06	AD	E3	eq
25	08:19:52	48.2503	-120.7030	7.1	1.8	Ml	020/036	107	0.22	BC	C3	eq
25	21:12:06	44.9787	-121.3082	17.5	0.8	Ml	010/015	122	0.15	BB	C3	eq
26	04:53:02	46.2218	-119.6008	7.0	1.1	Ml	011/018	212	0.08	AD	E3	eq
26	05:23:12	46.2013	-119.5997	8.1	0.3	Md	008/011	156	0.12	AC	E3	eq
26	12:36:56	47.6958	-120.3468	5.3	0.4	Ml	005/010	125	0.05	AB	N3	eq
26	19:32:26	47.2312	-118.8360	-0.5*	1.6	Ml	012/016	164	0.43	CC	N3	px
26	23:59:54	47.6900	-120.2573	3.3	0.2	Ml	006/011	115	0.02	AB	N3	eq
27	02:54:28	46.2023	-119.6080	9.4	0.1	Ml	008/011	235	0.05	AD	E3	eq
27	06:34:17	46.2218	-119.6045	7.3	0.2	Ml	008/012	210	0.05	AD	E3	eq
27	21:03:47	47.3247	-117.8663	-0.7*	2.1	Ml	010/013	111	0.45	CC	N3	px
27	22:42:33	44.2480	-120.9217	-1.6*	1.9	Ml	012/013	171	0.20	CC	N3	px
28	11:12:39	46.2012	-119.6000	9.2	2.1	Ml	032/040	129	0.10	AB	E3	eq
28	12:40:49	46.2262	-119.6060	7.3	0.8	Ml	014/019	204	0.06	AD	E3	eq
28	13:04:50	46.2195	-119.6003	7.0	0.8	Ml	013/019	215	0.06	AD	E3	eq
28	13:34:48	46.0630	-119.6253	7.2	0.9	Ml	008/014	206	0.15	BD	E3	eq
28	17:10:32	47.4762	-120.6777	-1.2*	1.1	Ml	009/011	163	0.13	CC	C3	px
28	20:51:01	45.6987	-119.1212	7.2	1.4	Ml	015/018	139	0.15	BC	E3	eq
29	04:54:45	46.2247	-119.5943	6.1	0.2	Ml	006/009	210	0.05	AD	E3	eq
29	16:03:23	47.6353	-120.2493	3.5	0.6	Ml	005/009	143	0.02	AC	N3	eq
29	22:26:39	45.1703	-118.2057	8.8	2.1	Ml	009/014	167	0.50	DC	N3	eq
29	23:39:00	45.4193	-117.6167	7.0	1.4	Ml	006/009	79	0.27	BC	N3	eq
31	19:13:39	48.2088	-117.8637	-1.0*	1.8	Ml	014/022	133	0.75	DC	N3	px
August 2023												
01	02:07:23	48.2250	-120.7603	5.4	0.4	Ml	010/012	126	0.18	BC	C3	eq
01	09:07:09	46.2182	-119.5902	7.0	0.3	Ml	008/012	234	0.07	AD	E3	eq
01	13:36:52	46.2218	-119.5838	11.4	0.5	Ml	009/015	216	0.08	AD	E3	eq
01	19:13:59	46.2223	-119.5995	7.2	0.3	Ml	008/012	211	0.04	AD	E3	eq
01	22:26:10	45.9558	-118.2453	-0.5*	1.3	Md	005/006	165	0.13	CC	E3	px
01	22:48:20	44.3348	-120.9915	-1.7*	1.8	Ml	005/006	335	0.09	CD	E3	px
03	14:20:19	47.6993	-120.1583	1.3	0.3	Ml	005/010	123	0.08	BB	N3	eq
03	15:08:09	46.9502	-120.3947	16.2	1.1	Ml	023/030	93	0.30	CB	E3	eq
03	21:50:50	48.6192	-119.5932	6.8	1.4	Ml	008/013	113	0.17	BC	N3	eq
04	08:21:54	46.6227	-119.8525	6.3	0.8	Ml	012/018	80	0.06	AB	E3	eq
04	14:03:16	46.2188	-119.6010	7.1	1.0	Ml	013/020	215	0.08	AD	E3	eq
05	15:53:38	48.6132	-119.6008	-0.0*	2.1	Ml	019/022	139	0.12	CC	N3	eq

05	18:38:17	47.9045	-120.0448	1.9	0.8	Ml	010/017	95	0.07	AB	N3	eq
05	18:40:44	46.2167	-119.6012	7.4	1.1	Ml	014/019	150	0.07	AC	E3	eq
05	19:09:37	46.2200	-119.6035	6.8	0.3	Md	007/012	213	0.11	AD	E3	eq
06	00:16:02	47.7410	-120.1870	-0.5*	0.3	Ml	007/014	101	0.09	CB	N3	eq
07	00:07:08	46.2253	-119.6035	7.0	0.6	Ml	008/010	206	0.05	AD	E3	eq
07	02:38:07	47.6700	-120.3405	1.5	0.9	Ml	013/018	97	0.06	AB	N3	eq
07	09:29:50	46.2218	-119.5985	7.3	1.1	Ml	015/019	212	0.06	AD	E3	eq
07	09:40:47	46.2148	-119.6012	7.6	1.3	Ml	015/022	168	0.09	AC	E3	eq
10	21:23:24	44.6200	-117.5478	-1.1*	1.8	Ml	004/004	330	0.05	CD	E3	px
10	22:23:31	46.2897	-118.5205	-0.4*	1.4	Ml	013/016	121	0.42	CC	E3	px
10	22:30:21	47.7977	-120.8453	6.3	1.2	Ml	012/019	104	0.15	BB	C3	eq
11	01:20:52	45.9832	-118.3390	9.1	1.0	Ml	008/012	78	0.21	BA	E3	eq
11	16:15:43	47.5660	-117.5042	-0.7*	1.8	Ml	009/007	126	0.04	CB	N3	px
11	21:30:49	45.1792	-117.9868	-1.0*	1.4	Ml	007/010	157	0.52	DC	N3	px
12	20:08:18	46.2230	-119.6028	7.2	0.3	Ml	008/012	209	0.04	AD	E3	eq
13	05:32:47	47.6530	-120.1360	6.0	0.8	Ml	013/023	67	0.05	AA	N3	eq
14	22:22:39	46.2062	-119.6113	9.4	0.4	Ml	007/009	230	0.08	BD	E3	eq
14	22:48:25	45.6583	-118.9380	-0.6*	1.6	Ml	006/008	109	0.17	CC	E3	px
15	04:54:20	46.2127	-119.6002	7.9	1.7	Ml	036/030	138	0.06	AC	E3	eq
15	05:21:08	46.2180	-119.6030	7.8	0.4	Ml	011/015	215	0.08	BD	E3	eq
15	14:25:58	46.0823	-119.1840	8.1	1.7	Ml	030/034	91	0.13	AC	E3	eq
16	20:23:51	46.1828	-119.6433	8.1	1.1	Ml	017/027	148	0.06	AC	E3	eq
18	20:28:30	44.4108	-120.8738	-1.5*	1.9	Ml	010/010	205	0.19	CD	E3	px
18	22:06:10	46.2462	-119.1323	-0.3*	1.0	Ml	008/012	191	0.26	CD	E3	px
19	06:51:26	46.0785	-119.1775	10.6	1.5	Ml	023/033	49	0.18	BB	E3	eq
20	22:50:16	46.6197	-119.8325	6.8	2.5	Ml	039/040	63	0.09	AA	E3	eq
21	01:14:28	46.6123	-119.8197	6.9	0.4	Ml	009/016	244	0.07	AD	E3	eq
21	07:04:40	47.6148	-120.3375	6.9	0.1	Ml	006/011	142	0.08	AC	N3	eq
21	19:41:31	45.6247	-121.0598	-1.0*	1.5	Ml	007/009	252	0.41	CD	C3	px
22	09:28:18	47.7088	-120.2232	-0.5*	0.1	Ml	006/009	133	0.09	CB	N3	eq
22	21:00:36	47.3982	-117.8735	-0.7*	2.1	Ml	012/012	90	0.36	CC	N3	px
24	21:26:12	47.4202	-121.3928	9.7*	1.2	Ml	024/033	83	0.17	CC	C3	eq
25	21:55:50	46.1688	-119.2573	-0.3*	0.8	Ml	008/010	195	0.17	CD	E3	px
28	11:04:48	46.8320	-119.7422	2.3	1.2	Ml	026/037	68	0.16	BC	E3	eq
28	23:21:00	46.6127	-119.8145	6.8	0.4	Ml	009/015	241	0.06	AD	E3	eq
29	04:11:54	47.6920	-120.0680	4.6	0.7	Ml	015/022	54	0.10	AA	N3	eq
29	04:15:20	47.6998	-120.0882	4.5	-0.1	Ml	005/010	104	0.11	AB	N3	eq
29	17:36:38	46.8088	-119.7605	21.0	0.7	Ml	011/020	101	0.21	BB	E3	eq
29	21:31:42	45.6320	-121.1708	-1.6*	1.6	Ml	007/008	252	0.37	CD	C3	px
31	19:01:19	46.1693	-119.2645	-0.3*	1.5	Ml	015/015	160	0.22	CC	E3	px
31	22:22:14	47.3385	-117.8757	-0.7*	2.0	Ml	006/006	166	0.14	CC	N3	px
September 2023												
01	12:56:00	47.6672	-120.3912	-0.2*	1.1	Ml	012/017	95	0.07	CB	N3	eq
03	23:16:30	46.0983	-119.3895	16.5	0.6	Ml	008/010	304	0.07	AD	E3	eq
04	00:03:05	45.9508	-119.4380	7.3*	1.1	Md	005/006	351	0.06	DD	E3	eq
04	06:54:21	46.0855	-119.3968	8.4*	0.6	Ml	009/014	305	0.15	CD	E3	eq
06	19:47:22	47.7098	-120.2458	3.3	0.3	Ml	010/017	75	0.09	AA	N3	eq
06	21:49:49	47.5500	-120.2695	-1.1*	1.3	Ml	009/009	196	0.23	CD	N3	px
06	22:17:39	47.6940	-120.0870	7.3	1.0	Ml	016/028	54	0.15	BA	N3	eq
09	01:32:56	47.6448	-120.1545	6.6	0.3	Ml	007/011	120	0.05	AB	N3	eq
10	07:11:22	47.9100	-119.3790	6.4	0.4	Ml	010/014	72	0.18	BC	N3	eq

10	07:44:23	47.7123	-120.1543	3.9	0.6	Ml	012/018	73	0.06	AB	N3	eq
10	14:44:08	46.9200	-120.5607	-0.3	1.8	Ml	029/039	91	0.76	DB	E3	eq
10	22:13:58	46.4652	-119.3370	15.3	1.0	Ml	021/031	48	0.12	AA	E3	eq
10	23:08:21	46.9225	-120.5485	-0.9	1.0	Ml	010/013	110	1.00	DB	E3	eq
11	21:53:11	47.8950	-120.8997	4.5	1.1	Ml	006/009	100	0.06	AB	C3	eq
12	02:48:48	47.6550	-120.1287	7.1	0.1	Md	006/011	86	0.07	AA	N3	eq
12	12:10:23	47.6805	-120.1875	1.9	0.7	Ml	011/019	107	0.08	AB	N3	eq
12	17:25:47	47.6458	-117.6878	7.8	2.7	Ml	012/015	63	0.08	AB	N3	eq
13	02:22:39	47.8287	-119.3260	-0.8	1.1	Ml	011/013	111	0.12	AC	N3	eq
13	07:19:57	47.8993	-120.8127	7.3	0.9	Ml	006/008	128	0.12	AB	C3	eq
13	20:53:22	44.5397	-117.4490	2.4	1.9	Ml	009/013	80	0.54	DC	C3	eq
14	13:11:03	46.0780	-119.6247	7.1	0.9	Ml	011/014	137	0.08	BC	E3	eq
14	13:37:43	46.0912	-119.6232	7.5	1.6	Ml	019/024	110	0.10	AB	E3	eq
14	13:42:53	46.2243	-119.2233	26.4*	0.5	Ml	004/006	360	0.08	DD	E3	eq
14	15:15:30	46.0873	-119.6118	7.2	1.0	Ml	008/013	312	0.07	BD	E3	eq
14	17:36:44	45.8818	-118.3685	-0.4*	1.8	Ml	006/006	117	0.23	CC	E3	px
15	08:25:27	48.9362	-120.7745	9.0	1.7	Ml	015/022	162	0.60	DD	C3	eq
15	17:36:33	47.6633	-120.1060	5.7	0.7	Ml	008/012	93	0.07	AB	N3	eq
16	01:14:55	47.6635	-120.8020	11.4	0.6	Ml	011/016	116	0.12	AB	C3	eq
17	21:38:44	47.6623	-120.7903	8.5	0.9	Ml	008/012	115	0.13	AC	C3	eq
19	02:07:50	45.9118	-119.2822	-0.3*	1.9	Ml	014/018	157	0.22	CC	E3	px
19	03:28:02	47.6790	-120.2402	2.9	0.3	Ml	004/008	186	0.02	AD	N3	eq
19	19:41:08	46.2948	-118.0535	3.2	1.6	Ml	013/012	125	0.21	BB	E3	eq
21	10:49:06	48.1783	-121.4965	10.0	0.9	Ml	011/017	108	0.18	BB	C3	eq
22	01:10:58	47.3203	-121.2767	4.8	0.6	Ml	012/012	232	0.07	BD	C3	eq
22	03:13:06	46.3940	-120.9078	1.2*	1.0	Ml	012/015	95	0.15	CC	C3	eq
22	11:31:07	46.7132	-121.4777	4.4	0.6	Ml	019/025	183	0.08	AD	C3	eq
23	00:27:54	46.8227	-121.1687	-0.1*	0.7	Ml	014/019	147	0.16	CC	C3	eq
23	10:27:46	47.6328	-119.5733	10.0	1.6	Ml	014/019	130	0.15	BC	N3	eq
23	12:11:32	48.6658	-120.3038	15.2	1.9	Ml	008/013	235	0.34	CD	C3	eq
23	14:23:21	47.6618	-120.1502	3.4	1.0	Ml	011/012	111	0.07	AB	N3	eq
26	22:05:49	44.0852	-121.3522	-1.4*	-5.0	Mh	010/009	132	0.12	CB	N3	px
27	02:54:34	47.7555	-120.2567	7.3	0.3	Ml	009/017	79	0.12	AB	N3	eq
27	08:46:35	46.9327	-120.5540	-0.9	1.9	Ml	018/021	81	0.70	DA	E3	eq
28	07:58:49	47.8320	-119.3370	12.5	0.8	Ml	005/008	199	0.29	BD	N3	eq
28	08:43:23	46.8243	-121.1770	4.6	0.9	Ml	019/026	108	0.22	BC	C3	eq
28	13:58:15	46.8160	-121.1853	1.2	1.4	Ml	031/044	107	0.26	BC	C3	eq
28	23:10:55	46.8237	-121.1752	0.8	1.4	Ml	033/045	108	0.19	BC	C3	eq
29	17:24:44	47.7830	-117.3982	-0.7*	1.9	Ml	008/008	152	0.15	CC	N3	px

5.0 Discussion of Seismic Activity – FY 2023

5.1 Summary

During FY2023, seismic activity increased slightly throughout eastern Washington. 426 earthquakes were cataloged in the region, of which about 32% (136) took place on or in the immediate vicinity of the Hanford Site. This is an increase from 316 earthquakes in the previous year. Several earthquakes took place in the historically active area of Entiat and Chelan. Within the vicinity of the Hanford Site, there was low to typical swarm-type activity, most strongly observed near the Horse Heaven and Cold Creek Swarm Areas.

The depth distribution and geographic pattern of the earthquakes for the year are tabulated in Tables 5.1 and 5.2 and plotted in Figure 5.1.

Table 5.1. Depth Distribution of Eastern Washington Earthquakes for FY 2023

Category	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	FY 2023
Shallow (0-4 km deep)	33	27	29	38	127
Intermediate (4-9 km deep)	36	39	53	80	208
Deep (greater than 9 km deep)	24	19	18	30	91
Total	**93**	**85**	**100**	**148**	**426**
Felt	0	1	0	1	2
Probable Blast	25	18	34	29	106

Table 5.2. Earthquake Counts for FY 2023 for Earthquakes near the Hanford Site

Seismic Source Zones	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	FY 2023
Frenchman Hills	0	0	0	0	0
Saddle Mountains	0	0	0	0	0
Wahluke Slope	1	0	0	2	3
Coyote Rapids	0	1	0	0	1
Wye	0	1	0	1	2
Cold Creek	1	4	1	2	8
Rattlesnake Mountain	0	0	0	0	0
Horse Heaven Hills	1	6	0	4	11
Total for swarm areas	3	12	1	9	25
Random Events	9	18	33	51	111
Total For All Earthquakes	**12**	**30**	**34**	**60**	**136**

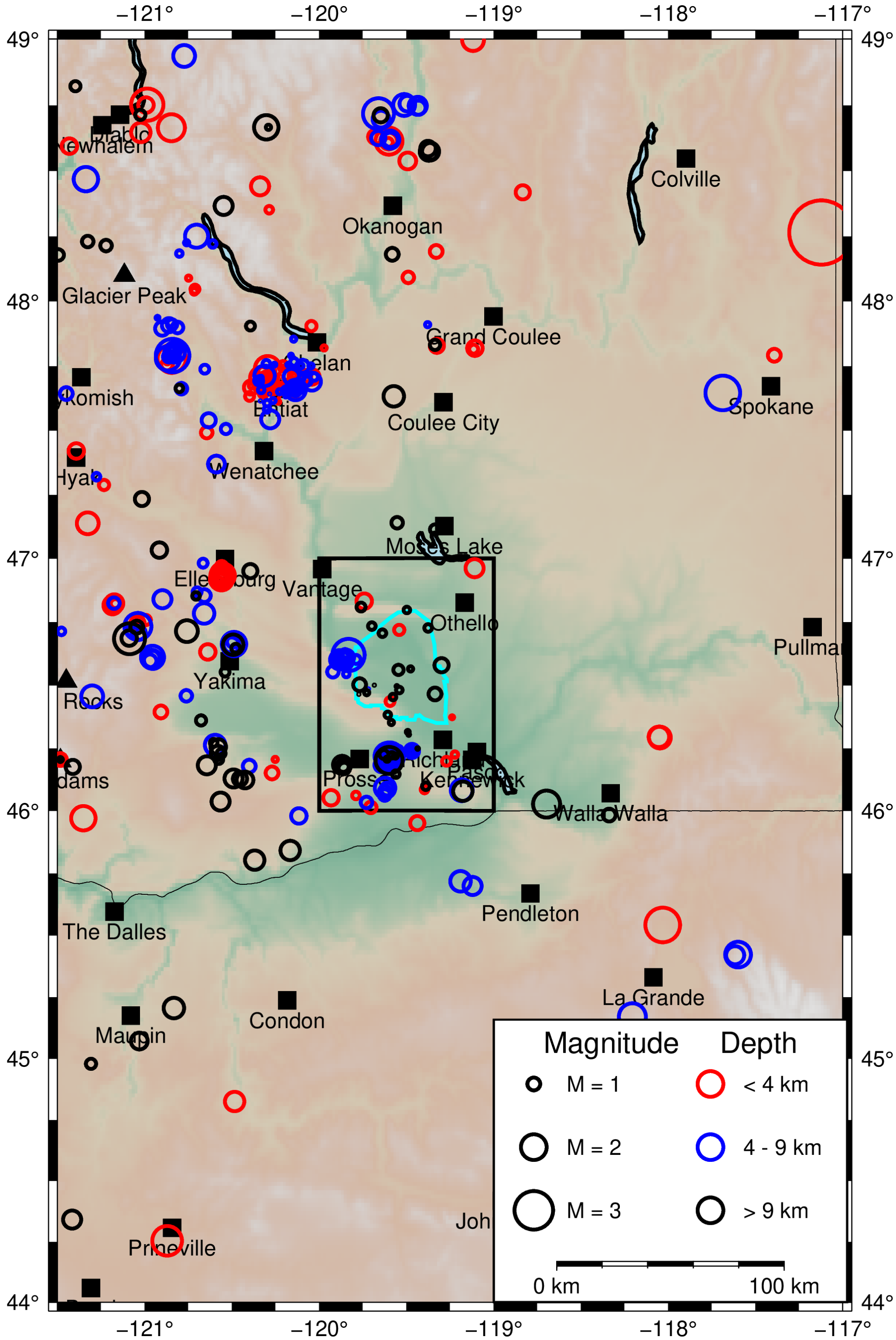

Figure 5.1. Hanford and Regional Epicenters of Earthquakes Recorded during FY 2023. Background color indicates elevation. Red circles stand for shallow earthquakes (0-4 km). Blue circles for intermediate-depth earthquakes (4-9 km). Black circles denote earthquakes deeper than 9 km.

6.0 Status of Monitoring

Overall, the monitoring capability of seismicity in the region surrounding the Hanford Site has improved. In addition to the improved network on the Hanford Site and just off the Site, PNSN (UW) has densified the seismic network in Eastern Washington using non-DOE funding. On the Hanford Site, HSN station UW.NIKE, installed in late 2017, may have to be removed due to water leaking into the Nike Missile Silo that houses the station. US National Net seismic station US.HAWA is co-located and may also need to be removed. The nearest station to NIKE is an old-fashioned, vertical-component, short-period station, RSW, that cannot be upgraded in place. Losing both NIKE and RSW would likely be detrimental to the monitoring effort.

Looking ahead, PNSN would like to make further upgrades to the network. Several instruments of the HSN and EWRSN are reaching end-of-life and exhibit (intermittent) issues. The five Kinemetrics Basalt dataloggers with internal Episensor ES-T accelerometers were purchased in 2012 and are now 10+ years old. The equipment purchased from IRIS in 2008 is 15+ years old; we had to replace the Q330 at DDRF, station PHIN still has all the original IRIS equipment. CCRK was rebuilt after it was destroyed by wildfire and has relatively new FY2017 equipment. The PNSN is phasing out operating analog-telemetry stations due to the inability to purchase new analog radios, and lack of staff trained in this old-fashioned technology. On the Hanford Site, three old-fashioned analog stations remain, BEN, LOC, and RSW. Given the density of digital stations on the site, we may be able to discontinue these three sites without losing significant monitoring capability. In the wider EWRSN, another eleven analog stations remain. PNSN plans to analyze the contribution of each analog site to the monitoring capability and propose which locations need to be retained, and which can be decommissioned.

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