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INL Seismic Monitoring Annual Report: January 1, 2010 – December 31, 2010

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September 2011

Idaho National Laboratory

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SUMMARY

During 2010, the INL Seismic Monitoring Program evaluated 11,606 earthquakes from around the world, the western United States, and local region of the eastern Snake River Plain (ESRP). INL located 2,085 earthquakes and man-made blasts within the local region outside and within a 161-km (or 100-mile) radius of INL. Of these events, 53 were small-to-moderate size earthquakes ranging in magnitude from 3.0 to 4.8. 672 earthquakes occurred within the 161-km radius of INL and the majority of these earthquakes were located in active regions of the Basin and Range Province that surrounds the ESRP. There were 10 microearthquakes within the boundary of the ESRP, all of magnitude less than or equal to 2.0. Five of those were located within and near the ESRP at Craters of the Moon National Monument (COM) at mid- and lower-crust depths and are interpreted to be related to fluid movement. Since 1972, INL has recorded 48 small-magnitude, microearthquakes ($M \leq 2.2$) within the ESRP (not including COM events) and 22 deep microearthquakes ($M \leq 2.3$) in the vicinity of Craters of the Moon National Monument.

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ACKNOWLEDGEMENTS

We thank Alan Marley for his continued support. We also thank staff at the University of Utah Seismograph Stations, U. S. Geological Survey, and Montana Bureau of Mines and Geology for their earthworm data shares. The research was funded in part by the Idaho National Laboratory through the U.S. Department of Energy Idaho Operations Office contract DE-AC07-05ID14517.

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ACRONYMS

ANL	Argonne National Laboratory
BLM	Bureau of Land Management
CFA	Central Facilities Area
COM	Craters of the Moon National Monument and Preserve
DAAS	Data Acquisition/Analysis System
DOE	Department of Energy
DSL	Digital Subscriber Line
EFS	Experimental Field Station
ESRP	Eastern Snake River Plain
GPS	Global Positioning System
INL	Idaho National Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center
IP	Internet Protocol
IRC	INL Research Center
LOFT	Loss of Fluid Test
MFC	Materials and Fuels Complex
M_s	Surface-wave Magnitude
NEIC	National Earthquake Information Center
NRF	Naval Reactor Facility
PBF	Power Burst Facility
PBO	Plate Boundary Observatory
P-wave	Compressional Wave
RTC	Reactor Technology Complex
RWMC	Radioactive and Waste Management Complex

S-wave	Shear Wave
SMC	Special Manufacturing Complex
SMA	Strong Motion Accelerograph
SSCs	Structures, Systems, and Components
STC	Science and Technology Complex
TA	Transportable Array
TAN	Test Area North
TRA	Test Reactor Area
USGS	United States Geological Survey
YNP	Yellowstone National Park

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1. Introduction

The Idaho National Laboratory (INL) has accumulated 38 years of earthquake data (1972-2010). This report covers the earthquake activity from January 1, 2010 through December 31, 2010 and is a continuation of previous annual reports on earthquake activity surrounding the eastern Snake River Plain (ESRP) and within and near the INL. It discusses the earthquake activity that has occurred around the local region and within 100-miles of the INL (a 161-km radius around the INL centered at 43° 39.00' N, 112° 47.00' W (Figure 1). It discusses the seismic station and strong motion accelerograph instrumentation used to record earthquake data and how the data were analyzed. It also includes a brief discussion of continuous GPS (Global Positioning System) stations co-located at INL seismic stations.

1.1 History of INL Seismic Monitoring Program

1.1.1 Purpose

The purpose of the INL Seismic Monitoring Program is to provide the INL with earthquake data and staff expertise to support the requirements set forth by Presidential executive orders, Department of Energy (DOE) directives, orders and standards, and the Nuclear Regulatory Commission for seismic safety of: Structures, Systems, and Components (SSCs); workers and the public; and operations at INL of reactors and waste management activities. The program supports safety of operations through continuous monitoring of earthquake activity, the development of INL seismic design criteria, assessments of seismic hazards for existing facilities and acquisition of major new programs, and early warning of potential future volcanic eruptions near INL. For example, the earthquake data are used to assess seismic hazards and develop seismic design criteria for the INL as required by DOE Order 420.1A "Facility Safety" (DOE, 2003).

The INL Seismic Monitoring Program operates 27 permanent seismic stations for the purpose of determining the time, location, and size of earthquakes occurring in the vicinity of the INL. The seismic data are compiled to develop an historical database that defines the zones and frequency of earthquake activity. Seismic stations are located within and around the INL near potential earthquake sources that include major range-bounding normal faults and volcanic rift zones (Figure 1). Additionally, GPS receivers are co-located at 16 seismic stations for the purpose of determining rates of crustal deformation. GPS velocities are used to identify regions of higher crustal deformation rates (such as Yellowstone, Wyoming) relative to regions of lower deformation rates (e.g. Snake River Plain, Idaho).

The INL Seismic Monitoring Program operates 22 strong-motion accelerographs (SMAs) for the purpose of recording strong ground motions from local moderate or major earthquakes. Half of the SMAs are located within INL buildings to determine the response of these buildings to ground motions in the event of a large earthquake. The other SMAs are located at "free-field" sites (not within buildings) at INL facility areas and are used to determine the levels of earthquake ground motions at the ground (rock or soil) surface. SMAs and accelerometers are also co-located with several INL seismic stations to record acceleration data and assess attenuation effects of small to large magnitude normal faulting earthquakes.

1.1.2 Seismic Stations

The INL seismic network has evolved from a single analog station to its current configuration of 27 digital seismic stations. The INL Seismic Monitoring Program also records data from seismic stations owned and operated by other seismic networks. The INL seismic network began with a single station in 1971 and expanded to three stations by October of 1972. In 1977, the INL began monitoring a station operated by BYU-Idaho in Rexburg, Idaho. The INL installed two additional stations in 1979 and from 1979 to 1985, the INL monitored earthquake activity using six seismic stations. In 1985, the INL installed a simulated Wood-Anderson system to improve the capabilities of measuring the magnitude of local earthquakes ($3.0 \leq M \leq 5.0$). During 1986, the INL began receiving seismic data from a station located in Pocatello, Idaho and operated by the University of Utah in Salt Lake City, Utah. Also in 1986, the INL began receiving data from a station located near Palisades Reservoir, Idaho that is operated by BYU-Idaho. A seismic station within the INL boundaries was added to the INL seismic network in 1987.

From 1990 to 1994, INL seismic network underwent a major expansion of seismic stations. During 1990, four seismic stations were installed within the INL boundaries. From 1991 to 1992, thirteen new stations were installed in support of construction and operation of the proposed New Production Reactor at INL. Shallow boreholes (<20 m) were drilled for seismic stations located within the ESRP. Also, monitoring of BYU-Idaho seismic station near Palisades Reservoir was terminated in 1991 to accommodate the addition of the new INL seismic stations. In 1994, two new INL seismic stations were installed near Gray's Lake, Idaho.

Several changes occurred to seismic stations from 1999 to 2003. During 1999, the INL Howe Scarp, Idaho (HWSI) seismic station was relocated further east to a new location now referred to as the Howe Fault, Idaho or HWFI because of a lawsuit filed against the Bureau of Land Management (BLM). With the implementation of the EARTHWORM computer software in 2000, up to 14 stations from several nearby networks were being recorded in real-time along with the INL seismic stations. During 2001-2003, analog seismic instruments at all INL seismic stations were replaced with digital instruments. In 2003, the University of Utah transferred ownership of the Pocatello, Idaho (PTI) seismic station to the INL Seismic Monitoring Program at which time a digital seismic station was installed. With addition of the PTI station, INL has operated 27 seismic stations from 2003 through 2010.

Beginning in 2007 and continuing through 2010, INL recorded data from Transportable Array (TA) seismic stations deployed in Idaho as part of the EarthScope Science program funded under the National Science Foundation (EarthScope, 2007). These seismic stations are three-component broadband stations that are temporarily deployed for 18-24 months in a grid that systematically covers the United States. In 2009, the INL acquired one TA station that was co-located at the INL's Crow's Nest, Idaho (CNCI) seismic station and incorporated this station into the INL seismic network. During 2010, data from two TA stations were recorded by INL.

1.1.3 Strong Motion Accelerographs

The INL accelerograph network, which began by installing eleven SMAs in critical INL facilities, consists of SMAs installed in buildings at INL facility areas and at free-field sites for both rock and soil conditions. The original network was composed of three SMAs installed within buildings at the Idaho Nuclear Technology and Engineering Center (INTEC) (formerly referred to as Idaho Chemical Processing Plant - ICPP), two located within the Materials and Fuels Complex (MFC) facilities (formerly referred to as Argonne National Laboratory – ANL), three installed within the Power Burst Facility (PBF), two located within buildings at the Reactor Technology Complex (RTC) (formerly referred to as Test Reactor Area – TRA), and one located at the Old Fire Station (OFS). From 1978 to 1979, four SMAs were installed at Test Area North (TAN) within the Containment Test facility (formerly referred to as

Loss of Fluid Test – LOFT facility). Just prior to the October 1983 surface-wave magnitude (M_s) 7.3 Borah Peak, Idaho earthquake, one SMA was installed at the INL Research Center (IRC), which is now part of the Science and Technology Complex (STC) in Idaho Falls, Idaho. Following the 1983 earthquake, two SMAs were installed within buildings at the Naval Reactor Facility (NRF). In 1984, two additional SMAs were placed within buildings at INTEC. During 1990, one SMA was installed at the Central Facilities Area (CFA). A digital SMA was co-located with an analog SMA at MFC in 1993. In 1996, two free-field SMA sites were installed, one at NRF and the other at PBF. In 1997, one SMA was installed as a free-field site at the Radioactive Waste Management Complex (RWMC). In 2003, the SMAs were upgraded to digital NetDAS SMAs. At that time, one NetDAS digital SMA replaced two SMAs co-located at Building ANL-767 (Kinemetrics analog SMA-1 and digital SSA-2 accelerographs). The SMA on the crane beam at PBF-620 was not upgraded, but removed due to decommissioning activities.

Over the years, several SMAs have been relocated because buildings have been decommissioned and demolished. In 1995, the SMA at OFS was moved to a storage building directly behind the fire station because the fire station was decommissioned. In 1997, when the storage building was demolished, this SMA was relocated to the Experimental Field Station (EFS). In 1996, the Containment Test facilities, or LOFT facilities, were decommissioned. Three of the SMAs from LOFT were moved to the TAN Hot Shop and one was placed at the TAN Air Monitoring building. In 1997, the SMA at CFA was relocated to CFA-1607 Refueling Building. In 2004, the TAN Air Monitoring building was demolished so the SMA was removed and was reinstalled in 2005 as a free-field near the TAN Hot Shop. In 2004, the PBF building was demolished and the three SMAs were removed. The SMAs were reinstalled in 2005 as free-field sites near PBF and RWMC. In 2006, four SMAs at TAN were removed due to demolition of the TAN Hot Shop. In 2007, two of these SMAs were reinstalled; one was installed at the Special Manufacturing Complex (SMC) and the other at a free-field site east of SMC. In 2008, two SMAs were removed and three SMAs were installed as a result of building demolition activities. One SMA at INTEC in building CPP-668 and one at RTC were removed. This SMA and two others were reinstalled at TAN, RTC, and the New Production Reactor seismic station, NPRI. During 2009, two SMAs were removed at INTEC from building CPP-601 as a result of building demolition activities. In 2010, the SMA at CFA, EFSF, was uninstalled, moved to the nearby pump house, and renamed to PHFF.

Three-component accelerometers and SMAs were added to some of the seismic stations. In 2002, accelerometers were added to four seismic stations: Bear Canyon (BCYI), Gray's Range (GRRI), NPRI, and HWFI. In 2003, accelerometers were added to seismic stations Telchick Spring, Idaho (TCSI), Split Crater (SPCI), and PTI. In 2004, the accelerometer at TCSI was uninstalled. In 2008, a free-field SMA was installed at the Craters of the Moon (COMI) seismic station. During 2010, the INL Accelerograph Network operated up to 20 SMAs within or near INL Site facility areas, two sites outside of the INL boundary (IRC and COMI), and five three-component accelerometers installed at seismic stations for a total of 27 sites with acceleration recording capabilities.

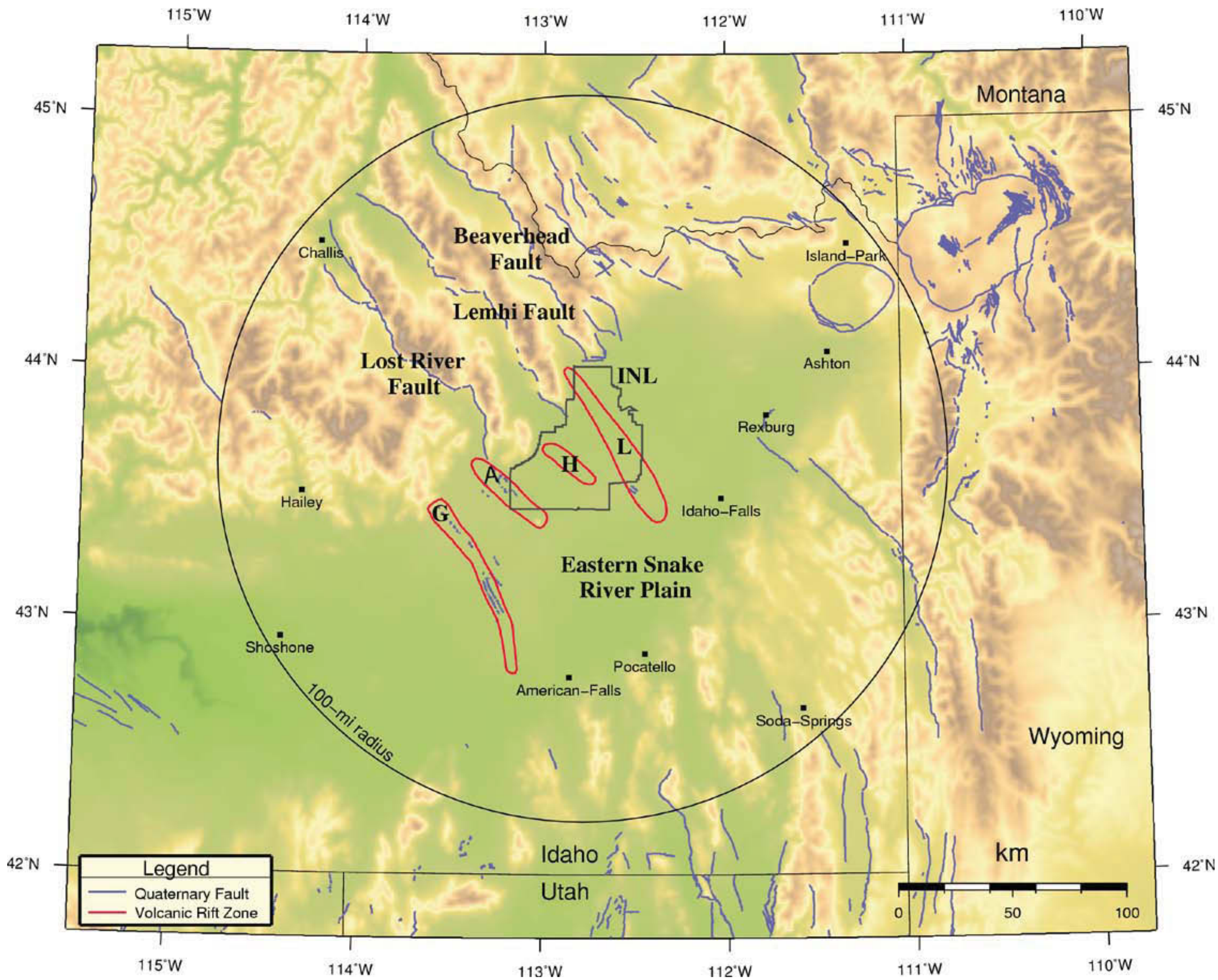

Figure 1. Map shows locations of the earthquake reporting area within a 161-km (100 mile) radius around the INL, Quaternary faults, and volcanic rift zones: G – Great Rift, A – Arco, H – Howe-East Butte, and L – Lava Ridge-Hell's Half Acre.

2. Instrumentation

2.1 Seismic Station Network

During 2010, the INL Seismic Monitoring Program operated 27 permanent seismic stations and monitored up to 50 seismic stations from other nearby seismic networks (Figure 2). Table 1 lists the name, location, and date of installation for the seismic stations owned and operated by the INL Seismic Monitoring Program. Table 2 lists the name, location, and operation dates of seismic stations owned by other agencies. Table A-1 (Appendix A) lists the information for the EarthScope Science Program TA stations. The INL recorded seismic data from these other seismic stations to improve the quality of earthquake locations within the 161-km radius of INL.

Instrumentation for INL seismic stations consists of digital recorders, one- and three-component seismometers, and three-component accelerometers. The digital recorder is a DAQSystems NetDAS field unit, which is an embedded LINUX computer with a GPS clock and Symmetric Research 24 bit digitizer. The NetDAS units have from 22 to 24 bits of data resolution over ± 20 volts for a four-channel unit or ± 10 volts for an eight-channel unit. Four channel units (NetDAS-CH4) are located at seismic stations that have one or three sensors; eight channel units (NetDAS-CH8) are at seismic stations that have more than three sensors (such as three seismometers and three accelerometers). Some seismic stations have pre-amplifiers that improve signal-to-noise ratios. The NetDAS digitizes data at the seismic station and time stamps the data with accuracies of ± 0.001 seconds. The seismic signals are transmitted by FreeWave Technologies DGR115 900 MHz Wireless Modem radios. These radios use standard IP (Internet Protocol) networking features that are included in their embedded LINUX operating system.

Single-component seismic stations have vertically oriented velocity sensors (or seismometers) that are a Mark Products model L-4C, Teledyne Geotech (TG) model S-13, or TG model S-13 Jr. seismometer. All seismic stations located within the ESRP have their vertical-component seismometer located at the bottom of 18 m or greater borehole to help dampen wind and cultural noise (Seismic, 1993) and seismometers at stations outside of the ESRP are buried within 3 m of the ground surface. Seismic stations with horizontally-oriented velocity sensors have two Teledyne Geotech model S-13 seismometers located within a concrete vault, in addition to the vertically-oriented sensor. Seismic stations with acceleration sensors have Applied MEMs Inc. model SF1500A, SF2500A, or SF3000L tri-axial accelerometers.

During 2009, the INL acquired the broadband seismograph station I14A that was installed and previously operated by the USArray component of the EarthScope project (Earthscope, 2007). As part of the INL seismic network, the broadband station – still called I14A – is co-located with INL's Crow's Nest, Idaho (CNCI) short-period seismic station. Instrumentation at I14A consists of a Quanterra Q330 data acquisition system and Guralp CMG-3T broadband seismometer. The instrumentation remains in the original vault installed by USArray and is currently networked to INL using the FreeWave radio at CNCI.

Where AC power is not available, seismic stations are powered by batteries, solar panels, and at some locations, small wind generators. Radio frequency compatible antennas transmit and receive the seismic signals. Several seismic stations are used as relay stations to allow transmission of seismic signals to the IRC in Idaho Falls. The seismic data are relayed by digital radios or internet Digital Subscriber Line (DSL) links (Appendix A). The data are acquired through EARTHWORM software over the Internet (discussed in Section 2.5). Digital seismograms are continuously displayed on three of four computer monitors referred to as "Webicorders." The fourth monitor displays a map of current earthquakes located by the INL Seismic Monitoring Program.

2.2 Strong Motion Accelerographs

The INL accelerograph network currently consists of 22 strong-motion accelerographs. Twenty one (21) are at INL facilities with 20 located at the INL Site and one located in the IRC at the STC. There are one to three accelerographs at each INL Site facility area (Figure 3). Additionally, since 2008, INL has operated one SMA outside of the INL boundary co-located at the COMI seismic station. Table 3 lists the location and date of installation for each of the SMAs in operation. During 2010, earthquakes did not trigger SMAs located within INL facilities.

INL SMAs are DAQSystems NetDAS digital accelerographs that have Applied MEMS SiFlex SF2500 tri-axial accelerometers contained within the unit. Excepting the SMA in RTC basement, each SMA is set to trigger and record to compact flash when ground motions exceed 2500 counts, which is equivalent to about 0.005 g. The SMA in the RTC basement, TRA2, is set to trigger when ground motions exceed 250 counts, or 0.005 g. The record lengths are set for 30 s of pre- and post-trigger thresholds. The tri-axial accelerometers have two horizontal components oriented in an orthogonal manner, generally aligned in the north-south and east-west directions. Appendix B lists the accelerometer orientation and instrument response for the horizontal and vertical components of each SMA. SMAs at free-field sites have GPS clocks to synchronize the internal clocks to an absolute time system. For some SMAs at free-field sites and locations within buildings, acceleration data are transmitted to the IRC via digital radios or the Internet. Other SMAs record data on compact flash disks that are retrieved by INL seismic personnel using a laptop computer.

2.3 Continuous GPS Stations

The INL Seismic Monitoring Program has a geodetic network for the purpose of monitoring crustal deformation in support of INL seismic hazards assessments. GPS data are used to investigate active crustal deformation that is on the order of millimeters of movement per year within the ESRP, the surrounding Basin and Range, and Yellowstone Plateau. GPS data help distinguish regions of high velocity gradients (or strain rates) having more frequent damaging earthquakes (e.g., Yellowstone – Hebgen Lake, Montana) from regions of low velocity gradients (e.g., eastern Snake River Plain). The regional spatial patterns of GPS data also help constrain the fundamental geodynamic processes that drive active continental deformation in the western United States.

During 2010, INL collected additional GPS phase data and teamed with Dr. Robert King at the Massachusetts Institute of Technology to process INL GPS phase data. As part of the Plate Boundary Observatory (PBO) under the EarthScope Science Program, there are currently 19 other continuous GPS sites near the Snake River Plain (Figure 4). One of these GPS receivers is co-located at INL's Great Rift, Idaho (GTRI) seismic station. In addition to continuously operating GPS sites, INL personnel collected GPS phase data at several campaign GPS sites. Dr. King processed all of INL's GPS phase data acquired up to 2010 and located within the ESRP and surrounding Basin and Range. He combined the INL GPS data with other data in the region to produce a horizontal GPS velocity field that encompasses the Pacific Northwest. Locally, the horizontal GPS velocities indicate the Basin and Range is rapidly extending at a rate greater than the very slowly deforming Snake River Plain, which is thought to explain its relative low seismicity (Payne et al. 2008; Payne et al. 2011).

An INL continuous GPS station consists of a Trimble NetRS GPS receiver connected to a Trimble L1/L2 dual frequency choke ring antenna. The antenna is attached to a 2.4 m steel rod that is drilled into a rock outcrop to a depth of about 1 m. Above ground the antenna is stabilized using a much larger PVC pipe filled with sand. This reduces the amount of wind noise within the GPS data, improving the accuracy. The NetRS receivers continuously collect GPS phase data. The phase data are relayed along with the seismic station data to DSL links, which are then accessed from the Internet at the IRC. Also, the phase data are downloaded daily from the Internet and archived by University NAVSTAR Consortium (UNAVCO).

2.4 Seismic Data Acquisition and Analysis System

The INL records earthquake data on a computer Data Acquisition/Analysis System (DAAS) at the IRC. INL began recording earthquake data on the DAAS June 8, 1991 using the U. S. Geological Survey (USGS) CUSP processing software. Since 2001, significant upgrades have been made to the DAAS as a result of computer hardware and software advances. The USGS CUSP data acquisition and analysis software that supported use of the TIMIT program were replaced with the earthquake analysis program SEISAN (developed by the University of Bergen, Norway) in 2002 and the USGS EARTHWORM processing software in 2003. From June 1991 to November 2002, earthquake data were analyzed using the USGS TIMIT program. As of December 2002, earthquake data are now being analyzed using the SEISAN program. Use of the SEISAN and EARTHWORM programs facilitated the upgrades of seismic stations and SMAs to the digital NetDAS data loggers, allowing concurrent waveform analyses of both velocity and acceleration data. Instrument responses of the NetDAS units at seismic stations and SMAs are now routinely determined and are integrated into the SEISAN database (see Appendices B and C). All digital earthquake data are also routinely archived to removable media after analysis.

Earthquake detection by the DAAS is carried out by the EARTHWORM program, which constantly monitors the ratios of the short-term average divided by the long-term average (STA/LTA) of incoming data amplitudes. This involves comparing the short-term root-mean square (RMS) average (1-s window) of the seismic data to a longer-term RMS average, which is the background noise or voltage level determined over a time interval of 20 s. The program determines that an earthquake has occurred when the STA/LTA ratios for several stations exceed a threshold value. When an earthquake is detected, seismograms are saved in a file on a disk. This file is labeled with a sequential number based on the date and time of the trigger for later reference to the earthquake in the SEISAN database. Each seismogram has 30 s of pre-event data and 20 s of post-event data stored within the file. This ensures capture of the entire earthquake waveform as in some instances, earthquakes have low-amplitude, emergent P-waves (compressional waves) with larger amplitude S-waves (shear waves). When this occurs the DAAS may trigger on the S-waves instead of the P-waves, thus, saving 30 s of pre-event time allows recording of the P-waves also.

The earthquake detection software is configured to trigger on earthquakes detected by several stations within a subnet. Subnets contain several stations that are likely to detect the same local earthquake. All INL seismic stations usually detect local earthquakes of magnitude 1.5. Subnets are specified for stations in close proximity to each other and their relationship to known seismic sources. For the ESRP though, a subnet was created for detection of small magnitude ($M < 0.5$) microearthquakes.

The EARTHWORM software also enables data sharing with other seismic networks in near real time over the Internet. The INL provides data from various seismic stations to the University of Utah, Montana Bureau of Mines and Geology, and National Earthquake Information Center (NEIC), which in return provide data to INL (Table 2). EARTHWORM records seismic data from INL and these other agencies, which are analyzed using the SEISAN program. In 2007, data from NEIC's Intermountain West seismic network were added to the data shares. From 2007 to 2010, data from EarthScope's TA stations were also part of the data shares. In 2010, INL began acquiring data from the US network station BMO near Baker City, OR. These data enhanced the azimuth coverage and magnitude determinations of earthquakes within the 161-km radius of INL.

Table 1. Seismic stations operated by INL.

Code	Station Name	Types of Sensors	Latitude North (º)	Longitude West (º)	Elevation (m)	Date Installed (Month/Year)
ARNI	Argonne North, Idaho	Borehole Vertical Seismometer; GPS Receiver	43.6667	112.6235	1533	09/1990
BCYI	Bear Canyon, Idaho	Vertical Seismometer; Three-component Accelerometers; GPS Receiver	44.3108	113.4052	2194	05/1992
CBTI	Cedar Butte, Idaho	Borehole Vertical Seismometer	43.3875	112.9115	1734	07/1986
COMI	Craters of the Moon, Idaho	Three-component Seismometers; Strong-Motion Accelerograph	43.4618	113.5938	1890	03/1992
CNCI	Crows Nest Canyon, Idaho	Vertical (Short-period) Seismometer; Three-component Broadband Seismometers	43.9283	113.4522	1914	05/1992
CRBI	Circular Butte, Idaho	Borehole Vertical Seismometer; GPS Receiver	43.8303	112.6345	1520	11/1987
ECRI	Eagle Creek, Idaho	Vertical Seismometer	43.0535	111.3705	2086	08/1994
EMI	Eightmile Canyon, Idaho	Vertical Seismometer; GPS Receiver	44.0742	112.9262	1963	04/1992
GBI	Big Grassy Butte, Idaho	Borehole Vertical Seismometer; GPS Receiver	43.9875	112.0633	1541	10/1981
GRRI	Grays Range, Idaho	Vertical Seismometer; Three-component Accelerometers; GPS Receiver	42.9380	111.4217	2207	08/1994
GTRI	Great Rift, Idaho	Borehole Vertical Seismometer; GPS Receiver*	43.2440	113.2410	1522	05/1992

Table 1. Continued.

Code	Station Name	Types of Sensors	Latitude North (º)	Longitude West (º)	Elevation (m)	Date Installed (Month/Year)
HHAI	Hell's Half Acre, Idaho	Borehole Vertical Seismometer	43.2950	112.3795	1371	06/1992
HPI	Howe Peak, Idaho	Vertical Seismometer; GPS Receiver	43.7113	113.0983	2597	10/1972
HWFI	Howe Fault, Idaho	Three-component Seismometers; Three-component Accelerometers; GPS Receiver	43.9257	113.0973	1743	10/1999
ICI	Italian Canyon, Idaho	Vertical Seismometer; GPS Receiver	44.3293	112.9412	2463	04/1992
IRCI	INL Research Center, Idaho	Low-gain Three-component Seismometers	43.5153	112.0333	1442	11/1988
JGI	Juniper Gulch, Idaho	Three-component Seismometers	44.0927	112.6768	1657	11/1979
KBI	Kettle Butte, Idaho	Borehole Vertical Seismometer	43.5907	112.3767	1678	05/1992
LJI	Lemhi Junction, Idaho	Vertical Seismometer	43.8208	112.8440	1643	05/1990
LLRI	Little Lost River, Idaho	Three-component Seismometers	43.7230	112.9330	1476	05/1990
NPRI	New Production Reactor, Idaho	Three-component Seismometers; Three-component Accelerometers; Strong-Motion Accelerograph	43.5975	112.8272	1495	09/1990
PTI	Pocatello, Idaho	Vertical Seismometer; Three-component Accelerometers; GPS Receiver	42.8703	112.3702	1670	10/1984
PZCI	Patelzick Creek, Idaho	Vertical Seismometer; GPS Receiver	44.3410	112.3172	2073	12/1991
SMBI	Sixmile Butte, Idaho	Borehole Vertical Seismometer	43.5022	113.2677	1716	05/1992

Table 1. Continued.

Code	Station Name	Types of Sensors	Latitude North (º)	Longitude West (º)	Elevation (m)	Date Installed (Month/Year)
SPCI	Split Crater, Idaho	Three-component Seismometers; Three-component Accelerometers	43.4500	112.6370	1553	06/1992
TCSI	Telchick Spring, Idaho	Vertical Seismometer; GPS Receiver	43.6193	113.4783	1731	05/1992
TMI	Taylor Mountain, Idaho	Three-component Seismometers; GPS Receiver	43.3057	111.9182	2179	10/1972

* - GPS instrumentation is owned by the Plate Boundary Observatory under the EarthScope Science Program.

Table 2. Agencies and stations from which INL receives data shares.

Code	Station Name	Latitude North (º)	Longitude West (º)	Elevation (m)	Operating Dates (Month/Year)	
National Earthquake Information Center, Golden, Colorado						
AHID	Auburn, Idaho	42.7653	111.1003	1960	11/1997	Pres
BMO	Baker City, Oregon	44.8525	117.3060	1154	11/2004	Pres
BW06	Boulder, Wyoming	42.7667	109.5582	2224	05/1996	Pres
DCID1	Drake Creek, Idaho	43.5945	-111.1845	1871	03/2005	07/2009
DLMT	Dillon, MT	45.3625	-112.5964	1569	08/2005	Pres
FLWY	Flagg Ranch, WY	44.0827	-110.6993	2078	08/2005	Pres
FXWY	Fox Creek, WY	43.6381	-111.0268	2254	07/2009	Pres
HLID	Hailey, Idaho	43.5625	114.4063	1498	08/1988	Pres
IMW	Indian Meadows, Wyoming	43.8970	-110.9392	2646	07/1980	Pres
LOHW	Long Hollow, Wyoming	43.6123	-110.6037	2121	01/1986	Pres
MFID	Camas Ranch, Mayfield, ID	43.4151	-115.8278	1302	12/2006	Pres
PLID	Pearl Lake, ID	45.0877	-116.0002	2164	08/2009	Pres
RRI2	Red Ridge, Idaho	43.3473	-111.3202	2558	07/1986	Pres
TPAW	Teton Pass, Wyoming	43.4902	-110.9507	2512	01/1986	Pres
University of Utah, Salt Lake City, Utah						
BEI	Bear River Range, Idaho	42.1167	111.7823	1859	11/1984	Pres
BMUT	Black Mountain, Utah	41.9582	111.2342	2243	10/1979	Pres
MCID	Moose Creek, Idaho	44.1903	111.1827	2149	12/1995	Pres
MLI	Malad Range, Idaho	42.0268	112.1255	1896	10/1974	Pres
NPI	North Pocatello, Idaho	42.1473	112.5183	1640	04/1975	Pres
YMC	Maple Creek, Wyoming	44.7593	111.0062	2073	12/1983	Pres
YPP	Pitchstone Plateau, Wyoming	44.2710	110.8045	2707	08/1996	Pres
Montana Bureau of Mines and Geology, Butte, Montana						
MCMT	McKenzie Canyon, Montana	44.8277	112.8488	2323	09/1989	Pres
MOMT	Monida, Montana	44.5933	112.3943	2220	10/1995	Pres
TPMT	Teepee Creek, Montana	44.7298	111.6657	2518	10/1992	Pres

Table 3. Strong-motion accelerographs operating in 2010.

Site Location (INL Facility Abbreviation or Seismic Station Code)	Building Number	Location	SMA Code	Year Installed
MFC	ANL-767	Basement	EBR	1973
MFC	ANL-768	Basement	FCF	1973
CFA	CFA-1607	Free-field	CFAF	1996
CFA	EFS[a]	Free-field	EFSF	1997
CFA	EFS	Free-field	PHFF	2010
COMI[b]	--	Free-field	COMF	2008
INTEC	CPP-666	Second Floor	FAS1	1984
INTEC	CPP-666	Second Basement	FAS2	1984
NPRI	--	Free-field	NPRF	2008
NRF	NRF-768	Free-field	NRFF	1996
NRF	NRF-A1W	First Floor	A1W	1983
NRF	NRF-S1W	First Floor	S1W	1983
PBF	--	Free-field	PBFF	2005
PBF	--	Free-field	ARAF	2005
RTC	TRA-602	Free-field	TRAF	2003
RTC	TRA-670	Basement	TRA2	1996
RTC	TRA-670	First Floor	TRA3	2008
RWMC	--	Free-field	RWMC	1997
RWMC	--	Free-field	RWME	2005
STC	IRC-602	First Floor	IRC	1983
TAN	--	Free-field	TANA	2007
TAN	TAN-601	First Floor	TANH	2008
TAN	SMC	First Floor	SMC	2007

-- – Not within a building.

[a] - Uninstalled and re-installed as PHFF.

[b]- Located at seismic station COMI, see Table 1.

Table 4. Continuous GPS sites co-located with INL seismic stations.

Code	Station Name	Latitude North (º)	Longitude West (º)	Elevation (m)	Year Installed
ARNG	Argonne North, Idaho	43.6667	112.6235	1533	2005
BCYI	Bear Canyon, Idaho	44.3108	113.4052	2194	2003
CRBG	Circular Butte, Idaho	43.8303	112.6345	1520	2007[a]
EMIG	Eightmile Canyon, Idaho	44.0742	112.9262	1963	2005
GBIG	Big Grassy Butte, Idaho	43.9875	112.0633	1541	2007[a]
GRRG	Grays Range, Idaho	42.9380	111.4217	2207	2007[a]
GTRG	Great Rift, Idaho	43.2440	113.2410	1522	1998[b]
HPIG	Howe Peak, Idaho	43.7113	113.0983	2597	2005
HWFG	Howe Fault, Idaho	43.9257	113.0973	1743	2007[a]
ICIG	Italian Canyon, Idaho	44.3293	112.9412	2463	2007
LLRG	Little Lost River, Idaho	43.7230	112.9330	1476	2009
NPRG	New Production Reactor, Idaho	43.5975	112.8272	1495	2009
PTIG	Pocatello, Idaho	42.8703	112.3702	1670	2007[a]
PZCG	Patelzick Creek, Idaho	44.3410	112.3172	2073	2007[a]
TCSG	Telchick Spring, Idaho	43.6193	113.4783	1731	2005
TMIG	Taylor Mountain, Idaho	43.3057	111.9182	2179	2007[a]

a - Although hardware was installed for the GPS receiver in 2007, the receiver began acquiring phase data in 2008.

b - Co-located at INL's seismic station GTRI, but operated by the Plate Boundary Observatory under the EarthScope Science Program.