The New England Seismic Network

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1.0 Abstract

From February 1, 2010 to January 31, 2012 Weston Observatory continued to operate a regional seismic network to monitor earthquake activity in New England (Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont) and vicinity. As of January 31, 2012, the network consisted of 16 broadband stations. The purpose of this monitoring is to compile a complete database of earthquake activity in New England to as low a magnitude as possible in order to understand the causes of the earthquakes in the region, to assess the potential for future damaging earthquakes, and to better constrain the patterns of strong ground motions from earthquakes in the region. The NESN coordinated earthquake monitoring in the northeastern U.S. (NEUS) with the Lamont Cooperative Seismic Network (LCSN) of Lamont-Doherty Earth Observatory as part of the Advanced National Seismic Network (ANSS) northeast center for earthquake monitoring (ANSS-NE). It also coordinated its activities with the National Earthquake Information Center (NEIC) of the US Geological Survey in Golden, CO and with the Earthquakes Canada group of the Geological Survey of Canada (GSC) in Ottawa, Ontario.

There were 257 local and regional earthquakes with magnitudes from 0.4 to 5.8 that were detected and located by the NESN network from February 1, 2010 to January 31, 2012, along with many microearthquakes and some other signals that were possible earthquakes; 98 earthquakes were centered in (or offshore of) New England proper. The M 5.8 event was the Mineral, VA earthquake of August 23, 2011, which was felt across all of New England. From 2010 to 2012 the earthquake activity in New England occurred at an increased rate compared with the time period from 2007 to 2010. Three earthquakes with M≥3.0 were detected in New England from February 1, 2010 to January 31, 2012, while there were no earthquakes with M≥3.0 during the prior three years. The rate of M≥3.0 earthquakes from 2010 to 2012 approached that from 1979 and 1984, which was a time of relatively high seismic activity in northeastern North America, including several M≥5.0 earthquakes in Canada and several M≥4.0 earthquakes in New England. The recent increase in M≥3.0 earthquake activity in New England may suggest that the probability of earthquakes with larger magnitudes in northeastern North American may have increased somewhat during the time period from 2010-2012 compared with the prior several years.

1.1 Changes Implemented to the NESN in this Reporting Period

During the current reporting period (2010-2012) our main goal for the NESN was to incorporate the new seismic station equipment that was installed with ARRA funding (see the Final Report G09AC00469 from Weston Observatory to the USGS) into the routine NESN operations. Under project G09AC00469, Weston Observatory upgraded the equipment at 12 NESN station, and at 6 of those stations new seismic vaults were constructed. The data from these upgraded seismic stations was integrated into the routine NESN operations. At the same time, new computer equipment at Weston Observatory was procured and installed for the acquisition, processing and archiving of the NESN data. The data acquisition system for the NESN was redesigned using this new equipment to a more redundant and robust system that is designed to better isolate and coordinate different parts of the system. The redesign, described in Section 1.3.1 below, is intended to keep most of the system seamlessly operating should one part of the system (either machine or data feed) fail. It is also designed with redundancy so that data are not lost in the event of a failure of one part of the system.

One new seismic station became operational during this reporting period. Station DUNH started operating on May 2, 2011 on the University of New Hampshire (UNH) campus in Durham, NH. This station, installed under the direction of Prof. Margaret Boettcher of UNH, is comprised of a three-component Trillium-120PA broadband seismometer and an RT-130 Reftek digitizer. The station is sampling at 40 samples per second. This station is sending its data directly to Weston Observatory, where the data are made available to the USGS NEIC and to other interested users. The location of this station in southeastern New Hampshire adds an important seismic monitoring site in this seismically active part of southeastern New England.

1.2 Importance of Earthquake Hazard Monitoring for Seismic Hazard Assessment and Earthquake Hazard Mitigation Measures in the NEUS

The NEUS is one of the most seismically active areas east of the Rocky Mountains. This area has a long and continuous history of earthquake activity going back to earliest colonial times, and it has experienced strong, damaging earthquakes on several occasions, most notably in 1638, 1663, 1727, 1737, 1755, 1884, 1904, 1940 and 1944. For the NEUS, the earthquake hazard is most clearly illustrated by the 1755 Cape Ann earthquake, which had a magnitude of about 6.0-6.2 (Ebel, 2006a). This earthquake did significant damage to masonry structures in Boston; Ebel (2006a) estimated peak ground accelerations (pga) to be in the range of about .08g to .11g, which corresponds approximately to the 5% in 50 yr ground motion on the 2008 USGS National Seismic Hazard maps. A recurrence today of the 1755 earthquake would probably lead to several billion dollars damage just within the city limits of Boston, with additional damage in the surrounding suburbs (based on a 1996 HAZUS study for the City of Boston). Damaging earthquakes also affected New York City in 1737 and 1884, and Newburyport, MA in 1727. Paleoseismological investigations have shown that the Newburyport area, which is located only 50 km from downtown Boston, also experienced a strong earthquake about 2,000 years ago (Tuttle et al., 2003).

The seismic hazard in the NEUS is compounded by the low attenuation rate of seismic waves in the northeast. Historically, cities in the NEUS have suffered damage from strong earthquakes centered even hundreds of kilometers away, so studies of the seismic hazard of the major NEUS urban areas demand an understanding of the seismotectonics, strong-motion excitation and propagation characteristics, and earthquake probabilities throughout the entire NEUS region as well as in nearby Canada.

At the present time, we still only have a very general understanding of where and how often strong earthquakes occur in the NEUS. While we have good estimates of the average seismicity rates for the region as a whole, we are not yet able to make useful estimates of the earthquake activity rates of individual geologic structures. Also, we still have much more to learn about the generation and propagation of strong ground motions in the region. These questions are now taking on increased importance due to the interest of the U.S. Nuclear Regulatory Commission (USNRC) as it considers a number of new license requests for nuclear power plants in the central and eastern U.S. The following is a brief summary of some of the important research questions that can only be addressed by continued, improved and expanded earthquake monitoring in the NEUS.

Improved understanding of historic and prehistoric seismicity in the NEUS: Ebel et al. (2000) argued that some or much of the small modern earthquake activity of the NEUS may be aftershocks of strong earthquakes that took place hundreds or thousands of years ago.

Identification of seismically active structures: Continued and improved earthquake monitoring is needed to help identify and delineate those geologic structures that are seismogenic and capable of hosting a future large earthquake.

Determination of earthquakes rates throughout the NEUS: The rates of earthquake activity in individual seismic zones must be estimated from the routinely detected seismicity at all possible magnitude levels.

Earthquake forecasting in the NEUS: Studies such those of Ebel and Kafka (2002) and Kafka (2007) can be used as a basis for forecasting earthquake probabilities in the region; continued earthquake monitoring is important to test these ideas on earthquake forecasting.

Earthquake source studies: Continued earthquake monitoring is needed to enlarge the database of earthquake source parameters such as focal mechanisms, time functions, and stress drops for earthquakes of all sizes and at all locations.

Strong-ground motion generation and attenuation in the NEUS: New instrumental recordings of strong-ground motions in the NEUS, especially near-source recordings, are needed to improve the current NEUS strong-motion attenuation relations and for calibration of ShakeMaps.

Strong ground-motion site effects in the NEUS: Many cities and towns in the NEUS are sited on soft soils. It is important to obtain instrumental measurements of actual earthquake ground motion on the soft soils as well as on nearby bedrock outcrops in the NEUS urban areas to provide quantitative estimates of amplification; seismic amplification estimates are needed to accurately assess seismic hazard in the northeast.

1.3 Present Status of the Weston Observatory NESN and Recent Improvements

1.3.1 Current NESN Stations and Data Collection

The Weston Observatory New England Seismic Network (NESN) presently comprises 16 broadband seismic stations distributed throughout the New England region (Fig. 1). At 12 of the broadband stations strong-motion accelerographs are colocated. The broadband NESN stations are all equipped with either 3-component Trillium-120PA seismometers or Guralp CMG-40T seismometers and with Reftek 130-01 dataloggers that provide 24-bit digitization. Currently all stations are sampled at 40 Hz and transmitted in real-time via ethernet link to the USGS NEIC and to Weston Observatory. Instrument responses are documented, both locally at the NESN Data Center and at the IRIS DMC, in dataless seed format. The RT-130 dataloggers stream continuous seismic data in real-time over the internet to the USGS NEIC, with data transmission also to a primary Reftek Transport Protocol (RTPD) server at Weston Observatory. In addition to the stations that WO operates, the NESN data collection system receives real-time data from approximately 20 additional stations in the region (Fig. 1). The RTPD server at Weston Observatory communicates with several software agents that monitor the network status, monitor the state of health of each station (e.g., GPS clock status, power) and report any delays in data reception. Reftek data packets are archived locally and are passed in real-time to the primary Earthworm server at Weston Observatory.

Earthworm has been the primary system for transmitting seismic data throughout the Weston Observatory data acquisition and analysis system. The implementation of the Earthworm system across various computers and platforms at Weston Observatory has been designed in a way to provide a high degree of data reliability and redundancy (Fig. 2). In order to ensure against overload and subsequent system failure, one Earthworm data server at Weston Observatory (edge1) was dedicated solely to the import and export of waveform packets in real-time from the NESN stations. A second data server (edge3) was to import and export data from LDEO, CNSN, and USNSN. The data from these primary Earthworm servers was then distributed to other servers where specific tasks, such as data archiving, the creation of helicorder pages and the extraction of waveform data for automatic or seismologist-reviewed event analysis was carried out. Exports of all NESN waveform data to the USGS NEIC, to LDEO and to the GSC was also done on one of the servers. All of the servers were backed up by new UPS systems, which in turn were backed up by an industrial-grade diesel generator able to power the entire observatory for 24-hours before needing refueling. The configuration in Fig. 2 was designed with the necessary software to isolate different data analysis functions to prevent the analysis systems from interfering with the data acquisition system. It also was designed with redundancy for the primary servers in the event of machine failure.

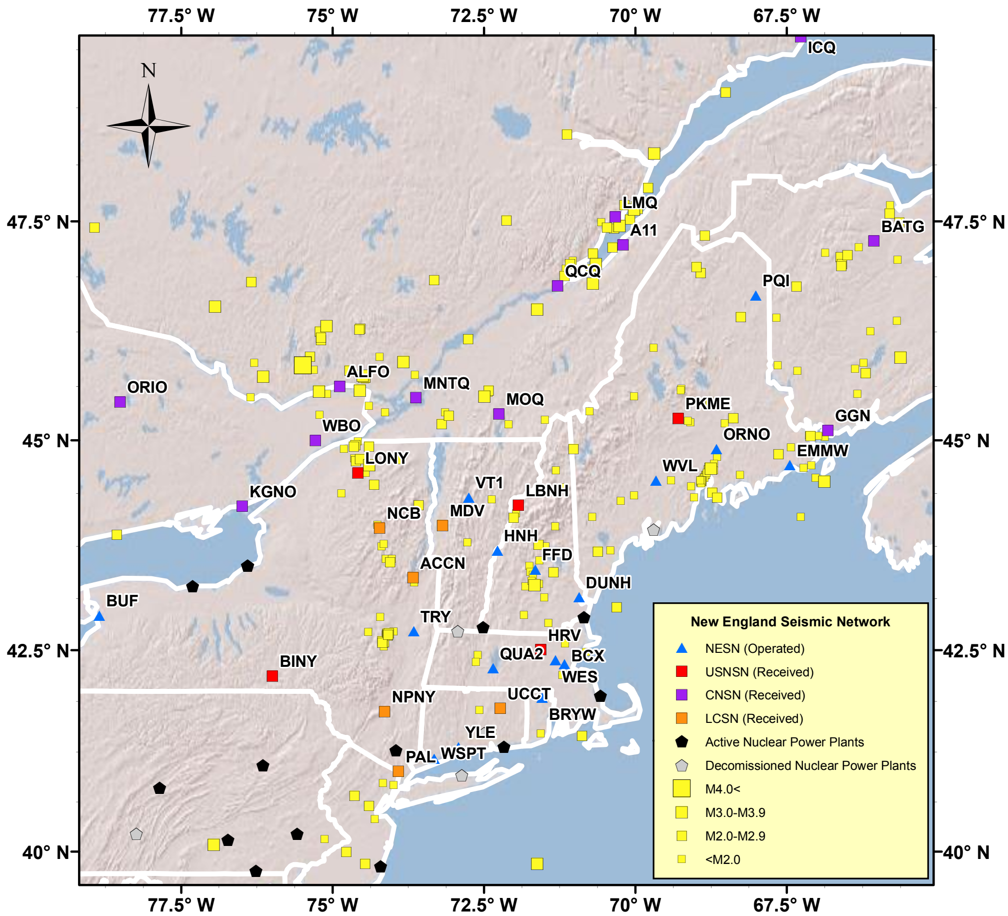

Figure 1. Map of the Northeast region showing stations operated by the New England Seismic Network (NESN), as well as those received in real-time from neighboring networks: USNSN, LDEO and CNSN. Also shown is the seismicity from 2/1/2010 to 1/31/2012.

Currently the majority of NESN stations are located on university campuses, where seismic noise can be rather high due to local vehicular traffic and machinery in nearby campus buildings. The decision to put the NESN stations at these sites was made a number of years ago due to budgetary constraints; by leveraging free power and internet offered by our university partners, we have been able to do a good job of monitoring earthquakes in New England at a minimal cost. Because our stations have hard-wired AC power and ethernet communications, our network has nearly perfect uptime, in contrast to the ANSS backbone stations in our network which provide higher quality seismic data but suffer long periods of downtime due to power and communications outages. The NESN sites are not ideal locations for sensitive seismic sensors as they experience a large increase in cultural background noise and numerous noise transients that degrade the quality of data recorded. In order to counteract this we designed and implemented a wavelet-transform based automatic detection system that uses the empirically determined noise levels at each station to optimize detection and identification of low signal-to-noise seismic events (Ebel, 2006b).

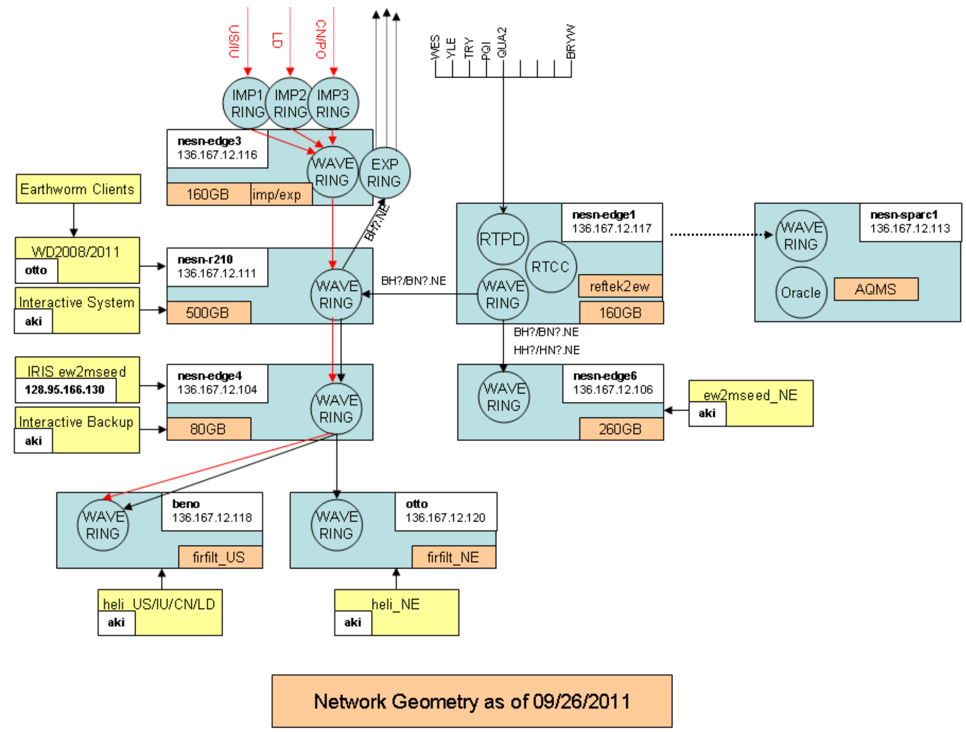

Figure 2. Schematic of the current NESN data collection system.

1.3.2 NESN Data Analysis System

The seismic data from the NESN stations along with that received from LCSN, CNSN and USNSN stations were processed both automatically in near-realtime and later by the on-duty seismologist at Weston Observatory. Weston Observatory operated an automated wavelet transform event detection, identification and location system written by John Ebel (Ebel, 2006b). The automated system was designed to handle the unique aspects of earthquake monitoring faced by the NESN in New England: a sparse, widespread seismic network; earthquakes scattered throughout the region with no one area of focus; sites with frequent transient noise bursts (due to vehicles, footsteps, etc.); and the necessity to pick arrival times from emergent body-wave phases in order to accumulate sufficient arrivals times for constrained earthquake locations.

In addition to the wavelet-transform event detection and identification system, an interactive earthquake analysis, location and notification system was in use at Weston Observatory. This internally developed system required relatively little time for an analyst to review and post an event to the NEIC. When the automated system detected an event, it paged all members of the NESN duty staff and created an earthquake event id that was passed on to the interactive system; the on-duty seismologist was then able to use the interactive system (from any computer with an internet connection and web browser) to quickly review the queued up event, adjust the picks as needed, relocate the event and post the reviewed location and magnitude to the USGS NEIC, typically within 30 minutes of an event.

(i.) Automated Earthquake Detection and Notification System

The system that was developed and now operates at Weston Observatory for the NESN is an expansion and improvement of the wavelet-transform (WT) event detector and identifier that was developed by Gendron et al. (2000) for computing event locations and magnitudes for sparse networks (Fig. 3). The automated system computes a discrete WT to 8 scales using the latest data received for each station. In the event of a detection, the software uses a Bayesian scheme (Ebel, 2010) to calculate the probability that the detection was a teleseism, a regional earthquake, a local earthquake, a quarry blast, the Rg wave only from a quarry blast (a common detection in New England), or transient noise at the station.

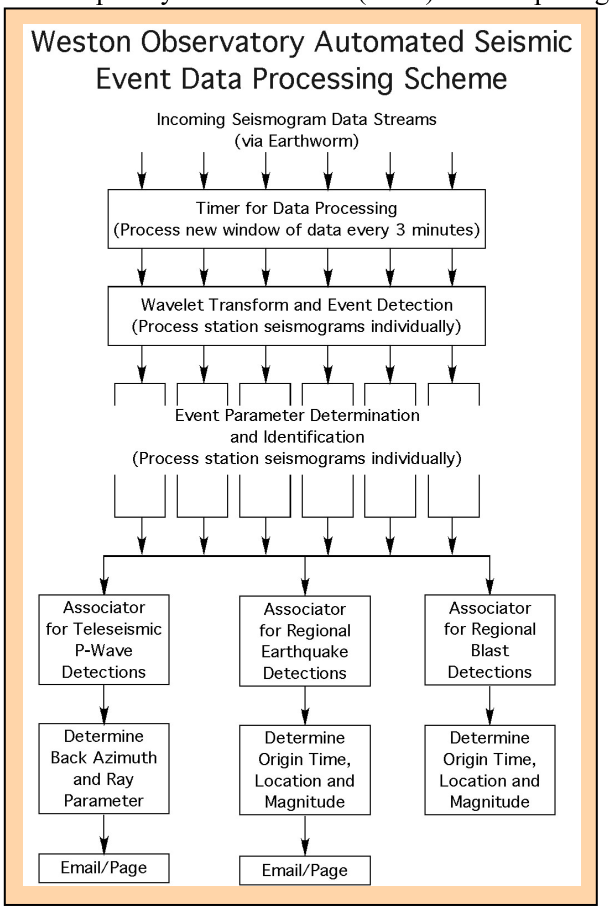

Figure 3. Flowchart of the automated data processing scheme at Weston Observatory

Once the single-station event parameters and event identification probabilities have been determined, this information is sent through a bank of three different event associators that associate the event detections from different seismic stations. If the data from 3 or more stations associate, the event wass located and Lg and coda magnitudes were computed and the event information was automatically sent via e-mail and SMS text page to Weston Observatory staff, NEUS stakeholders and other government officials on a need-to-know basis. Typically for small local earthquakes (less than magnitude 4.0), this information was sent out within 3-7 minutes of an event, meeting the ANSS standard for automated hypocenters and magnitude determinations in most cases.

An additional benefit of the improved system to automatically detect, identify and locate seismic events was that the number of small earthquakes found during routine NESN data analysis has significantly increased during the past few years. During the past several years there were a total of about 2,000-3,000 event detections each day for all the seismic stations received by Weston Observatory. Because the wavelet-transform event identification and association system does an excellent job of discriminating real events from noise transients, only a few dozen of these detections needed to be examined by an analyst, and a large number of them are indeed local earthquakes, quarry blasts, or teleseisms. Furthermore, during the summer months an average of about 10 quarry and construction blasts are detected each day in the NESN region, and those events must be discriminated from local earthquakes. As Table 1 shows, the number of local and regional earthquakes detected by the NESN has increased markedly since the implementation of the wavelet-transform detection and identification system in 2004.

Table 1.
Number of Earthquakes Centered in New England Detected by Weston Observatory from October 1, 2001 to September 30, 2011

Year	Total No. Earthquakes	# M >= 2.0 Earthquakes	# M < 2.0 Earthquakes
10/1/10-9/30/11	56	9	47
10/1/09-9/30/10	50	17	33
10/1/08-9/30/09	40	9	31
10/1/07-9/30/08	31	16	15
10/1/06-9/30/07	45	10	34
10/1/05-9/30/06	43	8	35
10/1/04-9/30/05	15	5	10
10/1/03-9/30/04	7	5	2
10/1/02-9/30/03	9	7	2
10/1/01-9/30/02	17	12	5

(ii.) Interactive Earthquake Location and Reviewed Event Notification System

When the automated system detected an event and issues a notification page, or when a felt report was communicated to the duty seismologist, either through Massachusetts Emergency Management (MEMA) or directly from the public, the NESN duty seismologist manually reviewed the seismic data to provide confirmation. To aid this, an interactive earthquake analysis, location and event notification system was developed and implemented at Weston Observatory over the past several years. Capabilities in the system include waveform picking, earthquake location, magnitude determination and event submission via QDDS/EIDS post, all accessible via standard internet browsers from any location (e.g., from home). Characteristics of this software system are that it is: free, likely to receive continued support from the seismic or, preferably, larger internet community, and modular. Modularity was key to our design because it ensured that if one component of the interactive processing system becomes obsolete, we can insert a suitable replacement with few modifications to the other modules, ensuring that the entire system can be maintained and adapted with minimal effort.

The interactive system allowed Weston Observatory staff to quickly pick waveforms, locate an event, post the solution to USGS NEIC via QDDS/EIDS, archive the event summary, update the online NESN event catalog and maps, and notify New England stakeholders, including state officials, via both text page and e-mail, from any remote machine capable of running a web browser. Coupled with the improved automated detection, location and paging system described earlier, the interactive system made it very efficient for the Weston Observatory staff to review and post an event, so that for most earthquakes within New England posted reviewed solutions to USGS NEIC could be made within 30 minutes of an event, even at night and on weekends.

1.3.3 NESN Data Delivery and Archiving

Following a seismic event, Weston Observatory computed a large number of automatic and interactive earthquake information and data products (see Tables A-3 and A-4) for official and public distribution. With the interactive data analysis system, we were typically able to post (via QDDS/EIDS) event information (location and magnitude) to USGS NEIC within 10 to 30 minutes of an event. Many of our important stakeholders – e.g., state emergency managers, state geologists, USACE – were notified of a reviewed event by email and text page sent directly through our interactive location system. Since 1994 Weston Observatory has had a memorandum of understanding (MOU) with the Massachusetts

Emergency Management Agency (MEMA) concerning all felt earthquakes in the New England region. According to the MOU, whenever a felt earthquake is reported to the authorities of any New England state, that information is relayed to MEMA. MEMA is charged with contacting a seismologist at Weston Observatory, who then verifies the occurrence of an earthquake. In an effort to provide rapid information in case of a felt or damaging earthquake, Weston Observatory established a 24/7 on-call schedule to review and process earthquake data. Each week, one of the Weston Observatory seismologists assumed the role of on-call seismologist and was responsible for reviewing and locating all seismic events at any time of the day or night. The NESN duty seismologist coordinated earthquake response with both the MEMA duty personnel and the USGS-NEIC duty seismologist. We provided both MEMA and the NEIC with our on-call schedule and a hierarchical list of NESN duty seismologist contact information.

Weston Observatory also provided earthquake information directly to the HHAN (Health and Homeland Alert Network Protocol), a new, robust emergency alert system that distributes emergency information throughout all six New England states. Also, with the interactive analysis system event summary information was instantly posted online at the NESN Data Center site (http://aki.bc.edu) for public notification. The NESN recent events catalog was automatically updated with the latest event, along with a link to an auto-generated location map, and the event was displayed on the New England Real-Time Earthquake Monitor.

At the end of each month, Weston Observatory electronically submits all final event solutions for that month to the CNSS Composite Catalog. After the end of each calendar quarter, Weston Observatory publishes all of its earthquake locations, phase readings, and amplitude information in quarterly seismicity reports via the Weston Observatory web page. These quarterly reports of seismicity contain the final, fully reviewed event locations and magnitudes for all earthquakes in New England and vicinity, and they also contain the Weston Observatory phase and amplitude readings for regional earthquakes that were centered outside of New England. Annual summaries of the seismic activity detected by the NESN are submitted to the USGS by Weston Observatory and are posted on the USGS web site http://erp-web.er.usgs.gov/ under the link Reports.

1.3.4 Leveraging Partnerships in New England to Coordinate Monitoring Resources

Weston Observatory worked with partners in New England to establish a cooperative program of earthquake monitoring to benefit both the stakeholders and Weston Observatory. Weston Observatory continued to work to procure and install new broadband stations in Maine (at the U. of Maine at Farmington and at the U. of Southern Maine in Gorham) and New Hampshire (at Keene State College). In all cases, we were asking for support from the local university or the state to purchase the station equipment, which would be installed and operated by Weston Observatory with the data transmitted to Weston Observatory for inclusion in the ANSS-NE data stream. For all of these proposed stations, the requested equipment was for broadband seismic sensors with Reftek 130 data loggers and digital radios to telemeter the continuous seismic signal from an isolated ANSS-style vault. If sufficient funding could be acquired, a strong-motion sensor was also requested as part of the station configuration, In addition to these sites, we were working closely with Earthscope as they roll out the TA and BigFoot Arrays into the Northeast over the next few years. As part of this effort, Dr. John Ebel at Weston Observatory is the principal investigator for one of the TA siting teams for southern New England and eastern New York. This station siting will take place during the summer of 2012.

Weston Observatory was also engaged in discussions with stakeholders in New England concerning the acquisition of strong-motion seismic data in the region. The US Army Corps of Engineers (USACE) operates 34 digital strong-motion instruments at various dams in New England. Currently, Weston Observatory and the USACE in Concord, MA are negotiating a Blanket Purchase Agreement (BPA) for Weston Observatory to receive and process the strong-motion data from the USACE dams in

New England. We expect to have the BPA in place sometime soon. Weston Observatory also is seeking the installation of strong-motion stations at other independently-operated dams in New England. For example, Weston Observatory submitted a proposal to First Light that includes setting up communications so that the continuous strong-motion data stream can be imported into the NESN processing system. In addition to these stakeholders, Weston Observatory was working to coordinate collection and dissemination of strong-motion data with the National Strong-Motion Program (NSMP).

Weston Observatory submitted a proposal to the Massachusetts Emergency Management Agency requesting funding to defray some of the costs of seismic network operations in New England. The requested funding will allow Weston Observatory to integrate more earthquake information into the new HHAN emergency information distribution system and to greatly expand the number of important stakeholders in the region who will receive the direct delivery of earthquake information via email and text pages.

1.3.5 Portable Instrument Pool

Weston Observatory currently maintained a pool of six Reftek RT-130 dataloggers and Guralp CMG-40T seismometers for use in aftershock surveys and temporary seismic deployments. In addition, WO had a Nanometrics Orion seismograph with a CMG-40T sensor for portable deployment. All portable instruments were purchased with Boston College funds. The portables were deployed in the New Hampshire as part of a graduate student thesis to study receiver functions in New Hampshire and Massachusetts. In May 2011 two of these instruments were deployed between Bucksport and Searsport, Maine to monitor a swarm of microearthquakes there. Two microearthquakes from that swarm were recorded, allowing high-precision absolute locations to be computed for those events.

1.3.6 Earthquake Outreach and Education at Weston Observatory

Weston Observatory has a strong commitment to public outreach and to seismology education. WO is open to the public for tours, and many people visit the facility each year. Seismic equipment can be viewed and literature about earthquakes, seismic monitoring, the ANSS, and other geoscience topics is available. Weston Observatory hosts a highly-acclaimed evening colloquium series on geoscience topics for the general public that culminates each June with our annual open-house. A listing of the 2011-2012 colloquium series presentations can be found at http://www.bc.edu/research/westonobservatory/educationlist/lectures.html.

The Boston College Educational Project (BC-ESP: http://www2.bc.edu/~kafka/SeismoEd/BC_ESP_Home.html) is another educational venture that utilizes seismic data recorded by the NESN of Weston Observatory and is led by Professors Alan Kafka, John Ebel and G. Michael Barnett (Boston College Lynch School of Education). Under the BC-ESP, middle schools and high schools in Massachusetts purchase an educational seismograph and computer for data digitization and display, and they also fund a Weston Observatory seismologist or graduate student to come into the classroom to run a series of classroom projects to teach the science of seismology. In just six years the BC-ESP has grown from 2 schools to over 30 schools. The program has become very popular in Massachusetts, and it is helping to raise the visibility of the Weston Observatory and its earthquake monitoring in the region.

A third public outreach program is provided by the NESN web pages. We have designed a digital helicorder display that can be customized for each of our partner institutions (e.g., universities throughout New England). Many of our contributing partners have set up computer kiosks in their lobby that feature the near real-time helicorder data from the seismic station that they host, displayed by a web server at

Weston Observatory. Each station display is customized to include the host institutions logo, in addition to those for Weston Observatory and the USGS-ANSS (follow the current seismograms link at http://aki.bc.edu).

1.3.7 Network Personnel

Funding levels for the NESN at Weston Observatory limited the regional network staffing to a full-time network manager (Dr. Michael Hagerty) and a part-time seismic analyst (Anastasia Macherides Moulis). The system manager's duties included maintaining the operations of all of the NESN stations (including hardware repair and maintenance), siting new stations or moving existing stations, maintaining Earthworm and related data analysis systems, and constructing the data delivery web pages (such as http://aki.bc.edu). He oversaw production and verification of dataless seeds and noise PDFs for all NESN stations. The seismic analyst was charged with checking the most recent event detections for earthquakes or quarry blasts, locating and determining the magnitude of each earthquake that is detected, updating the data lists of earthquakes and quarry blasts detected by the NESN, archiving all of the event data, and preparing the quarterly seismicity reports. The PI on this project, Prof. John E. Ebel, also spent, at no cost to the USGS, about 1/4 of his time on seismic network operations, including supervising all of the operations and staff involved in the project and participating regularly in analyzing the earthquake data. In addition to guiding graduate students who carry out research using the NESN data, he worked to improve the automated WT system for event detection, identification, association, and location/magnitude determination. Justin Starr, a graduate student at Weston Observatory, maintained the Weston Observatory web pages, including the lists of recent earthquakes in New England and vicinity, the quarterly NESN bulletins, links to other seismic network operators, educational seismology links, and other information concerning earthquakes in northeastern North America and around the world.

1.3.8 Reports and Dissemination of Earthquake Information and Data

Weston Observatory provided annual reports on this project in a timely manner as required by the USGS. In addition, quarterly reports on the seismicity of the region as detected and processed by the NESN were prepared and posted on the Weston Observatory web site along with other pertinent earthquake information such as earthquake catalogs and maps and station metadata. Following any NESN station upgrades and/or configuration changes, the NESN metadata database was updated in a timely manner and a new NESN dataless seed file were made available with the updated response information. Weston Observatory posted its solutions to the QDDS/EIDS system and to the ANSS public web pages as soon as possible after earthquakes occur, and submits all of its waveform data to the IRIS DMC along with maintaining a local archive of waveform data. Weston Observatory maintained excellent cooperation for the timely exchange of waveform and parametric earthquake data with LDEO, NEIC, the GSC and stakeholders in New England. Finally, Weston Observatory is a well-known center for earthquake information in New England. Weston Observatory staff members are frequently interviewed by TV, radio, newspaper and magazine reporters. The Observatory maintains many displays in its building concerning earthquakes in New England as well as around the world. Each year Weston Observatory hosts almost 1,000 visitors who tour the facility and collect information about earthquakes. All of these are means of disseminating information about earthquakes in the northeastern US and southeastern Canada.

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Ebel, J.E., Using Instrumental Earthquake Data for Non-Instrumental Seismology, XXVth IUGG General Assembly, IUGG2011 Melbourne – "Earth on the Edge – Science for a Sustainable Planet", abstract 3866, 2011.

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Ebel, J. E., A Strategy for Siting Strong-Motion Instrumentation in the Central and Eastern U.S., *Seismological Research Letters***,** Vol. 81, 155, 2010.

Ebel, J. E., Analysis of Aftershock and Foreshock Activity in Stable Continental Regions: Implications for Aftershock Forecasting and the Hazard of Strong Earthquakes, *Seismological Research Letters***,** Vol. 81, 155, 2010.

Ebel, J. E. and D.M. Smith, A Test of the Paleoseismicity Model in the Epicentral Area of the 1727 Newbury, Massachusetts Earthquake, *Seismological Research Letters***,** Vol. 81, 155, 2010.

Presentations by Dr. John E. Ebel Using Data from the New England Seismic Network

Ebel, J. E., Massachusetts Emergency Management Team Meeting, "The Past, Present and Future of Earthquakes in New England," Massachusetts Emergency Management Agency, Framingham, MA. (December 14, 2011).

Ebel, J. E., Seminar Series, "Using Wavelet Transforms and Bayesion Probabilities for Automatic Earthquake Detections, Identifications and Locations in New England and Vicinity," Institute for Scientific Research, Boston College, Newton, MA. (November 29, 2011).

Ebel, J. E., "The 1811-1812 New Madrid, Missouri Earthquakes," Museum of Science, Boston, MA. (November 22, 2011).

Ebel, J. E., Weston Observatory Colloquium Series, "The August, 2011 M 5.8 Mineral Virginia Earthquake and Implications for Nuclear Power Plants in the Central and Eastern United States," Weston Observatory, Weston, MA. (November 2, 2011).

Ebel, J. E., Monthly meeting, "Earthquake Monitoring in New England," Southeast Massachusetts Region, Massachusetts Emergency Management Agency, Taunton, MA. (October 28, 2011).

Ebel, J. E., AEG Monthly, "Earthquakes and Nuclear Power Plants in the Northeastern U.S.," Association Engineering Geologists, Burlington, MA. (September 15, 2011).

Ebel, J. E., NESEC Annual State Geologists Meeting, "Planning for USArray in New England," Northeastern States Emergency Consortium, Concord, NH. (May 18, 2011).

Ebel, J. E., Emergency Preparedness Conference, "The Past, Present and Future of Earthquakes in Maine and New England," Maine Emergency Management Agency, Augusta, ME. (April 29, 2011).

Ebel, J. E., 2011 Spring Symposium, "Seismic Hazard in New England and its Implications for Infrastructure," Association of Engineering Geologists, Chestnut Hill, MA. (April 2, 2011).

Ebel, J. E., New England Earthquake Scenarios Project, "Discussion of Scenario Earthquakes," Federal Emergency Management Agency, Boston, MA. (March 24, 2011).

Ebel, J. E., "Earthquakes -- Just a Shake Away," Rotary Club, Decatur, AL. (March 9, 2011).

Ebel, J. E., Public Lecture, "The Past, Present and Future of Earthquakes in New England," Weston Public Library, Weston, MA. (February 3, 2011).

Ebel, J. E. (Author & Presenter), Friday Informal Seminar Hour, "The Earthquake Activity of Northeastern North America," Earth Resources Laboratory, MIT, Cambridge, MA. (October 22, 2010).

Ebel, J. E. (Author & Presenter), Tsunami Awareness Emergency Manager Workshop, "New England Seismicity and Tsunami Deposits," Federal Emergency Management Agency, Boston, MA. (August 30, 2010).

Ebel, J. E. (Presenter), "Earthquakes in New England," Museum of Science, Boston, MA. (February 11, 2010).