ARKANSAS SEISMIC NETWORK

WHITE OAK LAKE STATE PARK HAS AN EARTHQUAKE MONITORING STATION!

Overview

Public awareness of the occurrence of earthquakes in the United States has primarily been focused on California, Alaska, or the western United States in general. However, Arkansas has had its share of significant earthquakes, most of which originate from an area of northeast Arkansas known as the New Madrid Seismic Zone (NMSZ). The NMSZ is the most seismically active area in the United States east of the Rocky Mountains. The presence of the NMSZ puts Arkansas and surrounding states at a significant risk for future, major earthquakes. Named for a small town in Missouri on a bend of the Mississippi River (see Figure 1),the NMSZ is an active fault system that extends northeastward from around Marked Tree in northeastern Arkansas to near Cairo in southern Illinois. In the winter of 1811-1812, a series of at least three catastrophic earthquakes with estimated magnitudes greater than 7.0 rattled the region. Cabins collapsed, people were frightened, and there was widespread land deformation. The NMSZ remains active and scientists believe it is still capable of producing large and damaging earthquakes (see Figure 2). On average, there is an earthquake in the NMSZ every other day, though most are too small to be felt. The felt threshold for earthquakes is generally above a magnitude 2.5, though locally there can be exceptions.

Prior to 2010, most of the seismic stations in Arkansas were concentrated around the NMSZ in northeast Arkansas where the seismic hazard is the greatest. However, earthquakes can occur at any time or location across the state. In 2008, a series or swarm of small earthquakes struck near Magnet Cove in Hot Spring County. An earthquake swarm is a series of earthquakes in a localized area that occur over a relatively short period of time. The Magnet Cove Swarm, coupled with the seismic risk that continues to be posed by the NMSZ, served as the impetus for the establishment of the Arkansas Seismic Network (ASN). The ASN initially consisted of six state-of-the-art, permanent broadband seismic stations strategically placed in 2010 within selected state parks across Arkansas. Three pre-existing broadband stations were added to the ASN in 2016. Installation of the initial six stations was funded through the Arkansas Governor's General Improvement Fund in 2008. The goal of the ASN is to establish better and more uniform earthquake detection outside of the NMSZ. The network is seamlessly integrated with other regional and national seismic networks and is operated and maintained in cooperation with the Arkansas Geological Survey (AGS), Center for Earthquake Research and Information (CERI) at the University of Memphis, and Arkansas State Parks. It was assigned the code of **AG** within the Advanced National Seismic System (ANSS). Since its establishment, the ASN has recorded seismicity such as the 2010 to 2011 earthquake swarm near the towns of Guy and Greenbrier in Faulkner County.

The six original ASN stations were located within state parks because these properties are owned by the State of Arkansas and the visitor centers have internet access. Internet access allows the seismic data generated at the station to be efficiently transmitted to CERI and the National Earthquake Information Center (NEIC) in Denver, Colorado for processing. Because vehicular traffic and other human causes of vibrations or "noise" is common in the immediate area of the park visitor centers, the stations were installed in remote or relatively quiet areas of the parks. The remoteness of the sites requires the seismic stations to be equipped with a radio transmitter and directional antenna which allow wireless transmission of the continuous stream of seismic data to a receiving antenna mounted at each of the visitor centers. The White Oak Lake State Park seismic station is located approximately 1,075 feet southeast of the park visitor center. Its ASN network acronym is **WLAR**. The ASN can be accessed via the AGS or CERI websites.

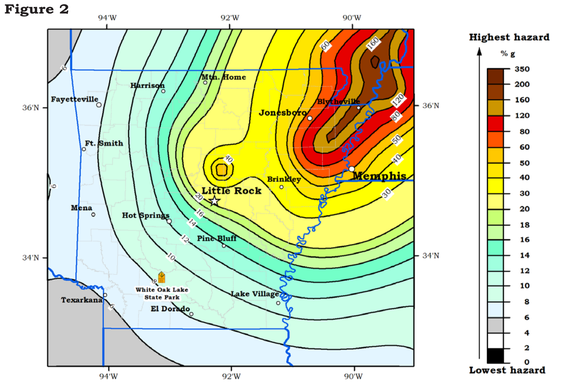
Each ASN station consists of a fiberglass, above ground equipment enclosure with a partially buried fiberglass vault located no more than twenty feet away. The above-ground equipment enclosure is weather-tight and contains a digitizer, radio transmitter, and four 12-volt batteries. Two south-facing solar panels mounted directly above the enclosure keep the batteries charged, ensuring that the seismic instrumentation will operate on a continuous basis (Figure 3). However, the station no longer relies on solar power as it was upgraded to AC power in March of 2014. The solar panels remain as a backup power source.

Ideally, the hole for the vault is excavated to the top of bedrock, however, this is not always possible due to the geologic conditions present at the site. Seismic instrumentation installed in the fiberglass vault includes two types of instruments: a broadband seismometer and a strong-motion seismometer or accelerometer. The broadband seismometer is a digital version of the traditional seismograph which senses vibrations over a large range of seismic wave frequencies or bands. An accelerometer is a special type of seismometer which is also known as a "strong motion" sensor. Strong ground motion is the engineer's measure of an earthquake's size. Accelerometers measure the movement of the ground at a particular site in terms of a percentage of gravity (g). This information is crucial to engineers when designing seismic resistant structures.

Wiring that supplies power to the vault and cables that convey seismic data from the vault to the above-ground equipment enclosure are run through a two-inch diameter polyvinyl chloride (PVC) conduit with a burial depth of approximately six inches. A removable lid is bolted down on top of the vault after placement of the instrumentation and, like the above-ground equipment enclosure, the fiberglass vault is weather-tight to protect the instruments from moisture intrusion and temperature extremes.

Arkansas Seismic Hazard Map

Figure 2

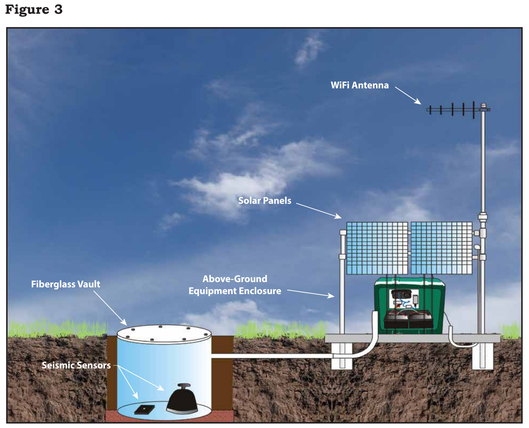


Seismic Hazard is expressed as Peak Ground Acceleration (PGA) on firm rock, in percent g, expected to be exceeded in a 50 year interval with a probability of two percent
Source: National Seismic Hazard Mapping Project (2016)

NOTE: **g** denotes acceleration of gravity

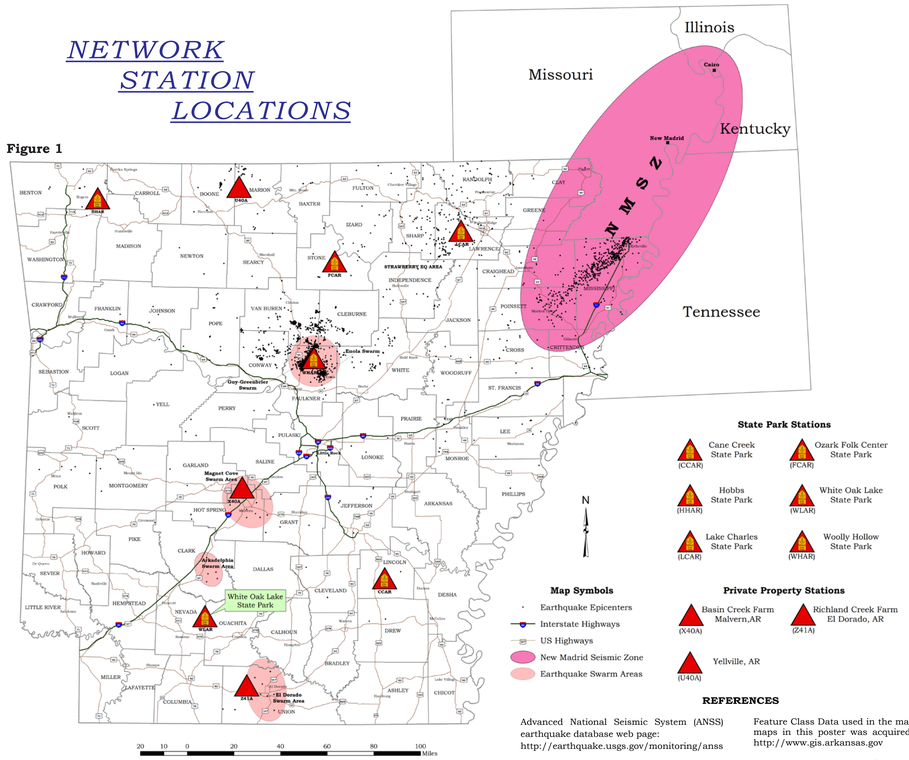
Seismic Station Schematic

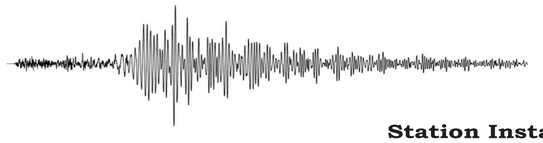
Figure 3



NETWORK STATION LOCATIONS

Figure 1





Station Installation


PLATE 1

Readying PVC conduit pipe leading to hole excavated for placement of cylindrical, fiberglass vault


PLATE 4

Placing fiberglass vault below ground


PLATE 7

Seismometer in vault with igloo protective cover


PLATE 2

Readying form and solar panel assembly for pouring concrete pad

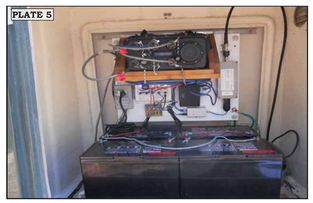


PLATE 5

Interior of above-ground equipment enclosure


PLATE 8

CERI technician going through final installation check


PLATE 3

Pouring concrete pad for above-ground equipment enclosure and solar panel support assembly


PLATE 6

GPS receiver (black) and seismometer (green)


PLATE 9

Mounting WiFi receiving antenna on mast at Park Visitor Center

REFERENCES

Advanced National Seismic System (ANSS) earthquake database web page: http://earthquake.usgs.gov/monitoring/anss

Center for Earthquake Research and Information (CERI) - New Madrid Earthquake Catalog: http://folkworm.ceri.memphis.edu/catalogs/html/cat_nm.html

Cox, R.T., 1991, Possible triggering of earthquakes by underground waste disposal in the El Dorado, Arkansas area: Seismological Research Letters, Vol. 62, No. 2, p. 113-121.

Feature Class Data used in the making of the maps in this poster was acquired online at http://www.gis.arkansas.gov

National Earthquake Information Center (NEIC) – Preliminary Determination of Epicenters (PDE) earthquake catalog for M2.5 and greater U.S. earthquakes and M4.5 and greater Worldwide earthquakes http://earthquake.usgs.gov/earthquakes/eqarchives/epic/

United States Geological Survey (USGS) Earthquake Hazards Program and National Earthquake Information Center https://earthquake.usgs.gov https://earthquake.usgs.gov/contactus.golden/neic.php

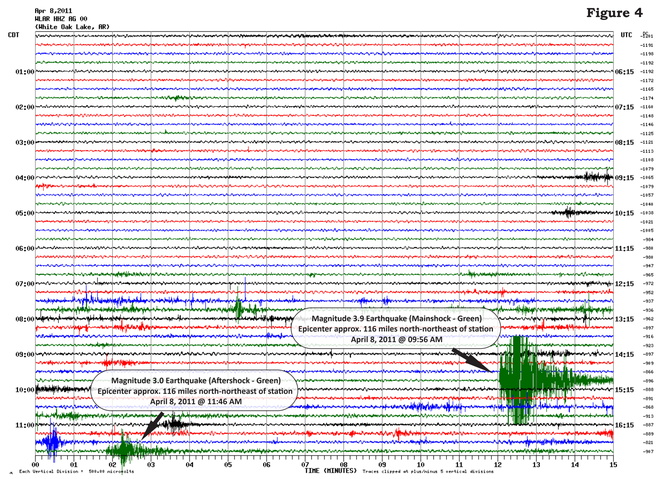
Completed Seismic Monitoring Station
White Oak Lake State Park


PLATE 10

Helicorder Display: Digital seismogram, WLAR seismic station
Two displays are generated each day (AM and PM)

Go to AGS website to view or download near real-time displays: http://www.geology.arkansas.gov

Figure 4



NOTE: Each horizontal, colored line represents 15 minutes

Area Seismicity

As depicted on the seismic hazard map (Figure 2), White Oak Lake State Park is located in a part of the State with a relatively low seismic risk. However, the map shows the seismic hazard increasing significantly as you travel northeast toward the core of the New Madrid Seismic Zone (NMSZ). Although not located in the NMSZ itself, the Park would be significantly impacted by the occurrence of a large NMSZ event or series of events.

Numerous earthquakes occur every year throughout the Natural State, but most go unnoticed by humans. Although very few events have been recorded in the area of the station (see Figure 4) over the last 300 years, at least 63 earthquakes have been documented by historical accounts and/or the United States Geological Survey (USGS) in Arkansas south of Little Rock. Notable among these events are three earthquake swarms that have occurred since 1974. As mentioned in the Overview section, an earthquake swarm is when numerous earthquakes occur in a localized area over a relatively short period of time. On February 15th and 16th in 1974, seven earthquakes ranging in magnitude from 1.6 to 4.2 occurred near Arkadelphia in Clark County. Three of these events were felt, but no reports of damage could be found. Although it's known that some earthquakes are human-induced, this short-lived burst of seismic activity, known as the Arkadelphia Swarm, is believed at this time to have been a natural occurrence.

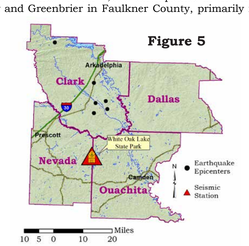
Beginning is 1983 and extending into 1989, twelve small earthquakes were recorded near El Dorado, Arkansas. Prior to 1983, there had been no detectable seismicity in the area, therefore, it has been suggested that the earthquakes were triggered by the nearby, underground disposal of bromine and oil field production wastewater via high-pressure, deep well fluid injection. Researchers have actually linked this subsurface disposal practice to the occurrence of over 1,300 earthquakes in the area of Guy and Greenbrier in Faulkner County, primarily from 2010 through 2011. In addition, there have been sporadic occurrences of what appear to be small earthquakes in the El Dorado area since 1989 with the most recent felt events occurring on December 17, 2013. These events, approximately seventeen in number, were too small or poorly constrained to be located, but were estimated to be around 1.0 in magnitude.

The third swarm in south Arkansas occurred near the town of Magnet Cove in November, 2008. There were a total of five events having magnitudes ranging from 2.0 to 2.7 with all of the epicenters located in eastern Hot Spring County. Except for a magnitude 2.4 quake near Rockport, the Magnet Cove swarm events were too small to be felt. Although they were initially thought to be naturally occurring events similar to the Arkadelphia Swarm, it is now considered quite possible that they were human-induced events associated with rock removal at a nearby quarry. This quarry is known to have been active in 2008 and it remains active today.

The WLAR station has played an integral part in the accurate location of many earthquakes that have occurred in Arkansas since its installation in 2010. Among these events are hundreds that were part of the Guy-Greenbrier Swarm. For example, Figure 3 above is a digital seismogram referred to as a helicorder display which shows the signature of a magnitude 3.9 earthquake that struck just northeast of Greenbrier on April 8, 2011. As can be seen on the display, this earthquake was followed a short time later on the same day by a magnitude 3.0 earthquake whose epicenter is within one mile of the magnitude 3.9 mainshock. This event is referred to as an aftershock. Aftershocks are smaller earthquakes that happen in the same general area during the days to years following a larger event or mainshock. Conversely, foreshocks are earthquakes that precede larger earthquakes in the same general location. There were no discernible foreshocks prior to the magnitude 3.9 mainshock.

It is worth noting that recently discovered evidence indicates large historical earthquakes have occurred outside and to the south of the NMSZ in Ashley, Drew, Lee, and Phillips counties. The White Oak Lake station will serve as an important monitoring point should earthquake activity resume in these areas.

Figure 5



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