Report of Studies Being Considered and Conducted by West Virginia Department of Environmental Protection Office of Explosives and Blasting December 31, 2010

This report is being submitted by the Office of Explosives and Blasting (OEB) to the Joint Committee on Government Finance in accordance with the requirement of W. Va. Code § 22-3A-10(b). Below is a summary of the various research projects OEB is currently working on or may work on in the future. The status of the various projects is discussed below.

Airblast Predictability

In 2009, OEB started research dealing with the predictability of airblast by acceptable methods using data related to blasts at surface coal mines in West Virginia. This project is in the final stages of research and more data is being collected to reinforce conclusions.

Typically, adverse effects of blasting are associated with ground vibrations and the related damage potential. The OEB has received complaints from citizens about their homes being shaken by blasts. Upon investigation it was determined that blasting ground vibrations should not be the cause of the complaints. It was discerned that the cause of the complaints were more likely airblast related. This, coupled with increased incidents of airblast violations, led OEB to examine the predictability of airblast and to reconsider current monitoring requirements. This study is evaluating the various methods of airblast prediction. The final results of this evaluation will help OEB determine a realistic method for ensuring compliance with airblast regulations in West Virginia. There are minimum scaled-distance factors developed by the United States Bureau of Mines (USBM) based on explosive charge weight and distance to structures to protect low-rise residential structures from blast damage caused by ground vibration. If this method is used as a compliance option, it has been recognized for decades that no damage should occur at low-rise residential structures. However, this compliance method does not directly ensure that there will be no adverse effects from airblast. The USBM also established a relationship for airblast by modifying this scaled distance equation using a cube root rather than a square root function.

In 2009, OEB studied past airblast violation incidents to gather base data for airblast compliance. In 2010, OEB placed five seismographs on the property of a large surface mine and gathered six months of blast data. The airblast data correlated well for blasts conducted on clear or rainy days. The air overpressure predictive relationship on rainy days was doubling that of clear days. The data on cloudy days is too varied for good correlation, probably because of the degree of cloud cover when the subjective term "cloudy" is reported on the blast log. OEB plans to repeat the study at different mine locations to verify the current data and conclusions.

When investigating blasting complaints, it is difficult to forensically determine the actual blast parameters and offsite effects in the absence of seismograph monitoring. Monitoring provides site-specific data for airblast and ground vibration from blast events. Cube root predictions can provide a safety factor, however, there can be blowouts or lightly burdened shots that create high airblast and go undocumented in the absence of seismic monitoring. When seismic monitoring is provided and high levels of airblast are recorded, the next step is to evaluate the blast parameter that contributed to the high airblast event.

Autonomous Crack Measurement

Dr. Charles Dowding has proposed a study to transfer autonomous crack measurement (ACM) technology, which is a method to measure changes in crack dimensions in residential structures to the state blasting regulators. This study and training exercise will train the OEB technical group in the deployment and use of the ACM technology for research and compliance evaluation of existing standards for specific structures. Dr. Dowding and others have studied effects of relative humidity, temperature, and other sources, including blasting vibrations on existing cracks in residential structures. Dr. Dowding requested funding from the United States Office of Surface Mining Applied Science Program for this study and was denied by OSM for fiscal year 2011. OEB will remain available for training and implementation of ACM technology as Dr. Dowding pursues other funding sources. When training is completed a final report will be generated.

Residential Structure Response to Excessive Ground Vibration and Airblast

In September 2010, a rare opportunity to monitor blasting effects on a low-rise residential structure where vibration levels would regularly exceed regulatory limits was presented to OEB. The unoccupied residential structure was located on a surface coal mine near Morgantown, West Virginia. The permittee recently purchased the residence and planned to mine up to the structure, have it torn down, and mine through the area. The house was a sound, one-story residential structure approximately 60 years old, like many dwellings near WV surface mines. The residence was remodeled approximately 20 years ago with the addition of a room and extension of an existing basement to establish a full basement under the structure. It appears that one whole side of the house had once been a porch, but is now part of the living room, an interior hallway, and a bathroom. The chimney top was reportedly in bad shape and was recently removed to the roof line after a portion fell onto the new metal roof. With very short notice OEB planned a vibration study of this structure.

The house received the required pre-blast survey conducted by the permittee. OEB conducted a follow up pre-blast survey inside and outside the house to document existing imperfections, i.e. cracks, hanging wallpaper, etc., prior to OEB monitoring of the structure and blasting vibrations. OEB placed seismographs inside and outside the house to monitor blasting vibration effects. Seismograph geophones were mounted on interior walls to measure corner and mid-wall structural responses relative to the blast vibration. OEB conducted periodic inspections of the house to document changes in the structure due to the blast vibrations and to collect data from the monitoring equipment. OEB is in the process of analyzing the data. Preliminary data indicates the need for more monitoring of structures that are within close proximity to blasting.

OEB has approached another surface coal mine for the purpose of monitoring unoccupied residences on and near its blasting operations. The mining company has purchased these residential structures in advance of the mining operations. These structures present an ideal situation for continued seismograph, structure response, and existing wall crack width monitoring research of blasting effects. OEB has made preliminary inquiries with the company for the purpose of studying these structures as mining advances towards them until they are eventually removed for the advancing mine. Academics from several universities have been contacted for possible joint project involvement in research at these houses. This could be a multiyear project. Discussions with the mining company and various universities are ongoing.

Comparisons Electronic Digital Detonators vs. Conventional Pyrotechnic Delay Detonators

A study is being conducted by Dr. Braden Lusk, a professor at the University of Kentucky, to evaluate the performance of electronic digital detonators compared to conventional non-electric pyrotechnic delay detonators at a West Virginia coal mine. OEB provided three of the ten seismographs being used in the study and assisted the research team with mine personnel relations, as well as deployment locations and installation of seismographs. Typically, conventional detonators have inherent errors commonly referred to as “cap scatter.” This cap scatter error can be as high as +/- 10% of the reported millisecond (ms) delay interval of the detonator (blasting cap). Digital detonators are new technology with very accurate reported delay intervals. This project involves baseline monitoring of non-electric blasts to get vibration parameters for the blast area, followed by monitoring of digital blasts to compare the blast vibrations.

The second phase of the project involves planning various shots using different timing configurations with digital electronic detonators. Digital detonators are very accurate and have less than 1% cap scatter in their millisecond timing. Therefore, blasts using digital detonators have the reported advantage of being able to reduce vibrations and improve fragmentation when compared to blast using non-electric pyrotechnic detonators.

The third phase of the project plans to design blasts with delay intervals of less than eight milliseconds. Blasting regulations and the industry have long held the standard of timing blasts and evaluating blast vibrations based on eight millisecond delay intervals for pyrotechnic detonators. The critical component of comparing these detonators will be to maintain consistency of blast parameters, i.e. burden, spacing, product usage, and other blast conditions.

Currently, phase two seismic monitoring of the project has begun and will continue with initiation of phase three blast monitoring planned for next year. OEB will be finished with its involvement once blasting is completed and the data is reviewed. Final data should be collected, reviewed, and analyzed next year. Dr. Lusk will coordinate his findings with OEB for comments and input.

Seismograph Monitoring Influences of Geophone Orientation

In 2008, OEB assisted Dr. Cathy Aimone-Martin in a study by monitoring surface mine blasts at multiple mine sites in West Virginia. The purpose of this study was to investigate the influence geophone placement and orientation may have on seismograph recordings. OEB proposes a project that will evaluate different blast monitoring methods and variance of vibrations from those methods. Although there are recommended guidelines for placing geophones for measuring ground vibration, the deployment of these instruments can vary depending on the individual application.

This study used four seismographs located side-by-side with various geophone coupling methods. These seismographs were located only a few feet apart to monitor the blast at the same location. The four methods of monitoring were: placement of the geophone on the surface without spikes; surface mounting with spikes; burying the geophone with spikes; and surface mounting with spikes and a sandbag. This monitoring was conducted for several blasts at several different mines to document the effect of geophone coupling on ground vibration readings. The intent was to strategically place the monitoring units so as to record readings in a vibration range of 0.2 to 0.8 inches per second. This should be the range of blast vibrations for most near-field blast operations. OEB assisted by providing field support and did not control accumulation of the data. Currently, the data has not been published or reported.