

# The Application of Forensic Geophysics to Duffy's Cut (MP 59) Archaeological Site in Malvern, PA



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## Abstract

This project used forensic geophysics on the Duffy's Cut Archeological site in an attempt to locate 50 of a total 57 bodies buried in 1832, and aid in the historic investigation. Previously, only a subtle seismic anomaly was found in the area of the suspected mass grave, and further study was needed to confirm the findings prior to excavation. I conducted 3-D Electrical Resistivity Surveys using a 56-Channel system over the stone monument, placing the electrodes in a square grid pattern and obtaining electrode height before placing an elevation file and measurement file into an inversion program. The inversion program then calculated the apparent resistivity and Jacobian matrix values to generate the two models (dipole-dipole and pole-pole), which gave a clearer picture of the two seismic anomalies found in the monument area of the site.

## Background

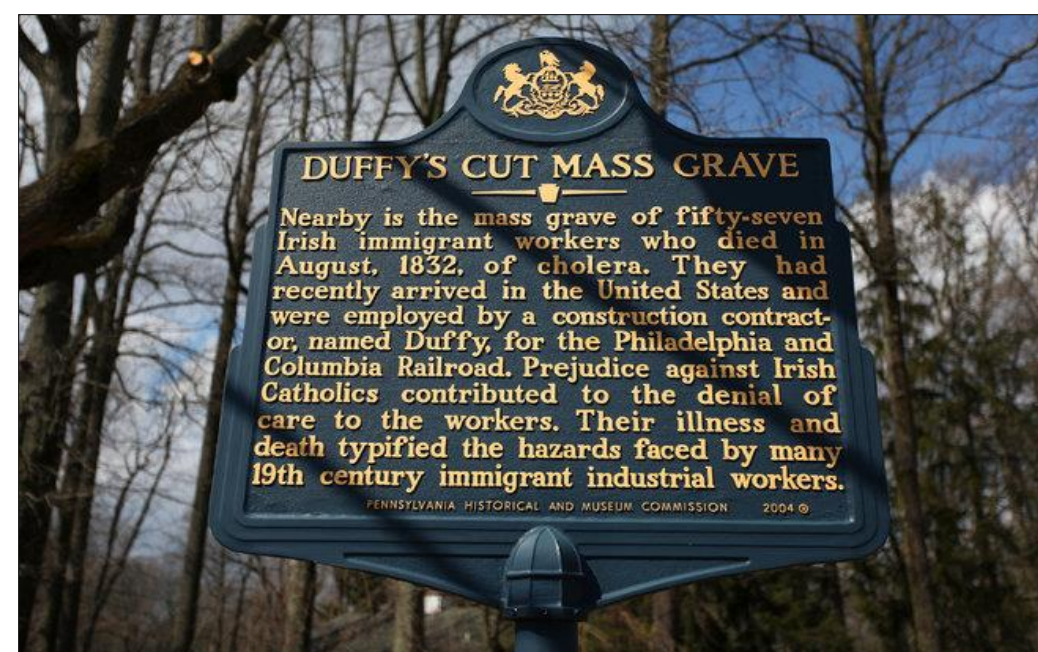


Figure 1: The historic sign near the site in Malvern, PA



Figure 2: Degraded human remains

Duffy's Cut is a site in Malvern, PA named after the railroad contractor hired to clear a 30 mile stretch of land that now serves as the SEPTA R-5 line. In 1832, he hired 57 Irish immigrants to clear the land, excavate and lay track, and all of the workers died within 6 weeks<sup>1</sup>. Their deaths were attributed to cholera, but seeing as only an estimated 50-60% of Asiatic cholera resulted in fatality<sup>2</sup>, Historians Frank and Bill Watson of Immaculata University suspected something else had occurred.

The brothers uncovered a 32 page historic Pennsylvania Railroad file owned by their grandfather that contained 22 documents (dating from 1889 to 1932) related to the deaths at Duffy's Cut. According to the documents, workers contracted cholera, were denied medical treatment, and tried to escape from the vicinity, but were forced back to their camp<sup>3</sup>. The Watsons partnered with anthropologist Dr. Janet Monge and geophysicist Dr. Timothy Bechtel (both from the University of Pennsylvania) to investigate the site. On March 20<sup>th</sup> 2009 the team recovered 120 bones, and uncovered a mass grave with 5 bodies.

Since that time, 2 subsequent bodies were unearthed, and Dr. Monge has found evidence of perimortem wounds on 4 of the skulls that were recovered. More evidence is needed to establish a causative link, but the historians suspect that the workers that did not suffer from cholera were killed by either railroad employees or a vigilante group in the community. Based on the information included in the Pennsylvania Railroad file, it is suspected that the remaining 50 men are also buried at this site.

## Methods

The initial survey method used at the site was Ground Penetrating Radar (GPR), followed by a seismic survey performed by Dr. Bechtel, using a fan-shaped array of geophones around a central shotpoint to identify geologic anomalies. The Seismic Fan Shot Data (Figure 5) identified two areas of interest, but to gain a clearer picture of the geology, it was important to utilize another geophysical method of analysis prior to excavation. The Seismic Refraction Cross Section illustrated 30' between the ground surface and bedrock, and indicated the presence of two distinct anomalies.

Electrical resistivity was chosen as the secondary geophysical method, and the survey was conducted by placing 56 electrodes in a square grid pattern at 10' spacing intervals and applying an electrical current (Figure 3, first dipole-dipole and then pole-pole). Two additional electrodes provided reference points and were added at a length of greater than 5 times the spacing in the grid area. Next, the site was surveyed to obtain electrode heights (site elevation=537') and when the data points were fully collected, the terrain elevation file and measurement file were loaded into the EarthImager 3D inversion program. The inversion program uses the coordinates plotted in the x, y and z directions to generate the 3-D Image, which can then be analyzed either as an entire inverted resistivity image, or in cross sections through the dynamic slice portion of the AIG Program.

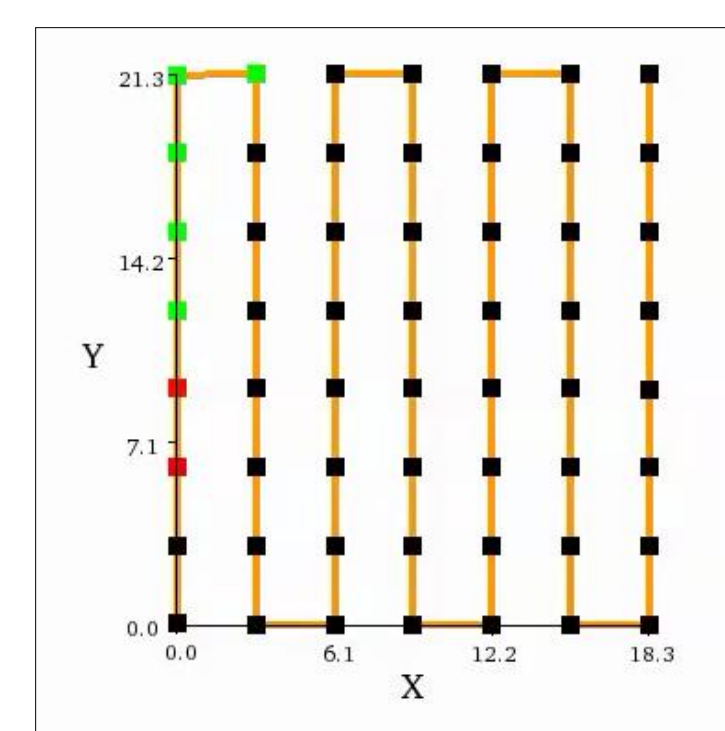


Figure 3: Screenshot of resistivity coordinates



Figure 4: 3-D Resistivity Survey equipment

## Analysis and Discussion

The 3-D image for dipole-dipole testing gives a shallow depth at a very high resolution, allowing for the two anomalies to show up clearly with lower resistivity. The anomaly to the right of the origin is positioned directly below the site's stone monument, as expected. The lower resistivity cell to the left of the origin extends beyond the survey boundary, and is thought to extend beneath the railroad tracks. The high resistivity areas represent the original embankment area, and the site's natural topography. These results match the anomalies identified in the Seismic Fan Shot Survey, and confirm that the excavation should focus on both anomalies in this small area near the monument and tracks.

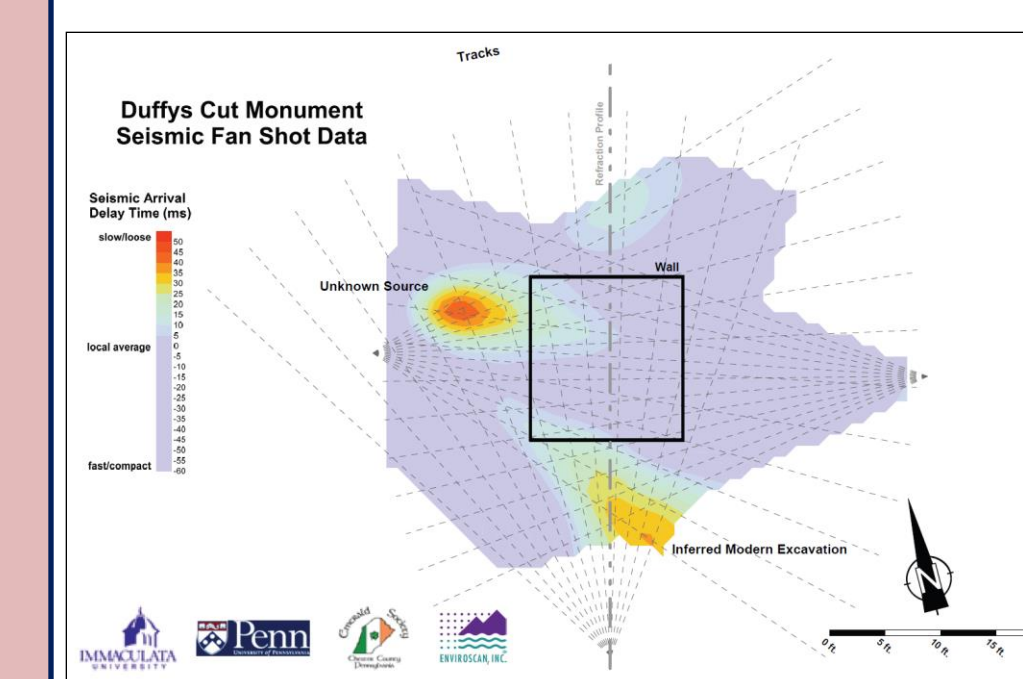


Figure 5: Results of the Seismic Fan Shot Survey

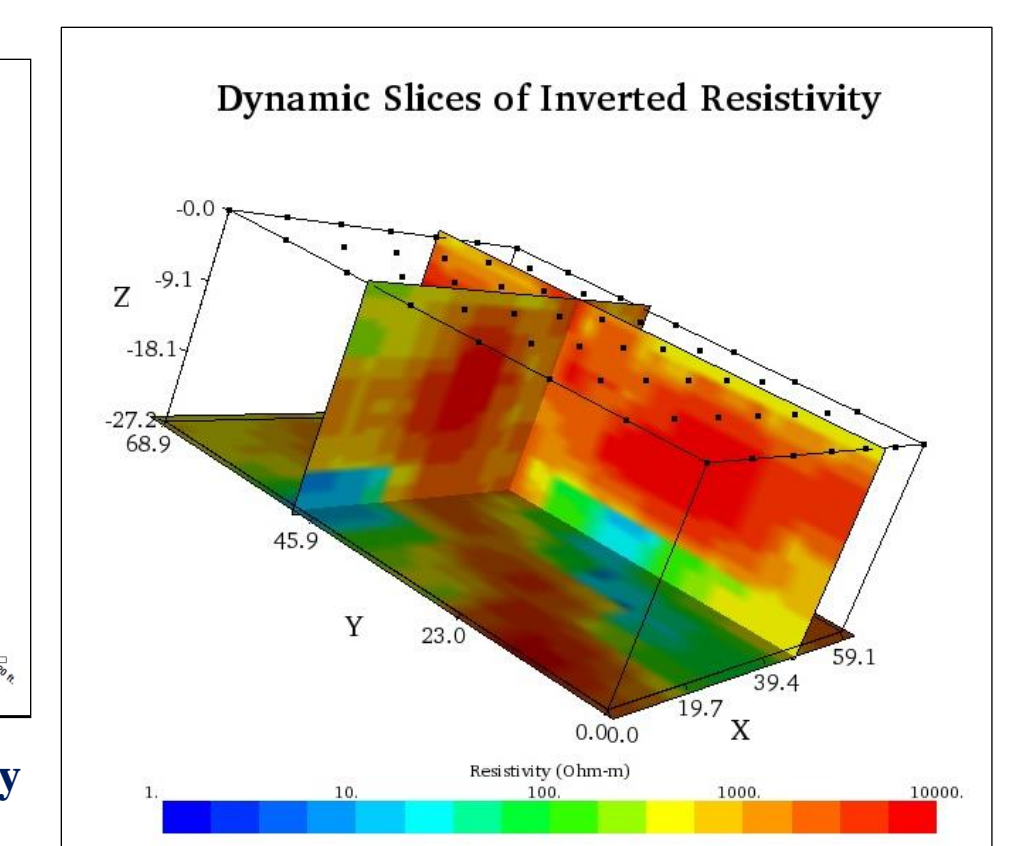


Figure 6: 3-D Resistivity Dipole-Dipole Results

## Conclusions

The best preserved skeletons at Duffy's Cut were still considerably degraded due to the region's acidic soils, with only isolated portions remaining (reference Figure 2). Because these bodies were not well preserved even when carefully buried in coffins, it is very unlikely that articulated bones will be located to allow for identification of the bodies in the mass grave. I recommend that any excavation focus on the anomaly to the right side of the origin to confirm that human remains are present and avoid interfering with the active railroad operations until the presence of human remains can be confirmed.

## Works Cited

1: Valania, Jonathan. "Murder in the Time of Cholera: Researchers suspect a cover-up in the Main Line deaths of 57 Irish railroad workers 178 years ago." Retrieved 1-5-2012. Available online at <http://www.philadelphiaweekly.com/news-and-opinion/cover-story/Murder-in-the-Time-of-Cholera.html?page=1&comments=1&showAll=#ixzz2HL3dQet6>. 2: Todar, Kenneth. "Vibrio cholerae and Asiatic Cholera". Todar's Online Textbook of Bacteriology. Retrieved 1-5-2013. Available online at <http://www.textbookofbacteriology.net/cholera.html.3>; Pirro, J.F. "Lost and Found." Main Line Today. Retrieved 1-6-2013. Available online at <http://www.mainlinetoday.com/core/pageetools.php?pageid=7705&url=%2FMain-Line-Today%2FMay-2010%2FLost-and-Found%2F&mode=print>. Figure 1: New York Times, Figure 2: Frank Watson, Figure 3: Kelsey Gibbons Figure 4: Kelsey Gibbons, Figure 5: Dr. Tim Bechtel, Figure 6: Kelsey Gibbons