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SYNOPSIS: Geotechnical and geophysical investigations are being performed at a site which is located within 60 km of the epicenter of the 8.7 magnitude New Madrid February 7, 1812 earthquake. The exploration is being performed to determine the seismic response of the soil profile and to evaluate the liquefaction potential of the site. Permanent downhole instrumentation for seismic monitoring will be installed.

INTRODUCTION

The Paducah Gaseous Diffusion Plant (PGDP) is a U.S. Department of Energy (DOE) facility which is, by contractual agreement, managed and operated by Martin Marietta Energy Systems, Inc. (MMES). The PGDP is located about nine miles northwest of Paducah, Kentucky and about four miles south of the Ohio River (Figure 1).

The PGDP was constructed in the early 1950's. At that time, awareness of earthquake design was not evident in the eastern U.S. In the past 15-20 years, the awareness of the need for earthquake design in the eastern U.S. and around the world has increased dramatically.

The PGDP is located near the New Madrid Seismic Zone in the central U.S. This zone is the location of the largest earthquakes known to have occurred on the North America Continent. These earthquakes occurred during the winter of 1811 and 1812, the first on December 16, 1811 having an estimated Richter magnitude of 8.4, the second on January 28, 1812 of magnitude of 8.6 and the third on February 7, 1812 of magnitude of 8.7. The PGDP site is within 60 km of the epicenter of the February 7, 1812 earthquake.

DOE issued General Design Criteria 6430.1A (1) on April 6, 1989 and UCRL-15910, Design and Evaluation Guidelines for the Department of Energy Facilities Subjected to Natural Phenomena Hazards (2), in June 1990. These documents define the criteria for seismic evaluation of DOE facilities and are the driving force behind the seismic evaluation of PGDP.

In order to implement the DOE seismic evaluation criteria the following program was initiated to define the seismic ground motions at PGDP.

A. Review the geology and seismology
B. Perform a geotechnical characterization
C. Perform a liquefaction evaluation
D. Define the seismic responses of the soil profile
E. Install seismic monitoring instrumentation

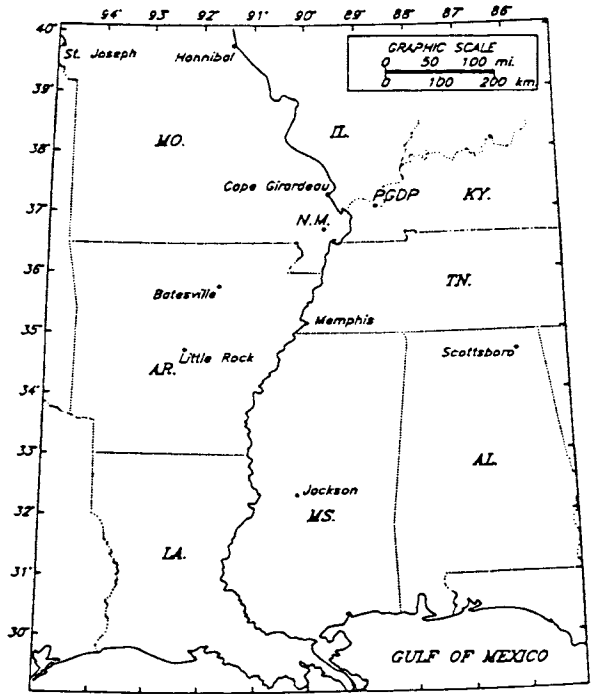


FIGURE 1 – LOCATION MAP

PGDP = U.S. D.O.E. PADUCAH GASEOUS DIFFUSION PLANT, PADUCAH, KY.

N.M. = NEW MADRID, MO.

This paper will present the details of this ongoing program and the results to date.

GEOLOGY

The PGDP encompasses about 3423 acres that is located in the Jackson Purchase Region of western Kentucky; 748 acres of the reservation are within the security fence. The location map (Figure 1) shows the PGDP with respect to other states and selected cities.

The ground surface in the region is relatively flat; elevations range from about 290 feet Mean Sea Level (MSL) to 430 feet MSL over a distance of several miles. For reference, the normal pool of the Ohio River (about 4 miles to the north) is 290 feet MSL. The area within the security fence was graded in about 1952; the ground surface in this developed area ranges from about 370 feet MSL to about 380 feet MSL.

Figure 2 shows the general stratigraphic relationships for the area. Note that although the pre-Cretaceous formations are present both north and south of the reservation, the post-Cretaceous formations differ from north to south. The Porters Creek Clay and Eocene sands (Claiborne, Wilcox Formations) present immediately to the south of the security area have been eroded and replaced to the north by Continental Deposits. Each formation or unit is discussed below in order of increasing geologic age and increasing depth below the present ground surface.

Recent and pleistocene age alluvium is present only in the flood plains of the adjacent creeks and the Ohio River. The surficial soil at the reservation consists of up to 25 feet of unstratified loess (wind deposited material) that consists of yellowish-brown clayey silt and silty clay that contains iron oxide concretions.

Continental Deposits

These non-marine sediments consist of an estimated 100 feet of unstratified to poorly stratified, interbedded and interlensing sand, gravel silt and clay.

These materials are predominately yellowish-brown and reddish-brown in coloration. Clay lenses and clay balls occur locally and thin intervals of the sand and gravel may be cemented by iron oxide. The available data show that the base of this granular interval, referred to as the regional aquifer, ranges from about 265 feet MSL to 290 feet MSL. Engineering data indicates that this interval is a uniform, very dense material with blow counts of more than 50. Accordingly, it has a high shear strength and a relatively low coefficient of compressibility.

Claiborne and Wilcox Formations

These marine formations of Eocene age are apparently present to the south of the PGDP, where they have not been removed by erosion. They are composed of interbedded and interlensing micraceous fine sand, silt and clay of various colors.

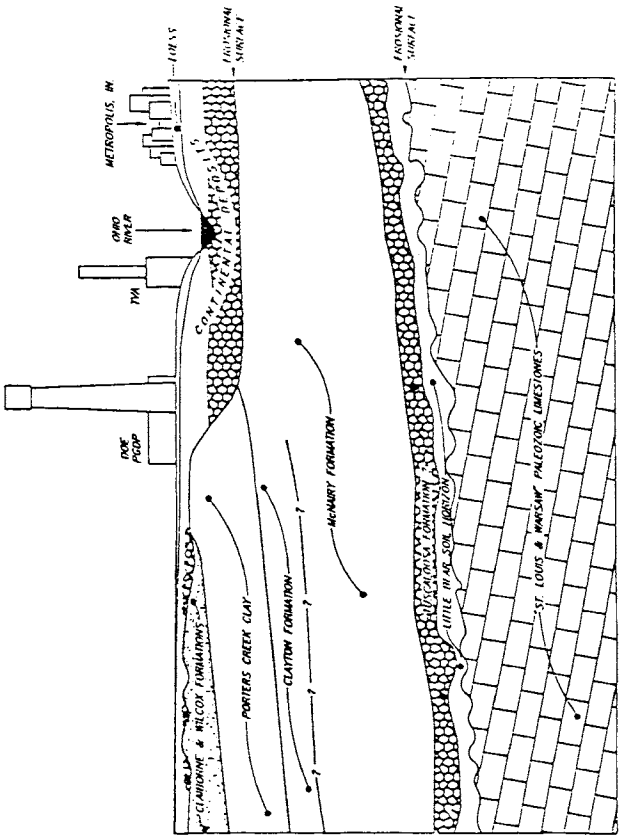


FIGURE 2
NORTH-SOUTH SECTION SHOWING STRATIGRAPHIC RELATIONSHIPS

orters Creek Clay

he Porters Creek Clay is present beneath the outhern portion of the PGDP and extending outhward where it has not been removed by post- aleocene erosion. Dark grey, medium grey and live colored micaceous clay characterizes this arine formation.

layton-McNairy Formations

hese marine formations underlie all of the lant area, being composed of interlensing and interlaminated clay and sand. Colors range from light grey to dark grey, orange, brown and white.

GEOTECHNICAL CHARACTERIZATION OF SITE

Many shallow borings have been drilled at the site since the 1950's, primarily for foundation investigations or for investigations related to environmental concerns.

Two holes have been drilled into the Mississippian age limestone in the summer of 1990 at the site. Twelve holes were drilled to a depth of approximately 100 feet, the tops of the McNairy formation. These holes were used to gather shear wave velocity data. The locations of the holes which were spread over 4 locations are shown in Figure 3.

LIQUEFACTION EVALUATION

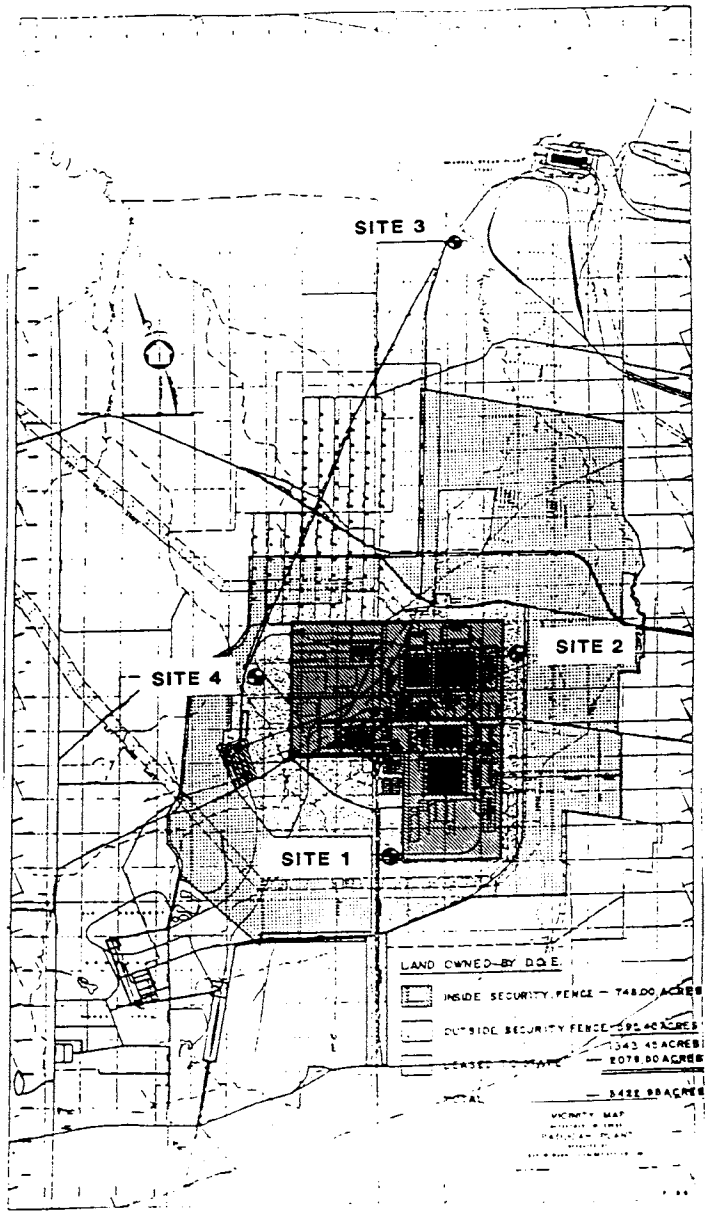
The liquefaction evaluation of the site will be a phased approach starting with simplified conservative methods and progressing to more sophisticated methods if required to provide a conclusive determination of safety.

The first phase will be to develop a detailed understanding of the site conditions from the geological, geotechnical and geophysical investigations and to perform a liquefaction evaluation using the approach defined by Seed, Idriss, and Arango (1). This evaluation is based on field - performance - based correlation between soil strength and standard penetration tests (SPT) blow counts.

Additional evaluations will depend on the results of the first phase and the finalization of the seismic response of the soil deposit.

SEISMIC RESPONSE OF SITE

A probablistic seismic hazard analysis is being performed for the site using the methodologies developed by the Lawrence Livermoore National Laboratory (LLNL) (4) and the Electric Power Research Institute (EPRI) (5). These methodologies were developed for the eastern United States where the causative faults of earthquakes are unknown. The methodologies should be used with caution in the near field of large known causative faults where the point source approximation breaks down and the finite nature of the rupture fault should be taken into account. An example of such an area in the Eastern United States is the New Madrid area.



PGDP FSAR DRILLING LOCATIONS
FIGURE 3

Since this site is near the New Madrid area, the seismic hazard methodology is being modified to consider the New Madrid area as a line source or rupture fault. The following paramaters are being evaluated for the line source modeling:

A. fault locations
B. rupture length
C. stress drop for large events
D. maximum magnitude distribution
E. rate of activity
F. depth of energy release
G. ground motion model

The seismic hazard analysis will provide uniform risk response spectra for bedrock motions and for a generic deep soil site.

A deterministic earthquake ground motion analysis is also being performed for the site. This analysis assumes the recurrence of the New Madrid 1811-1812 earthquakes at their historical locations and calculating site-specific bedrock motions at the plant site. These bedrock motions will be calculated using procedures discussed by Gwo-Bin Ou (6) and Michael L. Jost (7). The response spectra from these bedrock motions will be compared to the uniform risk response spectra and a final selection of bedrock motions will be made for use in a site response analysis of the soil deposit.

The results of the geotechnical and geophysical exploration will be used to define the soil profile and the appropriate material properties needed for an analysis of the soil deposit.

Downhole seismic monitoring instrumentation will be installed in one of the deep holes in order to record strong motion from future earthquakes. This data will be used to calibrate the analysis of soil deposit. Three accelerometers will be installed. One will be at the top of the Warsaw limestone, one at the top of the McNairy formation, and one at the free-field surface. The Department of Geological Sciences at the University of Kentucky Research Foundation will install and monitor the instrumentation.

CONCLUSIONS

The geotechnical and geophysical exploration has been completed. The two holes drilled to bedrock show the soil deposit is about 350-375 feet deep. The evaluation of the drilling logs, laboratory testing, and geophysical results has been started to define soil profiles and engineering properties which will be used in the seismic response analysis of the site and the liquefaction evaluation.

The analysis of the soil deposit and final definition of the earthquake ground motion will be completed in FY 1991.

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