USGS Report

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Project Title. Time-lapse electrical resistivity tomography and seismic reflection imaging of a shallow groundwater aquifer (0-50 m): Mississippi River levee seepage across the Duncan Point bar, Baton Rouge, Louisiana, U.S.A.

Short Title
Geophysical imaging across the Duncan Point Bar, Baton Rouge Louisiana

Abstract

Flood-induced seepage under the Mississippi River levees poses an economic risk to the Louisiana industrial corridor, its agricultural economy, state infrastructure and public safety. We characterized a zone of known seasonal ground-water seepage at Farr Park (Figure 1), a publicly accessible site, approximately 2.5 km S of Louisiana State University, Baton Rouge. We collected ground-based electrical resistivity (Figures 2 and 3) and seismic reflection data (Figure 4). Geotechnical borehole data well DPS6-UT was accessed through the US Army Corps of Engineers. The well site contains dominantly fine sand which corresponding to high electrical resistivity values (> 50 Ohm.m) (Figure 5). With the exception of a strong shear-wave acoustic impedance contrast between dominantly clay-rich and underlying silt-rich units, the remainder of the site shows relatively little variation in composition or acoustic impedance—this is probably responsible for poor reflectivity seen throughout most the section.

Seismic and electrical methods

The seismic data were assembled in Seismic Unix format, a shortened version of the SEG-Y format (Society of Exploration Geophysicists Exchange Format-Y https: //seg. org/Publications/SEG-Technical-Standards), that has the 3200-byte EBCDIC and 400-byte tape header removed. The data were uploaded online (https://zenodo.org/records/14776025) in the form of a a CMP brute-stacked seismic section.

During data collection, shotpoint location changed proceeding along a 136-degree azimuth (south-easterly direction; Figure 1, Table 1), and spaced every 1 m.

A total of 48, horizontal-component, 28-Hz geophones were planted, one every one meter and shotpoints were located half-way between geophones. Geophones remained fixed at their locations throughout the survey and so the CMP spacing is nominally 0.5-m but the acquisition fold varies linearly from a value of 1 from the start and end of the survey to a central maximum of 24. The seismic source consisted of a partially buried 20-lb, steel I-beam, struck repeatedly on either side three times by an 8-lb sledge hammer. Data of the same striking polarity were added in-phase in the field. Data with opposing polarity at each shotpoint location were subtracted later to enhance SH-wave data and suppress converted SH-to-P waves.

Seismic processing is minimal and consists of standard surface-wave muting, elimination of bad seismic traces, normal moveout, bandpass filtering (between 12 Hz and 50 Hz) and preliminary stacking with trace mixing every 3 CMPs. The data were stacked with a single velocity throughout that ranged from 80 m/'s (Vs) at 0.2 s, to 100 m/s at 0.35 s and reached 180 m/s at 0.5 s of two-way traveltime (Figure 4).

Geometry (UTM 15R N)	**Line 1**	**Line 2**
Azimuth	53º	56º
Start (electrode 1)	671,819 m E; 3,363,180 m N	671,819 m E; 3,363,180 m N
End (electrode 48)	671,657 m E; 3,363,012 m N	671,986 m E; 3,363,008 m N
Electrode spacing	5 m	5 m
Date	December 9, 2020	December 9, 2020
River gage at Baton Rouge (USGS)	17 feet	17 feet
	Line 3	**Line 4**
Azimuth	136 º	254º
Start (electrode 1)	672,2004 m E; 3,362,997 m N	671,678 m E; 3,363,034 m N
End (electrode 48)	671,782 m E; 3,362,924 m N	671,805 m E; 3,362,835 m N
Electrode spacing	5 m	5 m
Date	February 25, 2024	April 28, 2024
River gage at Baton Rouge (USGS)	26.7 feet	31.2 feet
	Seismic line	
SP 1	671915.00 m E 3363081.00 m N	
SP 48	671949.00 m E, 3363046.00 m N	
Date	March 24, 2024	
River gage at Baton Rouge (USGS)	24.7 feet	

Table 1: Geometric ranges of electrical resistivity and seismic lines (Figure 1)

To acquire the electrical resistivity profiles (Figures 2 and 3) we used a 48-electrodes using a multi-core cable with as many conductors as electrodes inserted in the ground at fixed distance intervals. The electrodes were spaced 5 meters apart over a length of 235 meters. A combination of transmitted electrical currents and measured voltages from the electrode pairs (Wenner and Schlumberger arrangements) were used to construct the sections. The acquired data are processed using a 2D commercial software package that uses a suitable tomographic scheme from the combined array data to generate an inverted accurate subsurface model (Figure 2).

Sediment, electrical and seismic findings

Nearby geotechnical (Figures 1 and 5) borehole data imply that the bottom of the Holocene point bar rests at ~ 35 m depth. The upper 5 m of sediment is dominated by clay-rich sediments, underlain by approximately another 10 m of silt-rich materials. Most of the remainder of the point bar body (20 m) to a depth of 35 contains fine sand and below that clay-rich units are repeated.

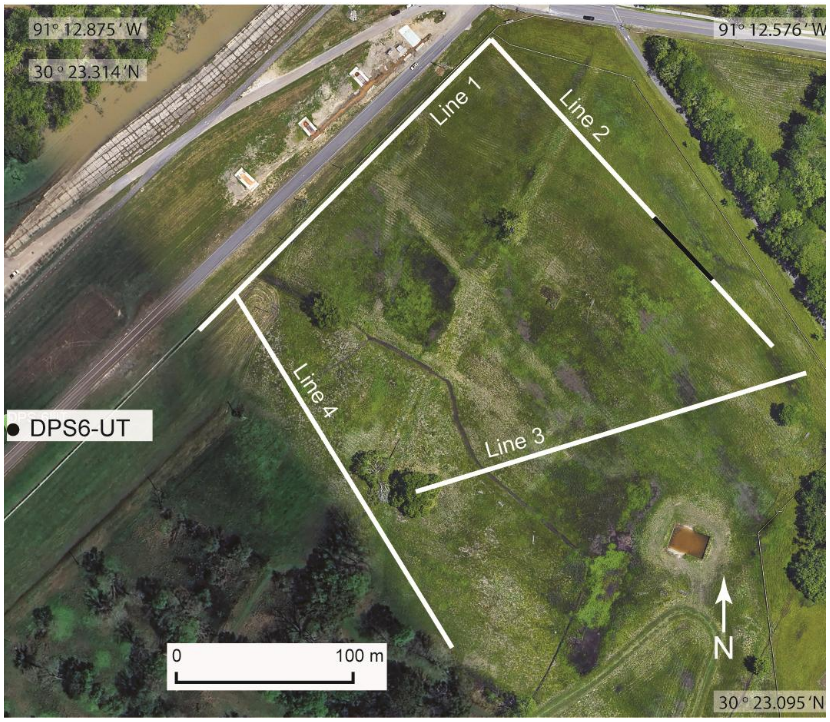

Figure 1 Google Maps satellite image background overlain by survey tracks for electrical resistivity survey lines (white) and seismic reflection line (black) in the study area, Farr Park, Louisiana. The artificial levee embankment on its western side is covered by water (brown color) from the Mississippi river.

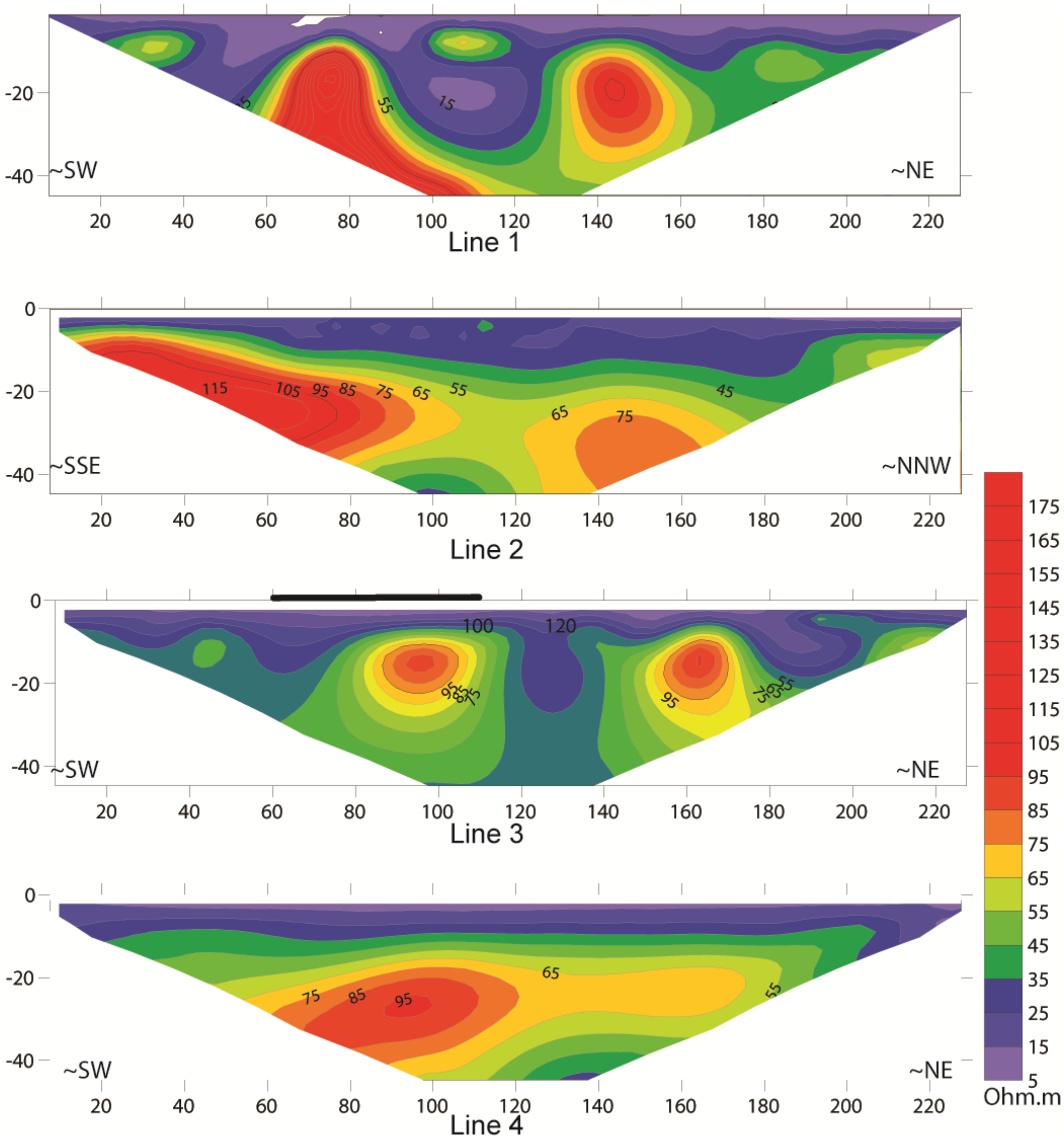

Figure 2. Results of tomographic inversion from electrical resistivity data sets (Figure 1) collected in the study area along four trajectories (Figures 1 and 2). Lines 3 and 4 were collected for the current project, and Lines 1 and 2 are inversion results from legacy data. Lines 1 and 3 run sub-parallel to the local direction of river flow, whereas the other Line 2 and Line 4 are oriented almost at right angles to the current river flow. The thick, black horizontal line located between ~60 and ~110 over the profile along Line 2 marks the horizontal extent over which seismic reflection data were collected (Figure 3).

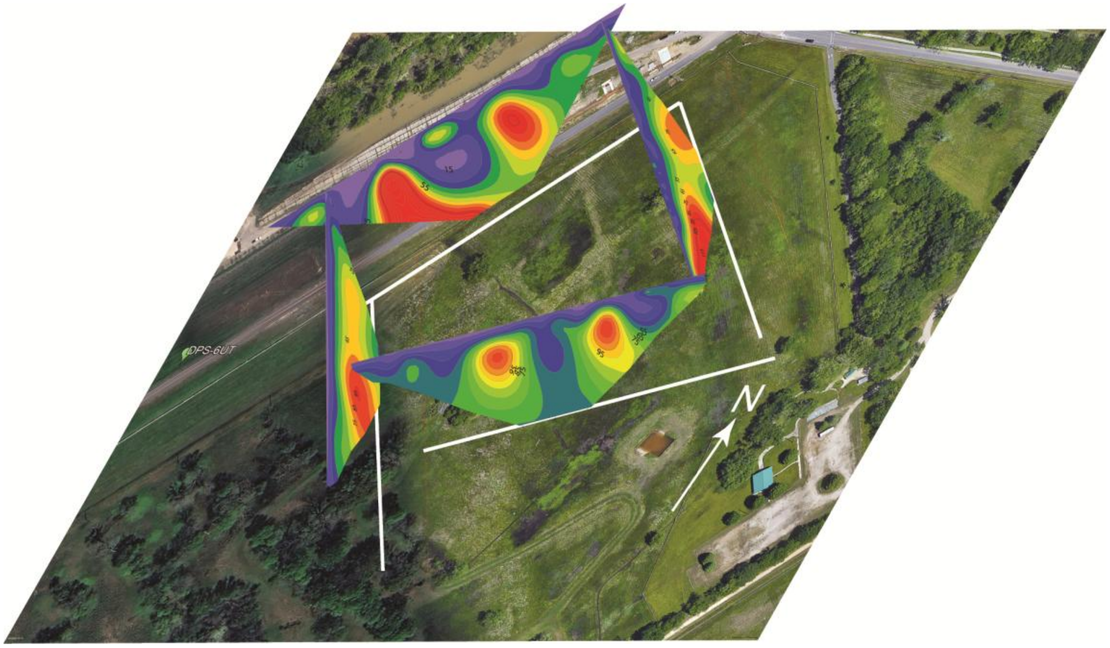

Figure 3. Electrical resistivity fence diagram displaying contoured images of inverted cross-sections over survey paths (white lines) superimposed on a satellite image of the study area (Figure 1). Orange colored zones indicate that generally deeper subsurface areas are more electrical resistivity. Comparison with well bore data (Figure 5) indicate that the highly resistive zones correspond to mainly fine-sandy sediments.

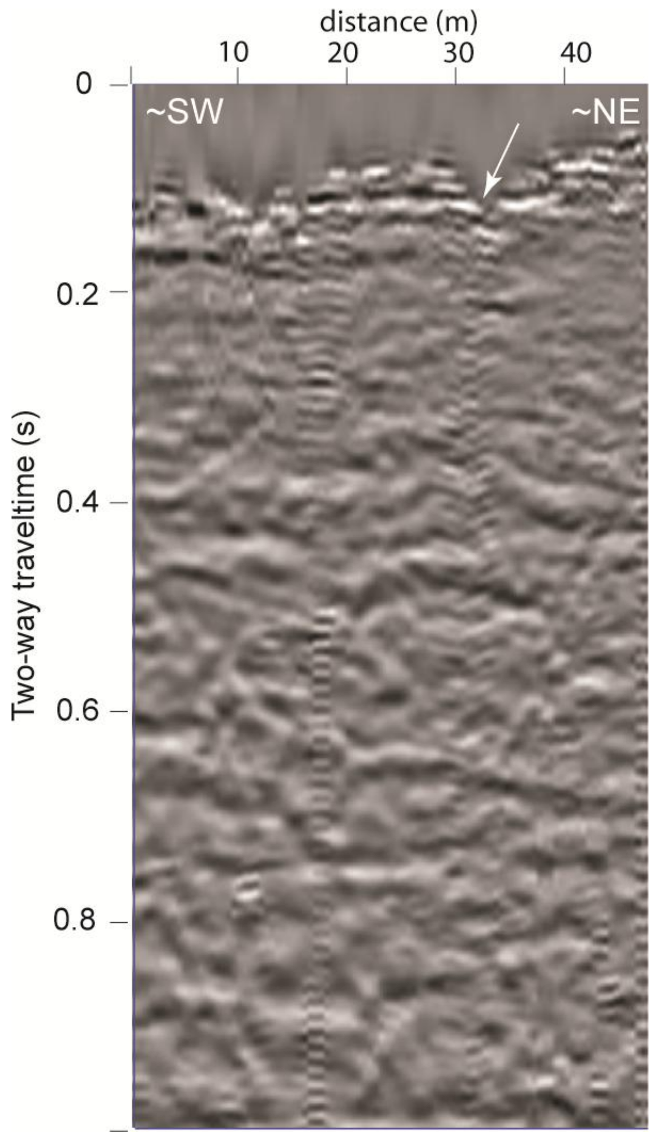

Figure 4. Horizontal shear-wave seismic CDP seismic reflection image shows a series of strong reflector at approximately 0.1 s of two-way traveltime (white arrow). The strong reflector is interpreted to correspond to the top of the clay-to-silt boundary detected in the nearby geotechnical borehole (Figure 5). This profile was collected long the same survey line as the electrical resistivity profile for Line 3 (Figures 1 and 2)

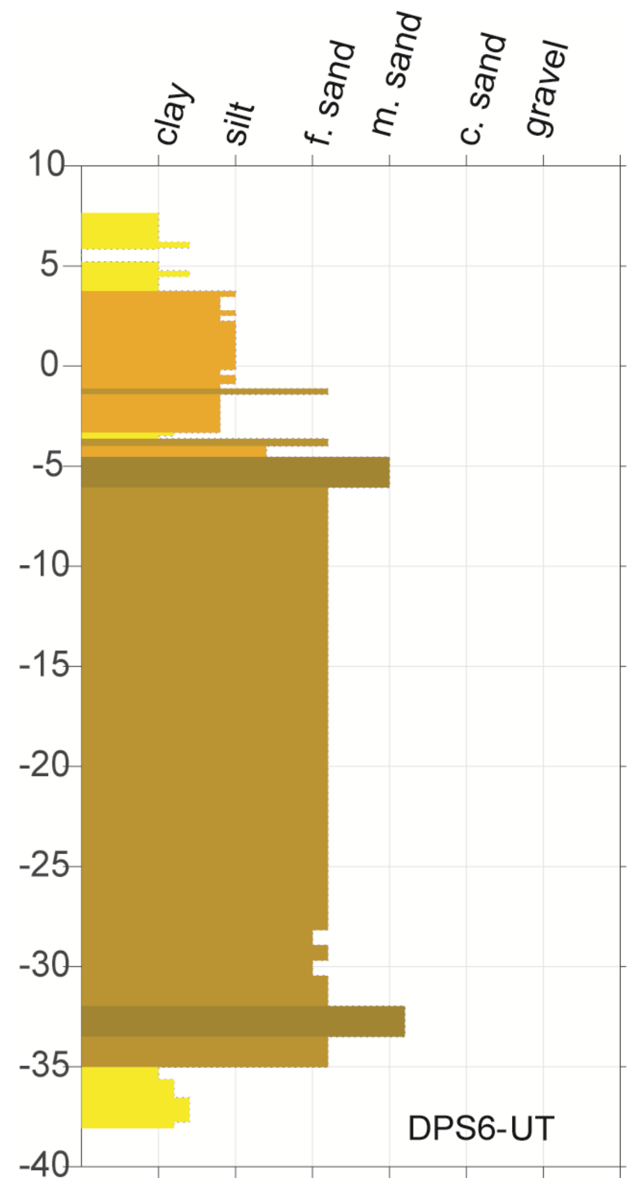

Figure 5. Sediment grain-size summary of geotechnical report from nearby well approximately 200 m immediately west of the study area (Figure 1) USACE borehole DPS6-UT sediment grains increase gradually in size to 35 m depth. (f.- fine; m-medium; c.-coarse)