RESTORE ACT CENTER OF EXCELLENCE FOR LOUISIANA
EXPENDITURE SUMMARY

Due within 30 days of the close of the award

CFDA/Fed Grant Number: 21.015/RCEGR260003-01-00
CEA Number: 2000249131
Subaward Agreement Number: CON 2513
Award Period (mm-dd-yyyy to mm-dd-yyyy): 8/1/2017 to 07/31/20
Project Title: An evaluation of faulting in Holocene Mississippi river delta strata through the merger of deep 3-D and 2-D seismic data with near surface imaging and measurements of vertical motion at three study areas
merger of deep 3-D and 2-D seismic data with near surface imaging and measurements of vertical motion at three study areas
Grantee Lead Institution: University of New Orleans
Grantee Principal Investigator and Contact Information:

First name: Mark Last name: Kulp

Title: Associate Professor Affiliation: Pontchartrain Institute for Env. Sciences

Mailing address: 2000 Lakeshore Drive, Univ. of New Orleans, New Orleans LA 70148

Phone: 504-280-1170

Email: mkulp@uno.edu

Year	Total Award	Total this Invoice	Invoiced to Date	Remaining Amount	Percent Expended	Technical Percent Completed
Year 1	214,191					
Year 2	134,983					
Year 3						
Year 4						
Year 5						
Total	349,174				98%	100%

RESTORE ACT CENTER OF EXCELLENCE FOR LOUISIANA
FINAL TECHNICAL REPORT

Due within 30 days of the close of the award

Project Title: An evaluation of faulting in Holocene Mississippi river delta strata through the merger of deep 3-D and 2-D seismic data with near surface imaging and measurements of vertical motion at three study areas

Principal Investigator:	Dr. Mark Kulp
Principal Investigator Institution:	University of New Orleans
Co-Principal Investigator:	Dr. Nancye Dawers
Co-Principal Investigator Institution:	Tulane University
Co-Principal Investigator:	Dr. Rui Zhang
Co-Principal Investigator Institution:	University of Louisiana Lafayette
Co-Principal Investigator:	Dr. Kevin Yeager
Co-Principal Investigator Institution:	University of Kentucky
Co-Principal Investigator:	Dr. John Lopez
Co-Principal Investigator Institution:	Lake Pontchartrain Basin Foundation
Co-Principal Investigator:	Dave Culpepper
Co-Principal Investigator Institution:	Culpepper Group
Co-Principal Investigator:	
Co-Principal Investigator Institution:	
Co-Principal Investigator:	
Co-Principal Investigator Institution:	

A. Technical Activities

1) Deliverables on proposed goals and objectives.

#	**Proposed goal / objective / activity**	**Target output / deliverable**	**Completed** (Y/N)	**Comments** (If No, please describe incomplete deliverable(s) or reason why actual output / deliverable deviated from the proposed)	**Topical area (s) and research need(s) addressed** (as described in the proposal)
1	Characterize the geometry and surface fault traces in eastern Lake Pontchartrain using industry seismic data	Fault location files and the upward projected location of potential surface fault traces	Yes		Deltaic Geology, Delta Building and Subsidence
2	Characterize the geometry and surface fault traces in Golden Meadow area, Bayou Lafourche using industry seismic data	Fault location files and the upward projected location of potential surface fault traces	Yes		Deltaic Geology, Delta Building and Subsidence
3	Characterize the geometry and surface fault traces in Terrebonne Bay area using industry seismic data	Fault location files and the upward projected location of potential surface fault traces	No	PhD Dissertation A.O. Akintomide Tulane University, not yet defended	Deltaic Geology, Delta Building and Subsidence
4	Determine if fault motion and geometry can be determined using repeat GPS surveys of roads crossing fault traces	Elevation surveys across roads crossing fault traces (Hwy 1, 3235,56,55,665 and Island Road),	Yes		Assess whether fault motion is affecting coastal infrastructure

#	**Proposed goal / objective / activity**	**Target output / deliverable**	**Completed** (Y/N)	**Comments** (If No, please describe incomplete deliverable(s) or reason why actual output / deliverable deviated from the proposed)	**Topical area (s) and research need(s) addressed** (as described in the proposal)
5	Determine if Lake Pont. faults have affected shallow Holocene stratigraphy and geomorphology	UNO MS thesis Bobby Mohollen	Yes		Deltaic Geology, Delta Building and Subsidence and impacts to infrastructure
6	Determine if Golden Meadow faults have affected shallow Holocene stratigraphy and geomorphology	ULL MS thesis Allison Scates	Yes		Deltaic Geology, Delta Building and Subsidence and impacts to infrastructure
7	Determine if Terrebonne faults have affected shallow Holocene stratigraphy and geomorphology	UNO MS thesis Joe Hankerson	No	Laboratory analysis of some sediment samples not yet completed during pandemic	Deltaic Geology, Delta Building and Subsidence
8			No		
9			No		
10			No		

2) **Summary of research project**. Similar to an abstract; include sentences that describe the introduction, research questions/hypotheses, methods, results, discussion, and conclusion. 400 words max.

The focus was to map the geographic extent and history of displacement on Cenozoic fault systems that trend across the Holocene Mississippi River delta plain. The work was concentrated in Terrebonne-Timbalier Bay, Bayou Lafourche near Golden Meadow, and the Lake Pontchartrain/Lake Borgne. Each of three Louisiana universities involved in this project hold license agreements with energy companies, who have provided access to high-quality, industry-standard 3-D and 2-D seismic reflection data that image Cenozoic strata in the study areas. These data allow for an assessment of whether deep-seated faults are present and if these faults extend upward into overlying strata. These seismic datasets are essential for the success of any study attempting to document the potential impact of faults on geomorphology, deltaic geology, and the stability of Holocene sedimentary units of the north central Gulf coast. Louisiana Master Plan efforts strongly rely upon an understanding of vertical elevation changes and if modern fault motion is occurring Master Plan efforts could be jeopardized. The research unites industry seismic reflection data (3-D, 2-D) with additional methods of data analysis including high-resolution seismic imaging, construction of near-surface stratigraphic sections, geochronology, GPS surveys and quantification of sediment accumulation rates. Primary research questions included: 1) Do geologic structures influence modern Mississippi River delta plain evolution?, 2) Are fault slip rates variable across the delta plain because of proximity to major late Pleistocene and Holocene depocenters and interaction with underlying ductile salt bodies?, 3) Can Holocene motion be detected using shallow, high-resolution seismic imaging, radiocarbon stratigraphic horizons, GPS surveys, and sediment accretion rates. All three of the industry seismic datasets image an array of faults, with variable lengths and geometries. The depth to which the faults can be projected upward varies between the datasets because of the quality of the industry seismic data but maps of suspected shallow faults can guide decision making and an assessment of potential fault impacts to Holocene strata and geomorphology. Only locally does high resolution seismic data clearly image the subsurface of the study areas because of shallow water and gas-charged sediments. Radiocarbon dated horizons locally indicate offset of Holocene strata as do geomorphologic features at the surface. Continued efforts to fully document the exact location and overall extent of latest Quaternary fault offsets across all of the delta plain should include the acquisition of additional industry seismic data, shallow seismic data, sediment cores, GPS surveys and radiocarbon dated strata.

3) **Results and scientific/technical highlights**. In 5-10 bullets: list and describe key outcomes and findings; new methods, technology, and/or advanced tools developed (e.g., models, biomarkers).

- Upward projected fault trends locally correspond with areas of marsh loss, drowned cypress swamps, and open-water on the down-dropped sides of the faults.
- Quaternary fault slip is locally influenced by salt domes, suggesting that either deformation or dissolution of subsurface salt may also affect the present geomorphology.
- Quaternary slip rates associated with the Golden Meadow fault zone are an order of magnitude faster than those of the Baton Rouge fault zone.
- Cone penetrometer test data along with and borings can be used to map the stratigraphy in areas of potential fault motion
- Large faults in the northern Terrebonne Bay area intersect earth's surface
- In Terrebonne Bay fault activity was generally rapid during the Miocene and Quaternary, whereas Pliocene activity was relatively low
- Mathematical vector analysis of surface streams locally may be used to help constrain fault locations and slip
- Some faults show a distinct surface scarp in the modern landscape, whereas some do not. Faults that do have a scarp may not have a scarp at every survey location.
- If faults do have a modern scarp, the morphology is such that subsidence near the traces tends to be greater than farther away from the trace. No universal scarp morphology appears to exist.
- Preliminary: higher rates of accretion on downthrown side of at least one Terrebonne Bay fault

4) Application of research results to the implementation of the Louisiana Coastal Master Plan by Coastal Protection and Restoration Authority. Please add each targeted output/deliverable under each relevant column. Refer to section *1) Deliverables on proposed goals and objectives* on page 2 to obtain your output/deliverables and to your notes/comments from the All Hands Meeting where this was discussed in the break out groups.

COASTAL PROTECTION AND RESTORATION AUTHORITY PROGRAM AND PROJECT IMPLEMENTATION						
Planning	**Feasibility**	**Engineering and Design**	**Operations, Maintenance, and Monitoring**	**Knowledge Base**	**Stakeholder Engagement**	**Communications**
Characterize the geometry and surface fault traces in eastern Lake Pontchartrain using industry seismic data; Fault location files and the upward projected location of potential surface fault	Characterize the geometry and surface fault traces in eastern Lake Pontchartrain using industry seismic data; Fault location files and the upward projected location of potential surface fault	Characterize the geometry and surface fault traces in eastern Lake Pontchartrain using industry seismic data; Fault location files and the upward projected location of potential surface fault	Characterize the geometry and surface fault traces in eastern Lake Pontchartrain using industry seismic data; Fault location files and the upward projected location of potential surface fault	Characterize the geometry and surface fault traces in eastern Lake Pontchartrain using industry seismic data; Fault location files and the upward projected location of potential surface fault		
Characterize the geometry and surface fault traces in Golden Meadow area, Bayou Lafourche using industry seismic data; Fault location files and the upward projected location of potential surface fault	Characterize the geometry and surface fault traces in Golden Meadow area, Bayou Lafourche using industry seismic data; Fault location files and the upward projected location of potential surface fault	Characterize the geometry and surface fault traces in Golden Meadow area, Bayou Lafourche using industry seismic data; Fault location files and the upward projected location of potential surface fault	Characterize the geometry and surface fault traces in Golden Meadow area, Bayou Lafourche using industry seismic data; Fault location files and the upward projected location of potential surface fault	Characterize the geometry and surface fault traces in Golden Meadow area, Bayou Lafourche using industry seismic data; Fault location files and the upward projected location of potential surface fault		

COASTAL PROTECTION AND RESTORATION AUTHORITY PROGRAM AND PROJECT IMPLEMENTATION						
Planning	**Feasibility**	**Engineering and Design**	**Operations, Maintenance, and Monitoring**	**Knowledge Base**	**Stakeholder Engagement**	**Communications**
Characterize the geometry and surface fault traces in Terrebonne Bay area using industry seismic data; Fault location files and the upward projected location of potential surface fault	Characterize the geometry and surface fault traces in Terrebonne Bay area using industry seismic data; Fault location files and the upward projected location of potential surface fault	Characterize the geometry and surface fault traces in Terrebonne Bay area using industry seismic data; Fault location files and the upward projected location of potential surface fault	Characterize the geometry and surface fault traces in Terrebonne Bay area using industry seismic data; Fault location files and the upward projected location of potential surface fault	Characterize the geometry and surface fault traces in Terrebonne Bay area using industry seismic data; Fault location files and the upward projected location of potential surface fault		
Determine if fault motion and geometry can be determined using repeat GPS surveys of roads crossing fault traces; Elevation surveys across roads crossing fault traces (Hwy 1, 3235,56,55,665 and I	Determine if fault motion and geometry can be determined using repeat GPS surveys of roads crossing fault traces; Elevation surveys across roads crossing fault traces (Hwy 1, 3235,56,55,665 and I	Determine if fault motion and geometry can be determined using repeat GPS surveys of roads crossing fault traces; Elevation surveys across roads crossing fault traces (Hwy 1, 3235,56,55,665 and I	Determine if fault motion and geometry can be determined using repeat GPS surveys of roads crossing fault traces; Elevation surveys across roads crossing fault traces (Hwy 1, 3235,56,55,665 and I	Determine if fault motion and geometry can be determined using repeat GPS surveys of roads crossing fault traces; Elevation surveys across roads crossing fault traces (Hwy 1, 3235,56,55,665 and I		
UNO MS thesis Bobby Mohollen; ULL MS thesis Allison Scates	UNO MS thesis Bobby Mohollen; ULL MS thesis Allison Scates	UNO MS thesis Bobby Mohollen; ULL MS thesis Allison Scates	UNO MS thesis Bobby Mohollen; ULL MS thesis Allison Scates	UNO MS thesis Bobby Mohollen; ULL MS thesis Allison Scates		

5) Peer-reviewed publications. Please provide pdf copies.

Authors	List author names of graduate students/ Postdocs	Title	Journal	DOI (or other identifier)	Published; submitted; in prep; planned?	Date
Allison Scates and Rui Zhang	Allison Scates	Geomorphic and shallow subsurface expression of growth faults in Mississippi River delta Holocene sediment: Golden Meadow, Louisiana	Journal of Coastal Research		In prep	Spring 2021
Bobby Mohollen, Mark Kulp and Nancye Dawers	Bobby Mohollen	Holocene displacement rates and lateral continuity of faults in eastern Lake Pontchartrain, Louisiana	Geomorphology or Marine Geology		In prep	Spring 2021

Authors	List author names of graduate students/ Postdocs	Title	Journal	DOI (or other identifier)	Published; submitted; in prep; planned?	Date
Akintomide, A.O., and Dawers, N.H.	Akintomide, A.O., PhD candidate	Quaternary activity in northwestern Terrebonne Bay, southeastern Louisiana: Implications for wetland loss	Journal of Coastal Research		Planned, based on draft of dissertation chapter	Spring 2021
Akintomide, A.O., and Dawers, N.H.	Akintomide, A.O., PhD candidate	Throw rate variability in the Terrebonne Salt Withdrawal Basin: Implications for subsurface salt flow and depocenter loading	Basin Research, or Environmental Geosciences		Planned, based on draft of dissertation chapter	Spring 2021
Kulp, Mark and Dawers, Nancye		Late Quaternary faulting in the Mississippi River delta	Quaternary Science Reviews		Planned	2021

6) Oral presentations and posters. Please provide pdf copies.

Presenter's Name	Co-author's Name	List author names of graduate students/ Postdocs	Title	Oral or poster?	Conference or meeting name	Location & date	Completed; submitted; planned?	Proceedings published (Y/N)
Amanda Johnston	Rui Zhang Amanda Johnston	Allison Scates	Mapping and Evaluation of Faulting and Subsidence in Mississippi River Delta Holocene Strata by Integrating Cone Penetrometer Tests, Shallow Wells, and Seismic Interpretations in Golden Meadow, Louisiana.	Poster	Symposium on the Application of Geophysics to Engineering and Environm	Portland, March 2019	Completed	Y
Allison Scates	Rui Zhang	Allison Scates	Locating Faults in Louisiana Gulf Coast Quaternary Stratigraphy by Combination of Cone Penetrometer Tests with Borings and Chirp Seismic Data, Golden Meadow, Louisiana	Poster	GeoGulf	Houston, March 2019	Completed	Y
Amanda Johnston	Rui Zhang, Raphael Gottardi, Nancye Dawers,	Amanda Johnston	Investigating The Relationship Between Structural Geology and Wetland Loss Near Golden Meadow, Louisiana By Utilizing 3D Seismic Re ection and Well Log Data,	Poster	AGU Annual meeting 2017	New Orleans, December, 2017	Completed	Y

Presenter's Name	Co-author's Name	List author names of graduate students/ Postdocs	Title	Oral or poster?	Conference or meeting name	Location & date	Completed; submitted; planned?	Proceedings published (Y/N)
Amanda Johnston	Rui Zhang, Raphael Gottardi, Nancye Dawers,	Amanda Johnston	Investigating the relationship between tectonics and land loss near Golden Meadow, Louisiana by utilizing 3D seismic and well log data	Poster	GSA Annual meeting,	Seattle, October 2017	Completed	Y
Akintomide, A. O.	Dawers, N. H.	Akintomide, A. O.	Spatial and Temporal Variation of Fault Activity in the Terrebonne Salt Withdrawal Basin, Southeastern Louisiana: Response to Salt Evacuation and Sediment Loading	Poster	Annual Convention and Exhibition of the American Association of	San Antonio, Texas, May 2019	Completed	Y
Akintomide, A. O.	Dawers, N. H.	Akintomide, A. O.	Subsurface Fault Control on Coastal Wetland Loss and Subsidence in Southeastern Louisiana	Oral	Annual Conference, National Association of Black Geoscientists	Houston on September 7th, 2018	Completed	Y
Akintomide, A. O.	Dawers, N. H.	Akintomide, A. O.	Influence of Subsurface Geology on Coastal Wetland Loss in the Terrebonne Salt Withdrawal Basin	Oral	Louisiana Coastal Geology Symposium	Baton Rouge on July 11th, 2018	Completed	N

7) **List other products or deliverables**. These can include white papers, patent applications, workshops, outreach activities/products. Describe and provide pdf copies, as applicable.

N. Dawers: Barataria-Terrebonne National Estuary Program Coastal Geology and Sustainable Restoration Dialogue
Contributed to the discussion on wetland loss and location of subsurface faults
Location: Nicholls State University, Student Union, Plantation suite

N. Dawers: Volunteered: explain the science and business of oil exploration to kids
Location: Children's Museum of St. Tammany, Mandeville, LA
N. Dawers: Volunteered every year at the Supersaurus Saturday
Venue: Louisiana Children Museum

M.Kulp: Presentation to Water Institute of the Gulf Expert Panel on Subsidence

N Dawers: Presentation to Water Institute of the Gulf Expert Panel on Subsidence

M. Kulp: Presentation at University of Louisiana Lafayette invited speaker series

8) **Data.** Making data publicly assessible in a timely manner is a key goal of the data management policy of RESTORE Act Center of Excellence. All projects must ensure that data and ISO metadata are collected, archived, digitized, and made available using methods that allow current and future investigators to address new questions as they arise. Per the U.S. Department of the Treasury's Office of Gulf Coast Restoration Data Accessibility and Management Best Practices[1] *"Data are generally expected to be made publicly available at the time of publication of a peer-reviewed article relying on the data or two years after the data are collected."* All information products resulting from funded projects must be associated with detailed, machine-readable metadata (ISO format) and shared in a regional or national digital repository or data center (e.g., National Centers for Environmental Information, Gulf of Mexico Research Initiative Information & Data Cooperative, Inter-university Consortium for Political and Social Research, DataOne Dash) for discovery and long-term preservation. Metadata, a brief description of the data, and location of the data (e.g., repository, DOI) must be provided to the LA-COE to enable tracking of all data and information products.

[1] https://www.fio.usf.edu/documents/flracep/program-documents/Treasury%20RESTORE%20COE%20data%20management%20best%20practices%20Jan%202018.pdf

#	Description of data	Repository or data center	Date by when data will be made available (2 years after final report)	DOI (or similar) if data are already uploaded
1	Non proprietary seismic and sediment core data (sediment core description sheets, high quality SEG-Y shallow seismic, if available)	NOAA National Centers for Environmental Information	In progress for target of summer 2021	
2	ArcGIS shapefiles with X,Y,Z data of roadway elevations	NOAA National Centers for Environmental Information	In progress for target of summer 2021	
3	Well logs from State of Louisiana	Louisiana SONRIS data system http://sonlite.dnr.state.la.us/pls/apex/f?p=108:2:14425627937169:::	Already available. See "well information" and "well logs".	http://sonlite.dnr.state.la.us/pls/apex/f?p=108:9085:11376329172169
4	ArcGIS shapefiles of surface fault and upward projected locations	NOAA National Centers for Environmental Information	In progress for target of summer 2021	
5				
6				
7				
8				

B. PARTICIPANTS AND COLLABORATORS

1) **Project participants and collaborators.** Please list researchers who are not post-doctoral researchers or students but have participated and/or collaborated in this research. This can be both unfunded and funded participants and collaborators on the research project.

First name	Last name	Institution	Project role
Chris	McLindon	McLindon Geosciences	mentor to several students
Brad	Robinson	University of New Orleans Earth and Env. Sciences	mentor to several students

2) Mentoring and Training. Please list post-doctoral and graduate and undergraduate student participants (provide pdf copies of thesis/dissertation).

First Name	Last Name	Postdoc/ PhD/ MS/ BS	# Years involved	Institution	Thesis/Dissertation title/ research topic or tasks	Did the student graduate? Y/N	If they graduated, what is their current position?
Bobby	Mohollen	MS	2	UNO	Lake Pont. Faults	Y	Geologist at BOEM
Allison	Scates	MS	2	ULL	Golden Meadow Faults	Y	Petroleum Geologist
Amanda	Johnston	MS	0.5	ULL	Golden Meadow Faults	Y	Petroleum Geologist
Joe	Hankerson	MS	1.5	UNO	Terrebonne Faults	Not yet	NA
Jared	Garcia	BS	0.5	UNO	Terrebonne Faults	Not yet	NA
Akinbobola	Akintomide	PhD	2	Tulane	Terrebonne Faults	Not yet	NA

C. CONTINUING RESEARCH

Please describe the next steps for this work, if applicable (5 bullet points max).

Continue the analyses of the sediment samples for accretion rates in the Terrebonne Area now that the Univ. of Kentucky laboratory is reopened.
Complete analysis of the final core in the Terrebonne Bay area now that the Univ. of New Orleans laboratory is reopened.
UNO MS student Joe Hankerson and Tulane Phd student Akinbobola Akintomide will both be completing their respective research projects on different areas of the Terrebonne fault systems during the next 6-10 months.
Separate from this project UNO is also completing detailed grain size analysis on samples from cores that were acquired during this project to test a hypothesis that grain size variability may exist on opposing sides of faults mapped in Terrebonne Bay.
Regroup with the project team to finalize publications and seek out additional funding sources to examine questions that arose during the course of this project.

D. CERTIFICATION

Please submit report no later than 30 days following the close of the award to:
Danielle Johnson
Grants and Contracts Manager
AP@thewaterinstitute.org

○ Certification: I certify to the best of my knowledge and belief that this report is correct and complete for performance of activities for the purposes set forth in the award documents.
Principal Investigator:
Signature: Mark Kulp
Digitally signed by Mark Kulp
Date: 2020.09.18 15:51:03 -05'00'
Name: Mark Kulp
Date Signed: 9/18/20

○ Approval: I have evaluated the final report and associated invoice and confirm that the project is finished.
LA-COE Technical Point of Contact:
Signature: Brendan Yuill
Digitally signed by Brendan Yuill
Date: 2020.10.15 14:37:31 -05'00'
Name:
Date Signed: 9/18/20

◉ Approval: I have reviewed the final report and approve for payment.
LA-COE Director:
Signature: Melissa M. Baustian
Digitally signed by Melissa M. Baustian
Date: 2020.10.15 14:31:59 -05'00'
Name:
Date Signed: 9/18/20