

NIST Special Publication NIST SP 1230-4

The Lumberton, North Carolina Flood of 2016, Wave 4

*Occupancy and Operational Status During the COVID-19
Global Pandemic*



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Flood of 2016, Wave 4**
*Occupancy and Operational Status During the COVID-19
Global Pandemic*

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In compliance with the Paperwork Reduction Act, NIST personnel did not participate in the collection or analysis of household survey data. NIST personnel did participate in the field inspections of damaged residential housing and collected data on the event and subsequent response by public officials and private sector entities.

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Abstract

This report documents the study conducted in Lumberton, North Carolina in 2022. Statement of purpose, scope, methods, results, and recommendations are contained herein.

Keywords

Business recovery; damage assessments; household survey; Hurricane Florence; Hurricane Matthew; Lumberton; online survey; recovery; resilience; windshield survey.

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Field Study Team Members

The Lumberton Wave 4 Field Study Team consisted of 19 people. As described in this report, Wave 4 consisted of two data collection efforts, including one remote and one in-person trip to Lumberton. There were two major teams during the remote portion of the data collection, namely the Housing Team and the Business Team, and one team for the in-person field trip. Team affiliations are listed as of the time of Wave 4 (Summer 2021).

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Executive Summary

This is the fourth report in a series that documents the impacts to and recovery of Lumberton, North Carolina following 2016 Hurricane Matthew. This fourth report captures occupancy status for housing and commercial units five years after the initial flooding in Lumberton and one year into the COVID-19 pandemic. The longitudinal field study in Lumberton is part of the National Institute of Standards and Technology (NIST)-funded Center for Risk-Based Community Resilience Planning (Center). The Center has teamed with researchers from NIST's Community Resilience Program, Disaster and Failure Studies Program, and the Applied Economics Office to conduct the field studies since 2016. Findings from the longitudinal field study are being used by the Center and NIST team to advance the state of knowledge of community resilience.

In early October 2016, Hurricane Matthew crossed North Carolina as a category 1 hurricane with some areas receiving as much as 45.72 cm (18 in.) of rainfall. In the days that followed, Lumberton, North Carolina, an inland community in Robeson County, was catastrophically flooded. The Center and NIST team conducted a quick response field study focused on housing damage, school disruption, and community-level disruption in Lumberton. Approximately one year later, the Center and NIST team returned to Lumberton to document and better understand 1) recovery progress with an emphasis on housing, schools, community, and state-level decisions, 2) business disruption and recovery, which was newly included in the scope, and 3) the intersection of these sectors on community recovery.

In September of 2018, Hurricane Florence caused a second major flood in Lumberton. The Center and NIST team conducted a quick response field study to document the initial damage to the housing units and businesses in our longitudinal samples. Through virtual and in-person reconnaissance, the team learned that the City of Lumberton had strategically deployed temporary berms and pumps and anecdotally observed and learned about different preparedness and mitigation actions taken by households and businesses in preparation for Hurricane Florence. Ultimately, the extent of flooding and impact caused by the flooding was quite different for Hurricane Florence than Hurricane Matthew, but the compounding effect was significant, especially for those hardest hit in 2016. A small team from the Center deployed to Lumberton in December 2018 to conduct a focused study on critical decisions being made to rebuild public housing, and interview public housing residents. Then, in April of 2019, a larger team returned to Lumberton to document the six-month recovery from Hurricane Florence and continued recovery from Hurricane Matthew. In this latter trip, the team was able to systematically document preparedness and mitigation actions taken by households and businesses, as well as learn about many planned capital improvement projects.

In April 2019, the team concluded that though recovery was underway, a long road of continued recovery still lay ahead for the Lumberton community. The team set intentions for a fourth wave of data collection to occur in spring 2020. In March 2020, however, the COVID-19 pandemic swept across the United States, shutting down universities, daycares, schools, and all non-essential businesses and activities with many unknowns as to when 'normal' would return. Human subjects research was also shut down, with NIST and universities associated with the Center adopting different policies and timelines for approving human subjects research and non-essential travel.

More than a year later, in spring of 2021, the Center and NIST team were finally able to execute a remote data collection effort, termed Wave 4a. As detailed in this report, Wave 4a expanded the longitudinal samples with a convenience sample for housing and refreshment sample for business and switched to a new goal of documenting resilience capacity across the community. Both survey efforts used postcards for recruitment to an online survey, and later tried out other techniques to boost response rates. Approximately 40 % of postcards for housing were not delivered and were returned, and a little over 30 % of postcards for businesses were not delivered and were returned. Both survey efforts produced very low response rates, and thus the information gained from the few completed surveys are not reported here. The team was concerned that the large percentage of undeliverable postcards was indicative of a dire situation in Lumberton brought on by a third disaster, specifically the COVID-19 pandemic, occurring in Lumberton in less than five years.

Given the outcomes of Wave 4a, an additional sub-wave of data collection, termed Wave 4b, was needed to determine if the low response waves were due to vacant housing and commercial units. The goal of Wave 4b was to document the physical existence of housing units and businesses, and, to the extent possible, to document occupancy status for housing and commercial units. A set of indicators for occupancy and vacancy were developed for both housing and commercial structures. In early December 2021, a small team deployed to Lumberton for Wave 4b. To prioritize team member safety and the safety of Lumberton residents, Wave 4b did not include human subjects research.

Wave 4b confirmed that only 2.6 % of housing units in the longitudinal housing sample did not have a building present, 64.6 % were occupied, and an additional 7.6 % of housing units that were probably occupied. Similarly, Wave 4b confirmed that most business units were occupied or probably occupied by a business, and 11.3 % were vacant or probably vacant.

Although only a minimal amount of information was gleaned from Wave 4 on the status of Lumberton's longitudinal recovery, the primary longitudinal metric for housing presented in past reports is occupancy status. The longitudinal comparisons made in Chapter 2 of this report show a higher proportion of occupied housing and commercial units in Wave 4b compared to Wave 3c thus indicating a positive recovery progress. Even still, approximately 20 % of housing units and 11 % of commercial units in the longitudinal sample are vacant.

This report describes the development of an online survey and the challenges associated with remote data collection efforts in a longitudinal setting. While data were collected regarding vacancies of both businesses and houses, researchers were unable to gather data to understand where capital improvement and recovery funded projects stand. As a result of the lessons learned while conducting Wave 4 of the longitudinal survey of Lumberton, NC, this report concludes with the recommendation that a fifth wave of data collection be conducted in person to systematically document the recovery status of Lumberton housing, businesses, schools. Additionally, a Wave 5 data collection effort could aid in understanding the status of capital improvement and recovery funded projects.

1. Introduction

The longitudinal study of Lumberton, North Carolina described in this report is a collaboration between researchers from the National Institute of Standards and Technology (NIST)-funded Center of Excellence for Risk-Based Community Resilience Planning (Center), and researchers in the Engineering Laboratory at NIST. This chapter will summarize the goals and activities of the NIST Center of Excellence for Risk-Based Community Resilience Planning and the Engineering Laboratory at NIST, provide an overview of Hurricanes Matthew and Florence and the longitudinal field study, and describe the 2021 (Wave 4) Lumberton field study.

1.1. The NIST Center of Excellence for Risk-Based Community Resilience Planning

Collective community needs and objectives, including post-disaster recovery goals, are not reflected in codes, standards, and other regulatory documents governing the design of individual facilities. Addressing these shortcomings requires an approach that addresses the interdependencies of a community's physical, social, and economic systems. Thus, modeling the resilience of communities against the disruption caused by natural hazards and disasters depends on many disciplines, including engineering, social sciences, and information sciences. As climate change increases the number and intensity of natural hazard events, it is becoming more likely and more common for communities to be faced with a major disaster before being able to fully recover from a previous disaster. Providing detailed and community-specific guidance on how to better prepare for and recover from disasters is the impetus for the Center's research.

The Center, headquartered at Colorado State University in Fort Collins, Colorado and involving twelve additional universities at the time of Wave 4, was established by NIST in 2015. The Center's overarching goal is to establish the measurement science for community resilience assessment and risk-informed decision-making. The measurement science is implemented on a platform called the *Interdependent Networked Community Resilience Modeling Environment (IN-CORE)*. It incorporates a risk-based approach to decision-making that enables quantitative comparisons of alternative resilience strategies. On the IN-CORE platform, data from the community can be seamlessly integrated which allows users to optimize community disaster resilience planning and post-disaster recovery strategies intelligently using physics-based models of inter-dependent physical systems combined with socio-economic systems. The Center is also engaged in research aimed at developing and validating the models housed within IN-CORE's advanced modeling environment. Full validation of the system architecture in IN-CORE will be possible through extensive field studies focused on community resilience and recovery rather than simply infrastructure damage and failure studies. IN-CORE will be able to answer detailed questions on the lingering effects of natural disasters on communities; population dislocation, health and the wellbeing of the residents, impacts across the economic spectrum as well as the fiscal impacts, thereby assessing community resilience and disaster recovery via a suite of resilience metrics. A longitudinal field study in Lumberton, NC is planned and executed approximately every 12 months in the same location with the same sample of housing units and businesses to support the following phases of resilience model development within IN-CORE: impact, disruption, dislocation, recovery, decision, and interdependency. The

Lumberton, NC field study will provide comprehensive datasets to support validation of the IN-CORE architecture.

The Center works to accelerate the development of system-level models and databases that will provide the technology for enhancing community resilience. Team members, at the time of Wave 4, include noted resilience experts from Colorado State University, East Carolina University, California Polytechnic University-Pomona, Oregon State University, Rice University, Stony Brook University, Texas A&M University, the University of Florida, the University of Illinois, the University of Kansas, the United States Naval Academy, and the University of Oklahoma. Ultimately, the decision framework created by the Center will provide decision-makers with a unique set of tools that can be tailored to the needs of individual communities. These tools will optimize the design and subsequent management of individual facilities and interdependent infrastructure systems to achieve resilience goals while managing life-cycle costs. Its use will provide a basis for targeting public investments and incentives for private investments, thus making it possible to establish a “business case” for investing in community resilience.

1.2. The Engineering Laboratory at NIST

The Engineering Laboratory (EL) at NIST promotes U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology for engineered systems in ways that enhance economic security and improve quality of life. In support of this mission, EL is conducting research in community resilience, disasters and building failure investigations, economic analysis and life cycle assessment, wind and seismic hazard impact reduction, fire prevention and control, engineering, and manufacturing materials. Researchers from EL’s Applied Economics Office (AEO), the Community Resilience Program (CRP), and the Disaster and Failure Studies (DFS) Program participated in the Lumberton field study. This work seeks to advance the disaster metrology research as well as to advance measurement and modeling needed to support community resilience planning.

Hazard events stress buildings and infrastructure in ways and on a scale that cannot be easily replicated in a laboratory. The study of disaster and failure events is essential to improving the performance of buildings and infrastructure, the safety of building occupants, and associated evacuation and emergency response procedures. NIST’s DFS Program seeks to standardize disaster field deployment, assessment, and reporting protocols to improve building and infrastructure performance. DFS implements these goals through the following activities: (1) monitoring disaster events to evaluate whether an event meets decision criteria for the establishment and deployment of a study team, (2) coordinating the establishment, deployment, operations and reporting of study teams, (3) ensuring that the study team’s safety, health and environmental requirements are met including relevant hazard reviews, training, and personal protective equipment prior to deployment, (4) building and maintaining effective partnerships and communications with other federal agencies, state/local governments, stakeholders and the general public, (5) establishing and executing standard operating procedures and criteria for disaster and failure studies, (6) promoting the implementation of recommendations from all DFS investigations, (7) creating and maintaining an archival data repository for DFS, (8) carrying out the statutory requirements of the National Construction Safety Team (NCST) Act, which includes providing the Secretariat for the NCST Advisory Committee and annual reports to

Congress, and (9) overseeing a disaster metrology research program that interacts with other groups in EL, to directly inform best practices for DFS program activities. The Lumberton field study directly supports the disaster metrology research activity of the DFS Program and has repeatedly served as a space for developing and/or testing new technology, data collection instruments, and methodologies. For example, in Wave 1, the team developed an integrated sampling methodology that prioritized both engineering and social science research questions and created data collection instruments to assess physical and socioeconomic impacts of Hurricane Matthew. The sampling methodology and data collection instruments are published on *DesignSafe-CI*. Likewise, in Wave 4, the team employed new technology to collect data on housing and business occupancy status using ESRI®'s *Survey123 Connect* survey design application. The contribution of the new technology to the field study was evaluated to inform recommendations associated with future disaster and failure studies.

Community Resilience Planning Guides - NIST also manages a multi-faceted program aimed at assisting communities and stakeholders on issues related to buildings, the interdependencies of physical infrastructure systems, and the social and economic functions they support. NIST CRP released the *Community Resilience Planning Guide for Buildings and Infrastructure Systems* in 2015 to help communities plan and implement prioritized measures for the built environment to strengthen their resilience to hazard events. Since 2016, NIST has been working to develop science-based tools for communities, professionals, and researchers to assess resilience and to support informed planning and decision making at the community scale for improving resilience in communities of all sizes. The three following Community Resilience Program research projects are directly supported by the field study in Lumberton, NC.

Community Resilience Systems Model – In the development of community plans (e.g., land use management, emergency response, economic development), the formidable challenges inherent in both the analysis and design of the resilience systems must be addressed. This project focuses on the development of a model to support community resilience decision-making. The NIST Alternatives for Resilient Communities model, or NIST ARC, is an interactive screening tool that is designed to assist communities in resilience planning. In its application of operations research methods, NIST ARC addresses many of those challenges related to the breadth, large scale, and interdependencies of the physical, social, and economic systems that determine a community's resilience. Given hazard and interdependency information, and socio-economic data, NIST ARC outputs alternative sets of actions across the community that can be taken to meet user-specified resilience and other targets (e.g., cost). The goal of NIST ARC is to decrease a community's burden in developing viable, sound alternatives for stakeholder consideration and to provide useful starting points for further, more detailed analysis. NIST ARC is designed to assist a collaborative planning team in the identification of solutions as outlined in NIST's *Community Resilience Planning Guide for Buildings and Infrastructure Systems*. The target user is an analyst facilitating the collaborative planning team's interactive use of the tool. The analyst assists in the refinement of targets and imposition of new constraints to address comments or concerns, and to explore tradeoffs between competing objectives. Data and information obtained throughout the Lumberton field study provided the foundational case study for the development of NIST ARC.

Community Resilience Assessment Methodology – Community resilience is a complex, multi-dimensional problem that relies on engineering, social sciences, earth sciences, and other disciplines to improve the way communities prepare for, resist, respond to, and recover from

disruptive events, whether those events are due to natural or human-caused hazards. This project will develop tools and metrics for communities to measure resilience at the community-scale. The assessment methodology will employ a complex systems perspective to make linkages between social and physical systems and will address resilience over time in order to provide useful information to inform an understanding of the factors influencing recovery following a disruptive hazard event. The goal of this research is to develop a simplified, science-based community resilience assessment methodology that can be applied to communities of any size for the purpose of assessing baseline resilience and changes in resilience over time. The Tracking Community Resilience (TraCR) methodology will ultimately be coupled with NIST ARC to provide a means of evaluating decisions for their contribution to resilience, among other factors. Field studies including Lumberton provide essential datasets for supporting multivariate analyses examining relationships between indicators of resilience and recovery, sensitivity and uncertainty analyses, and validation studies.

Cost-Effective Resource Allocation Strategies to Enhance Community Resilience -

Advancements in measurement science are needed to estimate the economic impact associated with community resilience planning for natural and human-made hazards. In addition to the development of a standard economic methodology for evaluating investment decisions aimed at improving the ability of communities to adapt to, withstand, and quickly recover from disruptive events, this project includes a focus on the measurement of disaster losses, focusing on major indirect losses, such as business interruption, and distributional effects —through the use of both data gathered in the field through surveys and interviews as well as secondary data sources. These data ultimately support measurement of the ‘resilience dividend,’ the (non-disaster related) community co-benefits from investing in disaster resilience and can be used to provide guidance to communities on approaches to assessing the net co-benefits associated with resilience planning. Since Wave 2, the Lumberton field study has included a formal business recovery component to establish data collection tools and methods for measuring the indirect losses like business interruption associated with hazard events.

1.3. Hurricanes Matthew and Florence, and Overview of the Longitudinal Field Study

In early October 2016, after devastating parts of the Caribbean, Hurricane Matthew skirted Florida, and continued up the eastern seaboard before turning out into the Atlantic Ocean off the coast of North Carolina and Virginia (see Fig. 1-1). More than 170 counties in Florida, Georgia, South Carolina, and North Carolina were included in Presidential Emergency Declarations and/or Presidential Disaster Declarations between October 6th and 11th, 2016. Economic loss estimates exceeded \$10 billion [1].



Figure 1-1. Path and Intensity Timeline of Hurricane Matthew.

More than a week after the storm turned out to sea, parts of North Carolina had yet to experience flood crests, with many communities experiencing flood levels at or higher than those for Hurricane Floyd in 1999¹. The Lumber River reached flood stage in Lumberton, NC on October 3rd due to local heavy rains. On October 11th, the Lumber River crested at almost 22 ft (6.7 m) above the gauge datum. The water level slowly fell, dropping below flood level on October 23, 2016.

As described in van de Lindt, Peacock, Mitrani-Reiser et al. [2], the Center Field Study team selected Lumberton for longitudinal study for many reasons, including the moderate population size of approximately 21,000 residents [3], the diverse socio-demographic makeup of primarily three race and ethnicity groups (White, Black, and American Indian), and that flood waters entered the City through a gap in the levee system that 13 years prior was reported to not meet the current FEMA regulations.

The Center and NIST team conducted a quick-response field study focused on the City of Lumberton, NC and the flooding it experienced from the Lumber River. The quick response field study was performed during the week of November 29, 2016. Denoted here as Wave 1, it was the first of a series of annual field studies to document and better understand Lumberton's recovery. Data collection during Wave 1 focused on the residential housing sector with two primary objectives: (1) to establish and document initial conditions for the longitudinal resilience field study of Lumberton's recovery, with a focus on the most heavily affected area located within a particular school zone; and, (2) to facilitate and document the development and first application of a combined engineering-social science field study protocol that provides a quantitative linkage

¹ At its peak, Hurricane Floyd was recorded as a Category 4 hurricane. It was reduced to a Category 2 by early September 1999 when it impacted North Carolina with a storm surge height exceeding 9 feet causing 51 fatalities and billions in damages. Flooding damage was tremendous with as much as 20 feet of floodwater staying for over a week in some areas and exacerbated due to Hurricane Dennis which hit North Carolina just a few weeks prior.

between flood damage and socio-economics including race, ethnicity, income, tenancy status, and education level. Population dislocation probabilities were found to be higher for Black and Native American households than for White households, for the same residential housing damage state following the flood. See van de Lindt, Peacock, Mitrani-Reiser, et al. [2] for the Wave 1 field investigation report.

Approximately one year after Hurricane Matthew, during the dates of January 19 to 29, 2018, the Center and NIST researchers returned to Lumberton for Wave 2 of the longitudinal study. As described in Sutley, Dillard, van de Lindt et al. [4], the overall purpose of Wave 2 was to (1) support on-going research at the Center and NIST through the collection of the necessary data to build and/or validate community-resilience models for business, housing, social institutions, and building functionality; and (2) advance understanding on the factors that influence recovery for two specific community sectors, namely residential housing and business, as well as to gain information on the recovery status of schools, households, public works, and the community as a whole.

In support of the overall purpose of the longitudinal study, the same housing sample from Wave 1 was adopted for Wave 2, and as a new feature, a sample of 453 businesses was added. For housing, one housing unit was dropped due to a hard refusal during Wave 1, resulting in a sample of 567 housing units for structured surveys in Wave 2. Of these 567 housing units, the team was able to survey more than 227 household respondents. For businesses, a stratified random sampling approach resulted in a sample of 350 businesses drawn from the *ReferenceUSA* database (now *InfoGroup*). While in the field, an additional sample of 103 businesses was drawn to address possible coding errors in *ReferenceUSA*, business closures, and response rates. The final sample resulted in 453 businesses, where 164 business owners and managers were surveyed. The business survey instrument used in Wave 2 assessed the damage from Hurricane Matthew through a series of questions built on analogous damage state descriptions designed for commercial buildings. Both the housing and business surveys included questions on physical repair and sector-specific recovery indicators to document recovery progress and asked about the availability and timing of a range of financial recovery resources. For the public sector data collection, meetings were held with four city representatives and four state representatives, including both government and the water utility, to understand the context for recovery of the community. Likewise, to understand the context for school recovery, interviews were conducted with nine school district representatives. At the time of Wave 2, recovery was still on-going for Lumberton households and businesses, with much Federal money having not yet arrived, and many rebuilding decisions yet to be made. See Sutley, Dillard, van de Lindt, et al. [4] for the Wave 2 field investigation report.

Hurricane Matthew was widely reported to be a 500-year rainfall event, but only two years later, another low annual exceedance probability (1000-year) event inundated Lumberton along with many areas in North Carolina because of Hurricane Florence. After reaching peak intensity and Category 4 status on September 11, 2018, Hurricane Florence made landfall on the US Eastern Coast on September 14, 2018, as a weakened Category 1 hurricane (see Fig. 1-2), bringing six days of heavy rainfall to North and South Carolina. The storm eventually lost strength over West Virginia and was downgraded to a post-tropical cyclone on September 17, 2018. Hurricane Florence inundated the city of Lumberton with 165 mm (6.5 in.), 380 mm (15 in.), and 350 mm (13.8 in.) of rain on the 15th, 16th, and 17th of September 2018, respectively. Due to its slow forward motion and heavy rains, the storm caused significant coastal and inland flooding. In

North Carolina, 22 stream gauges measured record peak flood stages due to the storm, with many breaking records previously set by Hurricane Matthew [1]. Post-Hurricane Florence flooding significantly affected businesses, residential structures, and agriculture in many areas that were still recovering from the 2016 flooding.

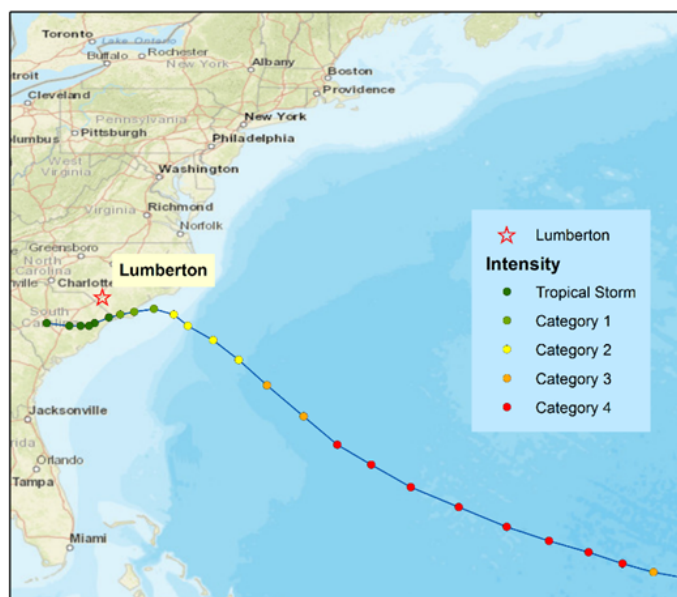


Figure 1-2. Path and Intensity of Hurricane Florence.

The Center and NIST team conducted a quick response field study October 16 – 19, 2018 to document the initial physical damage to the longitudinal sample of housing units and businesses, denoted as Wave 3a. As critical decisions were being made by the city on whether or not to rebuild vacant and damaged housing units since Hurricane Matthew, a small team of Center researchers returned to Lumberton December 2 to 5, 2018, to conduct focused interviews with key decision makers and public housing residents, denoted as Wave 3b. In April 11 - 21, 2019, the Center and NIST team returned to Lumberton to execute two systematic surveys – one to households and one to businesses – and to conduct semi-structured interviews with City contacts to learn more about the impact and disruption caused by Hurricane Florence and the progress or hindrance on recovery still unfolding after Hurricane Matthew. This latter trip was denoted as Wave 3c.

The Wave 3a damage surveys revealed approximately two-thirds of housing units that were damaged after Hurricane Florence experienced more severe damage after Hurricane Matthew. In total, approximately 18 % of housing units and 15 % of businesses were damaged by Hurricane Florence. Significant proportions of the housing and business samples were not damaged during Hurricane Florence given that the samples were designed based on the inundated area caused by Hurricane Matthew, and the two floods were considerably different for Lumberton. The Wave 3a team observed different mitigation actions that had been taken at the city-level, such as deploying pumps and temporary berms, as well as by individuals, such as elevating their AC units. These observations made for important follow-up questions the team would ask about in future waves.

Individual-level mitigation measures were only captured anecdotally in Wave 3a, and used to inform survey design for Wave 3c. In the surveys conducted during Wave 3c there was

systematic collection of data about mitigation to understand if and how widespread these actions were and to understand if and how they may have reduced property loss and collective damage.

The Wave 3c housing survey documented that 33 % of households who completed the survey reported still having unrepaired damage from Hurricane Matthew at the time of Hurricane Florence. Because of Hurricane Florence, nearly two-thirds of respondents were dislocated from their home for at least one day, and a majority indicated they returned home within two weeks. Although recovery was still an active process, 85 % of respondents reported intentions of remaining in their home for the next year, and more than 80 % indicated having the same access to school and grocery stores after Hurricane Florence as they did before Hurricane Matthew. Similar to observations in Wave 2, in Wave 3c small proportions of respondents received insurance payouts and other recovery resources. The Wave 3c survey asked about positive impacts of the two events as well, where approximately one-third of respondents indicated increased community involvement and approximately 40 % indicated increased contact with neighbors and extended family since before Hurricane Matthew.

The Wave 3c business survey documented that 17 % of businesses that completed the survey reported unrepaired damage from Hurricane Matthew at the time of Hurricane Florence. Due to Hurricane Florence impacts, 80 % of businesses reported losing electricity for at least one day, which was the most frequently reported utility loss. Furthermore, over 40 % of businesses experienced interrupted operations for at least one week. When asked to report their perception of their recovery, over half of businesses (58 %) reported being fully recovered relative to their state prior to Hurricane Florence. The Wave 3c survey asked business representatives to indicate mitigation and preparedness actions they had taken. Fewer businesses reported taking these actions compared to housing. See Helgeson, Hamideh, Sutley et al. [5] for the Wave 3 field investigation report.

1.4. Overview of the 2021 (Wave 4) Lumberton Field Study

Lumberton was still recovering from the 2016 Hurricane Matthew and 2018 Hurricane Florence and waiting on significant federal recovery resources when the COVID-19 pandemic started in 2020. Findings from Wave 3c revealed increased mitigation and preparedness employed by individuals, businesses, and the City for Hurricane Florence compared to Hurricane Matthew. Thus, there was still much to learn from Lumberton's recovery prior to and during the COVID-19 pandemic. This section provides an overview of Wave 4, which took place during the COVID-19 pandemic. Data collection for Wave 4 was executed in two parts, Wave 4a and Wave 4b; both are described herein.

To continue the longitudinal field study, Wave 4 was intended to take place during the spring of 2020. However, many of the institutions involved in the Lumberton study shut down human subjects research and nonessential travel for important ethical and safety reasons in response to the COVID-19 pandemic, which required a delay in Wave 4. The field study team was also affected by the pandemic further impacting when Wave 4 could take place. Although human subjects research was allowed to resume with limitations in Summer 2020, travel remained restricted until late Spring 2021. Institutional review board offices were slower in processing times due to their staff also being affected by the pandemic, as well as needing to be especially thorough to make sure approvals followed any new COVID-19 restrictions that had been put in

place. Plans for Wave 4 of the longitudinal field study were altered in response to the evolving guidance and restrictions provided by the institutions involved.

Wave 4a took place remotely and utilized an electronic-based survey instrument; the Wave 4a housing and business surveys were open from February 1 to July 1, 2021, and recruitment took place during the same time period. Expecting response rates to be substantially lower given the virtual nature of the surveys, the housing sample was expanded for Wave 4a. Two versions of the virtual survey were developed online. The first version was sent to the longitudinal sample, but since personal information beyond home address was never collected for the housing sample, phone and emailed surveys were not possible. Recruitment was conducted through multiple rounds of postcards. The second version of the housing survey had identical questions and was sent out to an unknown sample size and is referred to as the “convenience sample”. In surveying methodology, a convenience sample is a non-probability sample of potential respondents that are “convenient” to the researcher [6]. As such, recruitment occurred through emailing weblinks to various community organizations, using their public email addresses, and requesting them to share the weblink with the members of their respective organizations. Chapter 2 details the sample, data collection methods, and design of the housing survey used in Wave 4.

Business surveys were also administered electronically. Businesses in the longitudinal sample in addition to a refreshment sample were sent postcards for recruitment. The refreshment sample was created to mitigate low response rates and was created using the remaining businesses in the floodplain and a random sample of businesses outside the inundation and floodplain areas (n=270). Additionally, business email addresses were used, and phone numbers were called to improve response rates. Similar to the housing survey, the business survey included some questions on longitudinal recovery but mostly focused on mitigation and impacts from the COVID-19 pandemic. Chapter 3 details the business sample, data collection methods, and design of the business survey used in Wave 4.

As anticipated, response rates were low in Wave 4a; however, they were much lower than expected. A round of mailed surveys went out but ultimately did not pull a meaningful response. A high proportion of postcards and surveys were returned to sender by the USPS. Collectively these two outcomes caused significant concern about the status of the housing and business samples. The low response rate and high proportion of postcards returned to sender prompted Wave 4b, which took place December 1, 2021 - December 4, 2021. A small team visited Lumberton with the goals of determining whether the physical structures for the housing units and businesses were still standing, and to determine occupancy for housing and operational status for businesses, to the extent possible.

To protect the health and safety of Lumberton residents and field team members, data were collected through visual inspection of the housing and business samples; no human subjects research took place in Wave 4b. A form was created to document perceived occupancy and/or operational status of both housing units and businesses. The details of Wave 4b are provided in Chapters 2 and 3 for the housing and business surveys, respectively.

This report is organized as follows: Chapter 2 provides the findings on the housing sample, including specific study goals, team training and deployment, and results. Chapter 3 provides the findings on the business sample in a similar fashion as Chapter 2. Chapter 4 provides conclusions on the previous chapters’ findings, and next steps for the longitudinal field study.

2. Housing Recovery and Resilience

2.1. Goals and Objectives

The housing component of the Wave 4 field study is in support of ongoing research in the Center, including modeling household dislocation and relocation, housing repair and recovery, and understanding mitigation and capacity-building (e.g., social capital, utility backups) actions taken by households in Lumberton. Due to Wave 4 occurring during the COVID-19 global pandemic, the specific goals of this wave changed, as did the sample, recruitment, and data collection methods. As described in Chapter 1, Wave 4 took place in two parts; Wave 4a was conducted remotely with surveys administered to the longitudinal housing sample and a convenience sample. Given low response rates and high numbers of postcards and surveys returned from the USPS, an additional wave of data collection was necessary to understand the status of housing in Lumberton. As a result, Wave 4b was conducted in Lumberton which consisted of an in-person data collection with no human subjects research component, and focused on the longitudinal housing sample.

The goals of the housing data collection for Wave 4a included:

- Developing a better understanding of the impact that COVID-19 had on the housing repair and recovery processes following Hurricanes Matthew and Florence;
- Obtaining household-level data on resilience measures, including social capital, preparedness, risk perception, and mitigation.

The goals of the housing data collection for Wave 4b included:

- Completing missing information on whether housing units had been demolished and/or re-built since Wave 3c.
- Completing missing information on household occupancy status of housing units in the longitudinal sample.

2.2. Sampling Procedure

To continue the longitudinal study, Wave 4a utilized the same housing sample as Waves 1, 2, and 3c. Given the change from in-person to virtual data collection required for Wave 4a, an additional convenience sample was added. As the sample changed, so too did the goals of Wave 4a, with a shift from focusing on longitudinal impact and recovery processes to documenting impact of the COVID-19 pandemic and overall capacity-building across Lumberton.

The original Wave 1 longitudinal sample was defined by the school attendance zone for Lumberton Junior High, which includes the attendance zones for the two elementary schools (W.H. Knuckles and Tanglewood Elementary Schools). A two-stage non-proportional cluster sample was designed to capture a representative random sample of the study area, which included areas inundated by flooding as well as areas that were not flooded. Within this sample design, the penultimate sampling units (blocks) were census blocks and primary sampling units were housing units and households residing in those units. The blocks were selected utilizing a probability proportion to size (PPS) random sampling procedure with blocks in areas with a high probability of flooding selected 3 to 1 over areas with low flooding probability. Areas subject to high probability of flooding were identified as those inside the flood inundation areas predicted

based on the FEMA-designated 100- and 500-year floodplains (see Chapter 1 in van de Lindt, Peacock and Mitrani-Reiser et al. [2]). A 100-meter buffer was added to the floodplain to account for uncertainty in expected flood extents. Housing units within the sampled blocks were then selected at a fixed rate of 10 random units per block, where 8 units were identified as primary with 2 alternates. The combination of selection PPS with a fixed number of housing units selected, after weighting, ensures a representative sample of the area. Among the 830 blocks with five or more occupied housing units in the school attendance zone, the sampling process drew a random sample of 80 blocks based on a probability proportion to size, oversampling for high probability of flooding (56 census blocks in the high probability areas and 24 in the low probability areas). In the final sample, 75 of 80 census blocks were visited (54 census blocks in the high probability areas and 21 in the low probability areas), including 568 valid primary housing units, yielding an average of 7.6 housing units per block. For more detailed information about the sampling procedures for Wave 1, please refer to Section 3.2.1 in the Wave 1 report [2].

The 568 housing units, and the households living in these units, were the primary sample units for Waves 1, 2, and 3c, and the target sample units for Wave 4a. During Wave 1, one household did not want to participate and accordingly, this housing unit was dropped entirely from the Wave 2 housing sample. Therefore, Waves 2 and 3c consisted of a selected sample of 567 housing units. Similarly, Wave 4a started with the sampling frame from Waves 2 and 3c. The team was concerned that remote data collection would produce low and biased response rates, and that we would only receive responses from those households in a better position to respond (i.e., miss more socially vulnerable community members). Thus, Wave 4a added a “convenience” sample. In surveying methodology, a convenience sample is a non-probability sample of potential respondents that are “convenient” to the researcher [6]. Due to the nature of convenience sampling the sample size is unknown, nevertheless, the team hoped to receive at least 200 responses. The convenience sample was recruited through emails sent from the study team to 38 community organizations and contacts, and from those organizations to their members. In total, the Center reached out to 33 local faith-based organizations, as well as the Robeson County United Way, the City Manager, Housing Authority, Public Works Director, and Public Relations Officer with the Public School system. Respondents from the longitudinal sample and from the convenience sample were sent identical virtual surveys; the different samples were sent different links to access the survey in order to keep the samples separated. Because the convenience sample did not provide a sufficient number of additional survey responses, Wave 4b exclusively adopted the longitudinal sample from Waves 2 and 3c.

Given that the housing sample oversampled at a rate of 3 to 1 in census blocks with a high probability of flooding, survey responses should be adjusted to reflect community-level proportions. After adjusting for the oversampling, the proportioned sample consists of 861 housing units. Results presented in previous reports and in sections 2.5 and 2.6 of this report are based on the unadjusted ($n=567$) and adjusted ($n=861$) sample size and are labeled accordingly.

2.3. Data Collection Methodology

This section first describes the recruitment approach and survey development for Wave 4a, and then the data collection methodology for Wave 4b.

2.3.1. Recruitment and Data Collection for Wave 4a

Given that the field study team did not collect telephone numbers or email addresses throughout the longitudinal study for the housing sample and were prevented from using other incentives (e.g., paying for responses, providing gift cards, or purchasing phone numbers), the team was limited to contacting households via mail using the physical addresses on record from initially selecting and visiting their housing unit in previous waves. In addition, the team did not have the physical address for the convenience sample, and thus different recruitment approaches were taken for the longitudinal sample and the convenience sample.

For the Wave 4a virtual survey recruitment, the team mailed three rounds of postcards to all housing units in the longitudinal sample. The first round of postcards was mailed out on February 5, 2021; a second round of nearly identical postcards were mailed out on March 10, 2021. With very low response rates gained from the first two rounds of postcards, the team adjusted the recruitment strategy to prioritize a selection of housing units in the longitudinal sample (explained below) and mailed paper surveys (including postage paid return envelopes) to those prioritized housing units on May 10, 2021. Finally, a third round of postcards were mailed out to the full sample on June 15, 2021. The third and final round of postcards were slightly revised to include a statement on the importance of the households completing the survey, signed by our colleague and team member at East Carolina University, and contained the East Carolina University logo to provide a more local appeal. Figure 2-1a provides an image of the first and second round of postcards; Figure 2-1b provides an image of the third round of postcards. As shown in Figure 2-1, the postcards provided a weblink to access the virtual survey as well as a QR code that linked to the virtual survey. The only difference between the first and second round of postcards was that the second round greeted the household with “We missed you!” instead of “Dear Residents,”. The first and second round of surveys also mentioned a participant identification number (PIN) located above the address line. These PINs were used as a measure of redundancy to match the response to one of our sampled units.

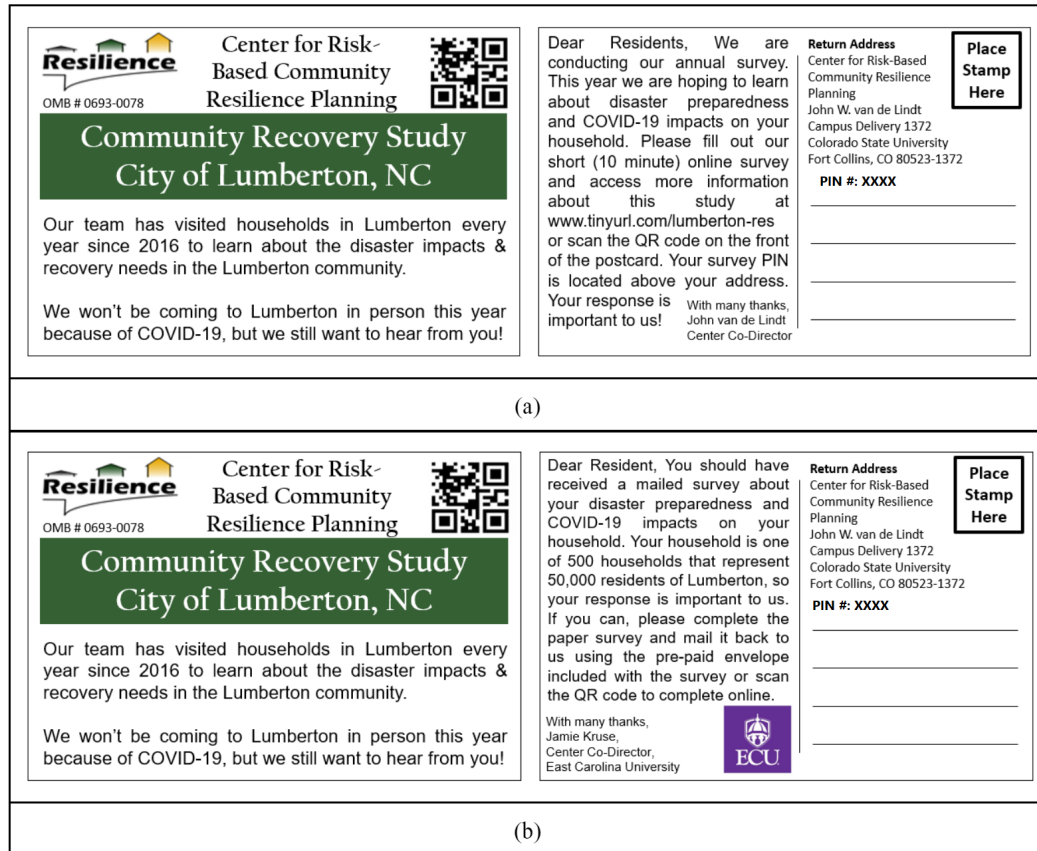


Figure 2-1. Postcards sent to recruit the longitudinal sample in Wave 4a: (a) first and second round of mailed postcards; (b) third round of mailed postcards.

As previously mentioned, a selection of housing units in the longitudinal sample were prioritized for receiving a mailed survey. These 201 housing units (out of 567) were identified based on responses and observations throughout the longitudinal study. If the team had at least two waves of damage inspections from Waves 1 or 3a, or, completed surveys from Waves 1, 2, or 3c, the housing unit was prioritized for receiving a mailed survey.

The convenience sample was recruited through emails to 38 community organizations and contacts, and from those organizations to their members. The 38 contacts received two emails, and when possible, two follow-up phone calls from the team for recruitment purposes. The emails to these contacts included a request to share the study's survey with their membership and an email they could then directly forward to their membership. The team was not copied on emails sent out through the community organizations, and thus do not know how many contacts followed through in sharing the recruitment email with their members. A similar message (as provided in the email) was added to the City's website during the data collection time frame through a request to the City Manager. Appendix A presents an example copy of the emails sent to these contacts.

The Wave 4a virtual survey was conducted via the *Qualtrics* electronic survey platform. A consent script was used on the opening page of the electronic survey and was accompanied with a required response checkbox for the user to affirm they understood the reason for the survey and that they were eligible to participate. On the opening page, we also informed the respondent that

the survey should require no more than 15 minutes of their time. The last page of the survey thanked the respondent for completing the survey and provided a link to download a flier with high-level results of the data collection in Lumberton since 2016. The electronic survey was available online beginning the first day the postcard invitations were mailed out, and remained open for 18 weeks, between February 1, 2021 through July 1, 2021, in order to maximize the response rate.

2.3.2. Wave 4a Survey Development

During development, the electronic survey instrument underwent several rounds of review by CoE researchers and NIST collaborators. Additionally, the survey instruments were reviewed by the broader interdisciplinary field study team. This iterative collaboration created a relatively brief yet thorough survey instrument. Lessons learned from three years of data collection informed both the form of the questions and the guidance to surveyors that was written onto the survey itself. Pretesting was an integral part of survey development, particularly to make sure any and all built-in logic worked as intended in the virtual survey, as well as to make sure questions were presented in an easy-to-follow fashion and were very clear about whether a specific flooding event or the COVID-19 pandemic was being addressed. Special attention was also paid to the length of the survey given the virtual nature of the instrument.

The final housing survey also went through review for the Paperwork Reduction Act (PRA) (1995, Pub. L. Count 104-13, 109 Stat 163). The purpose of the PRA review is to “ensure the greatest possible public benefit from and maximize the utility of information created, collected, maintained, used, shared, and disseminated by or for the Federal Government;” and to “improve the quality and use of Federal information to strengthen decision making, accountability, and openness in Government and society.” The instrument and data collection methodology for the household survey and the full Wave 4a Lumberton study were approved by the Institutional Review Board (IRB) at Colorado State University, which oversees the Center’s human subjects research.

Aside from the demographic questions, the Wave 4a survey largely did not build on surveys from Waves 1, 2, 3a, 3b, or 3c. This change was intentional given that surveys were sent both to the longitudinal housing sample and to a convenience sample specially adopted for Wave 4. The team used this increased sample size as an opportunity to gain information on the additional topics of risk perception, preparedness, and mitigation for future flood events, as well as a deeper understanding on the local effects of the COVID-19 pandemic. There are five main sections in the survey. Those include (1) identifying the location of the housing unit, (2) initial damage caused by either Hurricane Matthew or Hurricane Florence, (3) household risk perception, preparedness and mitigation, (4) impacts of the COVID-19 pandemic on household and housing recovery from Hurricane Florence, and (5) household socio-demographic characteristics. Appendix B presents a copy of the virtual housing survey with consent script used in Wave 4a. Appendix C presents a copy of the flier shared with respondents on high-level findings of the longitudinal study to-date.

After confirming consent, the first set of survey questions asked respondents in the longitudinal sample to insert the ID number on their postcard with a screenshot pointing out where they could find the ID number, then to enter their current home address. Even though the address for the respondents with ID numbers was known, the two questions allowed the team to validate these

important inputs. The convenience sample was not assigned ID numbers, and thus was only asked the latter question in this set. Remaining questions were identical on both surveys.

The next set of questions asked about the household in general, including the number of adults and the number of children, categorized with the cut off of 18 years of age. Respondents were then asked how many years they have lived in Lumberton, when they moved into their current home, and whether their home was damaged by either Hurricane Matthew or Florence. These questions help establish a baseline before asking questions on risk perception, preparedness, and mitigation.

The next set of questions asked about the household's perceived preparedness, including their tenure status, whether they have specific types of insurance (e.g., renter's, flood, or homeowner's insurance), and whether they felt their insurance coverage was adequate. Questions also asked if homeowners have a mortgage. The survey addressed changes in social capital by asking 'how has your contact with neighbors and/or extended family and friends changed since the COVID-19 pandemic?' This question framing avoids blurring the timeline of influence between hurricane recovery and the pandemic. Respondents are then asked how many major floods or hurricanes the respondent had experienced in their lifetime, how likely they thought it was for their home to be damaged during a major flood event in the future, and the likelihood their household would evacuate if given evacuation orders during a future flood event similar to Hurricanes Matthew or Florence. An open ended question followed, requesting the respondent to explain their evacuation decision.

Two questions were asked about mitigation and preparedness strategies, both with eight identical prompts. The first question asked what features the household had adopted at the time of the survey, whereas the second question asked about the household's plans to potentially adopt mitigation and preparedness strategies in the next six months thereby capturing the household's plans as they entered into the next hurricane season. Eight mitigation and preparedness strategies are provided as options: (i) elevate hot water heater; (ii) reroute ductwork from below floor to attic space; (iii) make an emergency plan with household members; (iv) gather supplies to last three or more days; (v) seek information on mitigation and preparedness; (vi) attend a local meeting or training on preparedness; (vii) set money aside for recovery or repairs; and (viii) anything else with the option to fill-in information. Responses to these prompts were 'yes', 'no', or 'don't know'. The last question on mitigation and preparedness asked respondents if they have an option to provide any utility services temporarily for their household, including through a power generator, solar panels, water storage tanks, gas tanks, community wi-fi, community information hub, and the option to fill in additional responses.

The next set of questions asked households about the impacts of the COVID-19 pandemic on their household, including if repairs to their home or their household's recovery from Hurricane Florence had been impacted. Questions then asked if members of the household were unable to work because of COVID-19 or reduced to part-time work because of COVID-19. If the respondent answered yes, questions then asked how long the household member was unable to work or was reduced to part time work. A second follow up question aimed to understand the source of work change with options of temporary closure of place of employment, permanent closure of place of employment, childcare issues, health issues, or other with the option to fill-in information. A third and final follow-up question was asked to respondents who had household members unable to work or reduced to part time work, and asked how the household's income had been disrupted with answer choices of significant, moderate, minimal, none, or don't know.

The final set of questions captured information on the household in general, focusing on socio-economic and demographic characteristics, including whether any individuals in the household had electricity-dependent needs, the highest level of schooling completed by any household member, whether the household identified as Hispanic or Latino, what race the household identified as, if the household identified as female-headed, and the household's combined annual income with 15 income categories to select from.

Finally, the survey included an open-ended question prompting respondents to share any comments, thanked the respondent for completing the survey, shared a link to download a summary of the study results to date, presented weblinks to the study website and the first report, and the Office of Management and Budget (OMB) Burden Statement.

2.3.3. Wave 4b Data Collection Methodology

Due to the low response rates (6 %) of the online survey and the large portion (41 %) of returned survey invitation postcards, an in-person visual inspection was necessary to ascertain housing unit status to support determination of next steps of the longitudinal study. The team developed a set of questions to determine if a) there was a structure on the property, and if so, if it was a residential structure, and b) if there was evidence of the residential structure being occupied. This classification was supported by the development of "potential occupancy/non-occupancy indicators". This indicator list was more general in nature and included items that would make the determination of occupancy or vacancy obvious, even to the casual observer. For example, in terms of assessing occupancy, indicators of "people visible inside or outside"; "lights on or activity inside"; "holiday decorations present"; and "vehicle in driveway" and others, were suggested. Holiday decorations were expected to be seen more than typical due to the deployment being conducted in December. In terms of assessing vacancy, indicators such as "visibly abandoned (e.g., doors & windows boarded)", "foreclosure/condemned sign", and "landscaping not maintained" and others, were included (see Tables 2-5 & 2-6). As the research team reviewed the list, it became apparent that there would be cases when the occupancy status was indeterminable. As a result, an "Other" answer option was added to both the vacancy and occupancy questions to allow for the researchers to note further evidence of their findings that the residence was "probably occupied" or "probably unoccupied."

Due to COVID-19 restrictions, Wave 4b was planned and executed without any human subjects research. A windshield survey was conducted using three cars with two to three researchers per car. The team adopted several new health and safety protocols in light of the ongoing COVID-19 Pandemic. All team members were required to have a negative COVID-19 test result prior to traveling to Lumberton. Team members were also encouraged to get a vaccine booster if they were eligible. Team members were tested every 48 hours after their original negative test result for the duration of the field study. To limit interaction and exposure, vehicle teams were composed of the same personnel for the entirety of data collection. Masks and social distancing measures were taken for all group meetings. The use of electronic data collection tools eliminated the need to manually enter data at the end of each day, which also reduced potential exposure.

Survey zones were created in ESRI®'s *ArcGIS Desktop* application that divided the study area into three areas with an approximately equal number of housing units per zone. The survey vehicles were each assigned a zone to conduct the windshield survey. Within each of the zones,

the housing sample was prioritized according to the responses from previous waves. For example, if the resident of a housing unit had not responded to the Wave 4a survey but did respond to the Wave 2 or Wave 3 survey, the unit was given a priority level of 2. However, if there was a response registered for a housing unit for Wave 2 and Wave 3, it was given a priority of 1. If there was a response from a housing unit for Wave 4a, it was given a priority of 0 as there was no need to determine occupancy.

Once the lists of indicators were finalized and approved by the research team, a survey was developed in ESRI®'s *Survey123 Connect* survey design application. The first entry in the survey was the date and time of the visual inspection; this field was set to be automatically populated. The second entry in the survey was "Car Number", which was used to identify the car/team collecting the data for the sampled housing unit. The next entry required in the survey instrument was regarding the type of structure on the property, if any; options included "House", "Business", "No building present", and "Other." If "House" was chosen, options appeared to allow the researcher to enter further details (i.e., the aforementioned indicators of occupancy or vacancy). Another entry was required to capture the PIN of the sampled unit. Finally, the instrument allowed the option of including up to five photographs of the housing unit to accompany the survey response. The survey instrument was published to an *ArcGIS Online* website and made available for the field researchers via ESRI®'s *Survey123* application, an application that was downloaded to each researcher's phone and used to collect the data for the housing units in the sample. Appendix D hosts a copy of the Wave 4b survey.

The survey was accompanied with a map depicting the locations of the 567 housing units in the sample for use in ESRI®'s *Field Maps* application. The *Field Maps* application was downloaded to each researcher's phone and used in the field for directions to the housing unit locations in the sample frame. Once a survey was completed in *Survey123*, a data field was populated in the map attributes indicating such. This field was then used by a Dashboard application which allowed a remotely-based researcher to monitor the progress of the team (Fig. 2-2).

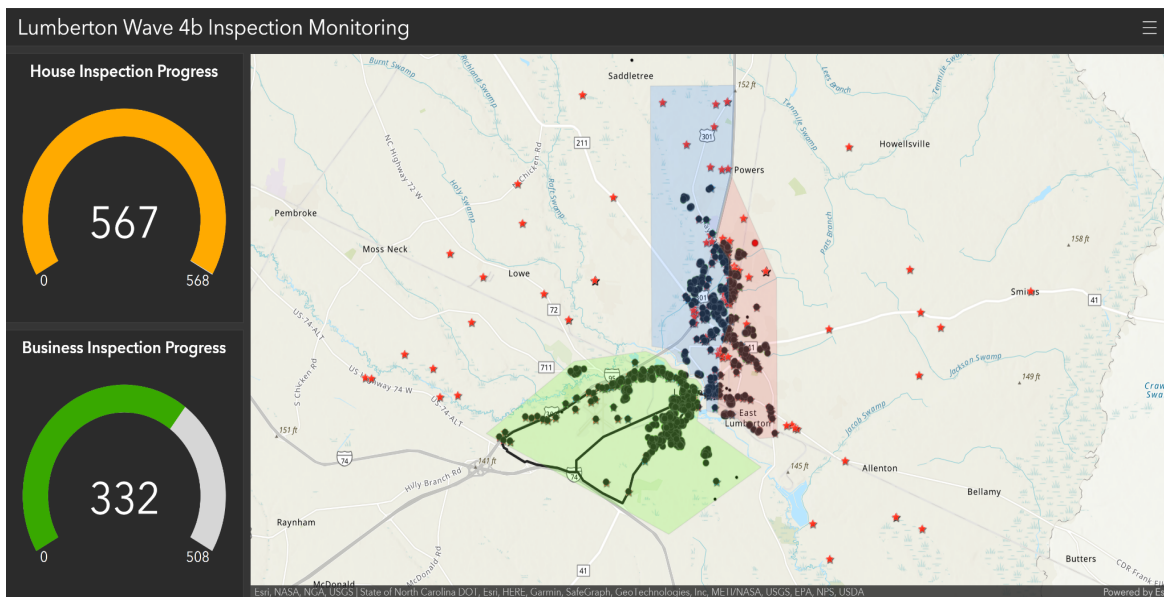


Figure 2-2. Dashboard depicting the final results of the survey team efforts for Wave 4b.

2.4. Wave 4a Survey Response Rates

It is known that electronic surveys generally experience low response rates [6, 7]. As such, the team targeted a response rate of 15 %, where responding to more than 50 % of the survey questions was determined to be a complete survey response. Categorizing a survey as “complete” when 50% of the questions are answered is common practice in reporting survey response rates [6, 8, 9]. All questions were optional; thus, it was expected that some households would answer only a portion of the questions. Table 2-1 provides the Wave 4a response rates for the longitudinal sample (n=567), and Table 2-2 provides the Wave 4a response rates for the adjusted longitudinal sample (n=861). Despite the team’s best efforts, it was not able to achieve the target response rate of 15 %, and instead reached a response rate of 6 %. In addition to the longitudinal sample, four responses were received from the convenience sample. Given the low response rate, survey results from Wave 4a are not presented.

Table 2-1. Wave 4a response rates for longitudinal housing sample.

n=567	Completed Surveys	Returned from USPS	No Response
Count (No.)	34	234	300
Percent (%)	6.0	41.2	52.8

Table 2-2. Wave 4a response rates for the adjusted longitudinal housing sample.

n=861	Completed Surveys	Returned from USPS	No Response
Count (No.)	58	286	517
Percent (%)	6.7	33.2	60.0

2.5. Wave 4b Observation Rates and Visual Observations

Table 2-3 presents the results of the occupancy status identified for each housing unit in the sample where only 2.6 % of sample points did not have a building at the corresponding address. Using the indicators described in Section 2.3.3, the team documented their confidence in occupancy or vacancy status. The survey team could not determine the status for 3.2 % of housing units. The majority of housing units were occupied (64.6 %) or probably occupied (7.6 %), while a significant portion were identified as vacant (16.9 %) or probably vacant (5.1 %). Table 2-4 presents the results of the occupancy status identified for the adjusted sample (n=861), which has similar proportions of occupancies and vacancies as the unadjusted sample (n=567).

Table 2-3. Wave 4b housing occupancy status.

n=567	Occupied	Probably Occupied	Vacant	Probably Vacant	No building present	Unsure (cannot or did not assess)
Count (No.)	366	43	96	29	15	18
Percent (%)	64.6	7.6	16.9	5.1	2.6	3.2

Table 2-4. Wave 4b housing occupancy status (adjusted sample).

n=861	Occupied	Probably Occupied	Vacant	Probably Vacant	No building present	Unsure (cannot or did not assess)
Count (No.)	573	61	102	40	19	66
Percent (%)	66.6	7.1	11.8	4.6	2.2	7.7

A major concern from Wave 4a was the return of many recruitment postcards from the USPS. The team was concerned that the large number of returned postcards might be an indication of increased vacancies or demolitions of housing units in Lumberton. Figure 2-3 depicts the occupancy status assessed during Wave 4b with the number of postcards returned during Wave 4a. As shown in Figure 2-3, 105 (44.3 %) of returned postcards were delivered to addresses with vacant or probably vacant housing units, whereas 124 (52.3 %) of returned postcards were delivered to occupied or probably occupied housing units. This latter case is likely explained by the national context and ongoing situation with the postal service at the time of Wave 4a, as explained by Bogage and Denham [10].

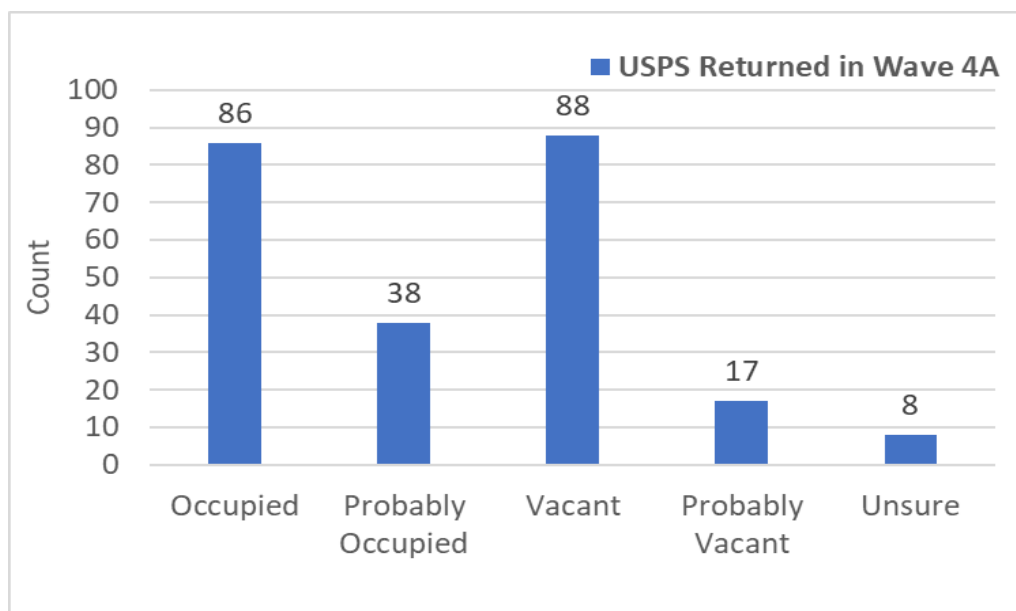


Figure 2-3. Comparison of Wave 4a returned postcards from USPS with Wave 4b occupancy status (n=567).

Six indicators were used to assess occupancy, and four indicators were used to assess vacancy. Table 2-5 presents the number of housing units that were assigned each occupancy indicator. In Table 2-5, percentages do not sum to 100% given that many housing units cited multiple reasons for occupancy determination, and percentages are calculated considering the total number of all reasons cited for either occupancy or vacancy. As shown in Table 2-5, the most common indicator used for assessing occupancy was a vehicle being present in the driveway at the time of the assessment (39.4 %), followed by holiday decorations present (30.9 %), followed by the other category. The “Other” category had notes written in by the surveyors such as toys or bicycles being present in the yard or on the porch, packages at the door, chairs, grills, or other furniture on the porch, potted plants, or a well-kept landscape, and in nine cases, occupancy was confirmed by a neighbor or with maintenance personnel.

Table 2-5. Reasons for occupancy determination.

Cited Reason(s) - Occupancy	Count (No.)	Percent (%)
Holiday Decorations Present	176	30.9
Lights on or Activity Inside	22	3.8
People Present Inside or Outside	45	7.9
Pet in yard	16	2.8
Trash or Recycling Bins at the End	77	13.5
Vehicle in Driveway	224	39.4
Other	141	24.8

Table 2-6 presents the number of housing units that were assigned each vacancy indicator. As before in Table 2-5, percentages do not sum to 100% given that many housing units cited multiple reasons for vacancy determination, and percentages are calculated considering the total number of all reasons cited for either occupancy or vacancy. For the case of vacancy, having broken doors or windows present and thus appearing visibly abandoned was the most common indicator assigned to 13.2 % of the housing sample, followed by the other category assigned to 10.5 % of the housing sample. The other category had notes written in by the surveyors such as bare studs or no furniture being visible through the windows, the entire apartment complex being closed, debris present in the driveway or yard, and over-filled mailboxes. Comparing Table 2-5 to Table 2-6, indicators of occupancy were more often used than indicators of vacancy, which is also evident in Table 2-3 findings.

Table 2-6. Reasons for vacancy determination.

Cited Reason(s) - Vacancy	Count (No.)	Percent (%)
Foreclosure condemned posting	13	2.2
Landscaping not maintained	16	2.8
Mail piled at doorstep	1	0.1
Visibly abandoned (e.g., doors & windows boarded)	75	13.2
Other	60	10.5

2.6. Longitudinal Findings

The COVID-19 pandemic created a situation that made it difficult to collect longitudinal information for the housing sample in Wave 4, resulting in the need to draw a convenience sample and design the survey around questions that were mostly not longitudinal from Waves 1, 2, or 3. However, a core metric for tracking longitudinal recovery presented in the Wave 3 report [5] was housing occupancy status. Thus, this section presents occupancy status based on the Wave 4b team's observations. Three categories are presented in Figure 2-3: perceived or confirmed occupancy (including "probably occupied" for Wave 4b), perceived or confirmed vacancy (including "probably vacant" for Wave 4b), and not assessed (including "unsure" in Wave 4b). The latter category varies based on the field study team size and time in the field across waves. For example, Wave 3a had the smallest team and shortest duration and Wave 4b had a small team, short duration, and the least number of metrics to assess. The decision to present these data is to provide information about the full sample of housing units in each wave, as opposed to changing portions of the sample which completed surveys during each wave.

As evident from Figure 2-4, the highest proportion of the housing sample was perceived to be occupied during Wave 1, where all 861 units in the adjusted sample were assessed. As shown, there is significant change in occupancy and abandonment status across waves. In Wave 2, 13 of the units were not assessed, 105 units that were perceived as occupied in Wave 1 were recorded as abandoned in Wave 2, whereas 45 of the housing units perceived as abandoned in Wave 1 were

recorded as occupied in Wave 2. Approximately six months later and shortly after Hurricane Florence hit, 106 units that were recorded as occupied in Wave 2 were recorded as abandoned in Wave 3a. Whereas 32 units that were perceived as abandoned in Wave 2 were recorded as occupied in Wave 3a. Wave 3a had the highest proportion (24 %) of the sample not assessed, which consisted of 174 units recorded as occupied in Wave 2, 37 units recorded as abandoned in Wave 2, and 160 were recorded as occupied six months later in Wave 3c. At the time of Wave 3c, 640 (74 %) housing units were recorded as occupied, and 25 % were recorded as abandoned. Most recently in Wave 4b, the second highest proportion of the sample was not assessed (6.1 %), including 37 of the homes perceived as occupied and 16 of the homes perceived as abandoned in Wave 3c. A high proportion (574 or 67 %) of those perceived as occupied in Wave 3c continued to be perceived as occupied in Wave 4b, where 30 housing units that were perceived as occupied in Wave 3c were recorded as abandoned in Wave 4b. Similarly, of the 219 homes recorded as abandoned in Wave 3c, 116 continued to be perceived as abandoned in Wave 4b, whereas 87 were perceived as occupied in Wave 4b. These changes are due to many reasons, including the timing of the inflow of recovery resources, the different coverage and impact caused by the flooding in 2016 (Wave 1 assessment) compared to the flooding in 2018 (Wave 3a assessment), and potential error and bias in the surveyor assessment. Overall, Wave 4b had the smallest proportion of the sample perceived as being abandoned (17 %) since Wave 1, which may speak positively towards progress in longitudinal recovery in Lumberton.

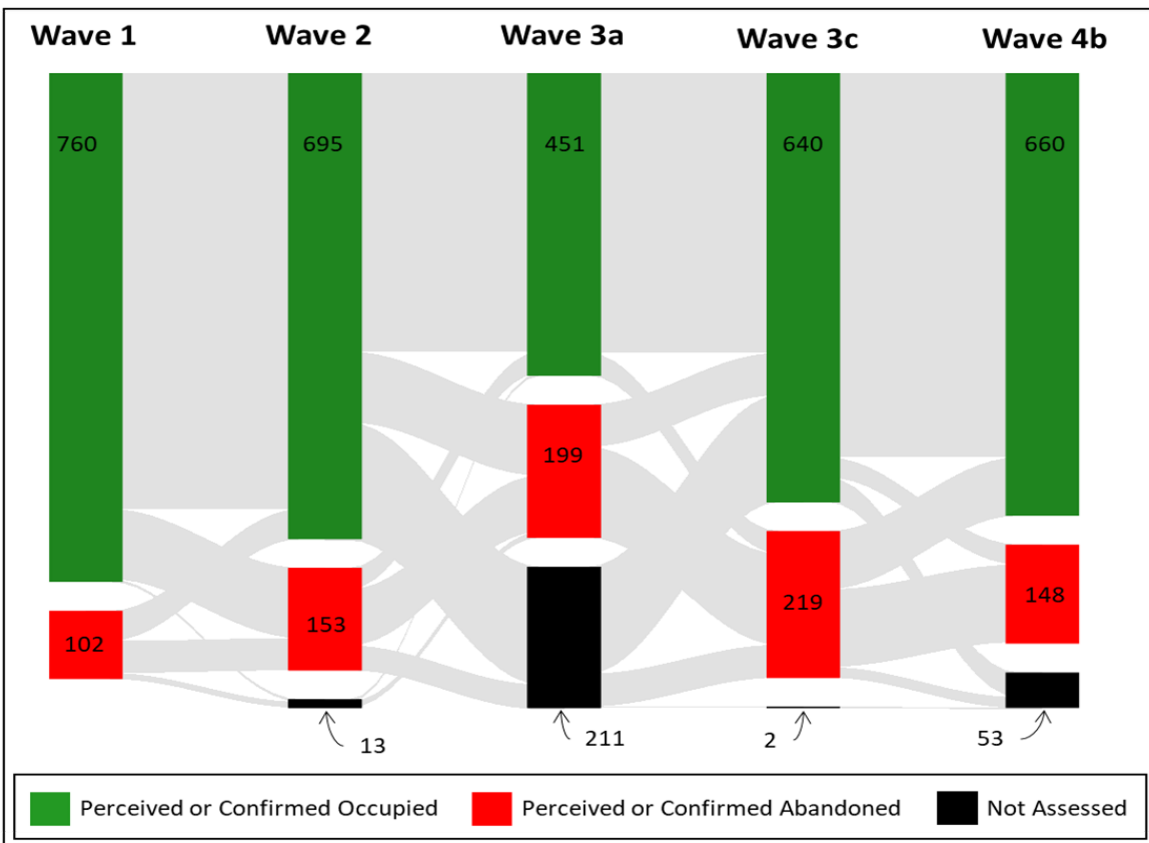


Figure 2-4. Sankey diagram depicting perceived or confirmed occupancy and abandonment of the housing sample across the Waves 1, 2, 3a, 3c, and 4b.

3. Business Recovery and Resilience

3.1. Goals and Objectives

The business component of the Wave 4 field study supports business-level interruption and recovery modeling efforts in the Center. This includes predicting and understanding factors behind initial days of closure and the resulting effects on levels of profitability, staffing, and capacity through time. The field study is a valuable source of learning about types of mitigation adopted and adaptation behaviors and the types of resources available to businesses surrounding a disaster. Given that COVID-19 had a major effect on individuals and businesses, business data collection efforts for Wave 4 had similar adjustments as those made to the housing data collection effort in terms of goals, sample, recruitment, and data collection methods.

The goals of the business data collection for Wave 4a included:

- Developing a better understanding on the impact that COVID-19 had on the business recovery processes following Hurricanes Matthew and Florence;
- Re-evaluating the generalizability of business impact and recovery metrics in light of COVID-19;
- Understanding preparedness, mitigation, adaptation strategies and financial resources used by individual businesses and the role of these strategies and resources in COVID-19 performance.

The goals of the business data collection for Wave 4b included:

- Completing missing information on businesses that had closed or newly opened since Wave 3c.
- Verifying the operating status of the longitudinal sample.

3.2. Sampling Procedure

Wave 4a utilized the same longitudinal business sample as Waves 2 and 3c; however, as noted in Section 1.4, a refreshment sample was added in Wave 4 for several reasons. First, some attrition in longitudinal surveys is to be expected. However, the team also anticipated that the move to virtual data collection would likely have a detrimental effect on response rates given the low response rate of the sample to previous phone recruitment efforts (please see Chapter 3 in Sutley, Dillard, and van de Lindt [4]). The team also anticipated that low response rates and overall survey burden would be compounded by other efforts to understand the economic impact of COVID-19 and the impact of COVID-19 business operations. This section will describe this additional sample as well as the original longitudinal sample from Waves 2 and 3c.

The longitudinal sample was created through a combination of the predicted flood inundation area calculated using the FEMA 100-year floodplain to capture businesses that were either likely to have flooded due to Hurricane Matthew or were at risk of future flooding (though they were not flooded in 2016). Data from *ReferenceUSA* (now Data Axle) were geocoded and sampled based on their location in these areas; all businesses were sampled from the inundation area and a random sample was taken from the remaining businesses in the northern floodplain. This procedure resulted in an initial sample of 350 businesses. After exclusions based on ineligibility, substitutions, and data collection in Wave 2, the final sample included 164 surveyed businesses

and an additional 65 businesses with observational data on operational status (please see Chapter 3 in Sutley, Dillard, and van de Lindt [4]). Data collection from Wave 3c and information gleaned from updates to online records resulted in the exclusion of 11 businesses that were identified to be nonprofits and the inclusion of seven new businesses that began to occupy commercial structures in the sample after Hurricane Matthew (please see Chapter 4 in Helgeson, Hamideh, and Sutley [5]). The longitudinal sample for Wave 4 consisted of 218 businesses.

Given that all businesses in the inundation area were included in the longitudinal sample, the refreshment sample was created using the remaining businesses in the floodplain and a random sample of businesses outside the inundation and floodplain areas. A total of 270 businesses were sampled as part of the refreshment sample, 90 from the floodplain and 180 from outside. The 180 businesses outside of the floodplain and inundation areas, although not necessarily at risk for future flooding, serve as important controls for the effect of COVID-19. Healthcare businesses were excluded from the refreshment sample to match the previous sampling strategy and to prevent survey burden on healthcare workers during the pandemic. Between the longitudinal and refreshment samples, the overall business sample for Wave 4 totaled 488 businesses.

3.3. Data Collection Methodology

3.3.1. Recruitment and Data Collection for Wave 4a

Given the anticipated challenges associated with COVID-19 and virtual data collection, a diversified approach was taken to garner responses to the survey. The team decided that allowing businesses a range of options for responding to the survey outweighed the risk of introducing bias through use of different survey modalities. Data collection, therefore, was a five-step process:

1. Go through the sample and find an online presence for all businesses, record phone number and email
2. Mail postcard to sample (done twice during the survey period)
3. First follow-up: email reminder (if applicable) or phone
4. Second follow-up: phone call
5. Final follow-up: mailed survey

The first step was to take a first pass through the sample using the virtual presence of the sample. A business's virtual presence includes its official website, Facebook profile, Yelp page, Google page, yellow page listing, or other internet listing or communication channel. This digital verification allowed for the data collection team to collect a first impression of the business's operating status, identify any newly opened businesses, and collect contact information for survey recruitment. For the refreshment sample, this process also allowed the data collection team to identify ineligible businesses resulting from database errors (this has been the case in previous waves, see Chapter 3 in Sutley, Dillard, and van de Lindt [4]).

After this initial pass was complete, a postcard was mailed to the business sample. The postcard contained a short description of the project and a link to the survey on *Qualtrics*. The design of the postcard is shown in Figure 3-1 with the link and contact information removed. A picture of the postcard was displayed in the *Qualtrics* survey landing page to help businesses identify their survey PIN for de-identified response. More information on survey design is included in Section 3.4.



 OMB # 0693-0078 Center for Risk-Based Community Resilience  Community Recovery Study City of Lumberton, NC Our team has visited businesses in Lumberton every year since 2018 to learn about the disaster impacts & recovery needs in the Lumberton community. We won't be coming to Lumberton in person this year because of COVID-19, but we still want to hear from you!	Hello! We are conducting our annual survey. This year we are hoping to learn about disaster preparedness and COVID-19 impacts on your business. Please fill out our short (10 minute) online survey and access more information about this study at <Survey Placeholder> or scan the QR code on the front of the postcard. Your survey ID number is _____. With many thanks, John van de Lindt Center Co-Director	Return Address Center for Risk-Based Community Resilience Planning Colorado State University Fort Collins, CO 80523-1372 _____ _____ _____ _____	Place Stamp Here
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Figure 3-1. Business postcard for Wave 4 data collection.

After the initial wave of postcards were sent, data collection was conducted through email invitation (if applicable), phone, and mailing recruitment in that order. Emails were used if there was one listed for the business (generic), owner, or manager on its online page(s). Emails were sent from *Qualtrics* and contained a similar description of the project as shown on the postcard, the business's unique PIN, a link to the *Qualtrics* survey. The phone call protocol included asking for an owner or manager, verbally describing the project, and asking whether there was an email to which we could send the survey link. If no email was available, the surveyor could go through the questions verbally. For the final reminder, or for businesses that did not have a phone or email address, a paper survey was sent out in addition to a stamped return envelope. All postcards and mailing envelopes were addressed to both the most up-to-date business name that could be found "or current business." Appendix E hosts an example copy of the emails sent to business contacts.

There were some businesses in the longitudinal sample that chose to provide their contact information in Wave 2 and/or Wave 3c for future survey waves. In this case, the surveyor utilized their preferred contact method, whether phone or email for recruitment and reminders. If the contact person was no longer at the business, the previous protocol was followed. This virtual data collection will be discussed in more detail in Section 3.6.

3.3.2. Wave 4a Survey Development

The survey instrument for Wave 4 was similar to previous waves, with modifications for online administration and additional COVID-19 content. Whereas in previous waves *Qualtrics* was used for data entry from verbally- or self-administered paper surveys, businesses used *Qualtrics* to self-administer the survey and consented to the survey online. The first screen of the *Qualtrics* survey consisted of the information sheet for the business to review. A link was also available for the business to download the information sheet for their records or for additional review. At the bottom of the page, the first question asked, "Are you over the age of 18 and willing to proceed to the survey?" If the business responded "yes," they would be taken to the survey; if the business responded "no," they would be taken to the end of the survey. The final screen thanked the business for completing the survey, provided a link to download a flier with a summary of previous household and business survey results, linked to the Center website and previous technical reports, and provided the OMB Burden Statement.

Care was taken to make the survey as short as possible and able to be taken on a mobile device. A progress bar was provided and a short one-sentence summary of each section was used to help introduce the preceding questions and orient the business operator as to whether the questions in the section would be about Hurricane Matthew, Hurricane Florence, COVID-19, or all of the above. As previously mentioned in Section 3.3.1, the survey link provided in the postcard included a picture of the postcard design where they could find their unique PIN. This picture was not included in the email links since the PIN was provided in the email body.

Major sections were similar to previous waves and included: (1) impact and recovery from Hurricanes Matthew and Florence; (2) response, mitigation, and preparedness actions; recovery finance; and (3) business information. Questions on damage and disruption were limited since many businesses answered these questions in previous waves, indicating that their recovery was at a steady or complete state; however, that data still needed to be collected from new respondents or businesses in the refreshment sample. Two new categories of questions were included in Wave 4a: COVID-19-specific questions and questions on social and institutional networks. Because the pandemic was ongoing, disruption metrics used in previous surveys were converted to monthly increments, for example which months the business experienced higher or lower revenue, increased or decreased staffing, or temporary closure. Businesses were asked whether the pandemic affected their on-going recovery from Hurricane Matthew and/or Hurricane Florence and whether the pandemic impacted their preparation for the 2020 hurricane season. With respect to social and institutional networks, businesses were asked whether they received or provided support to the community during the COVID-19 pandemic. Appendix F hosts a copy of the virtual business survey with consent information used in Wave 4a.

3.3.3. Wave 4b Data Collection Methodology

Data collection for Wave 4b was planned and executed very similarly for housing and business. The specific elements for the business sample are provided here; please see section 2.3.3 for details on the overall process and housing specific information.

Data collection for Wave 4b used a combination of the ESRI® *Field Maps* and the ESRI® *Survey123* phone applications. Broadly, ESRI® *Field Maps* was used for navigation, assigning sample priority and team zones for data collection, and updating visitation statistics in real time, and ESRI® *Survey123* was used to enter survey responses. Geocoded business locations were entered as point data in ESRI® *Field Maps* prior to data collection. Each point contained address and business information in addition to the assigned priority for the business sample. For Wave 4b, businesses were assigned one of four priority levels:

- Priority 0: these businesses were deleted from the 4b sample and were businesses that had responded in Wave 4a;
- Priority 1: businesses that did not answer in Wave 4, but answered in both Wave 2 and Wave 3;
- Priority 2: businesses that did not answer in Wave 4, but answered in either Wave 2 or Wave 3; and
- Priority 3: businesses that were new businesses, added in Wave 4a as part of the refreshment sample.

These priorities helped team members determine which businesses to visit first, but often a lower priority business would be visited along with a higher priority business if it was located nearby.

Team zones included both businesses and housing units and team members could visit either at their own discretion. The survey instrument for Wave 4b was the same for both housing and businesses, therefore, the data collection methodology for the business sample follows that of the housing sample outlined in Section 2.3.3.

Team members would indicate that the building was a business, which would then lead to business-specific questions on its occupancy status. Businesses could be marked as “vacant,” “probably vacant,” “unsure,” “probably occupied,” and “occupied.” Depending on the response, team members would then indicate all the relevant factors that led them to indicate occupancy or non-occupancy. Because of the turnover rate for businesses, the survey also asked whether the business name on the building matched what was displayed in ESRI®’s *Field Maps*. If not, the new business name could be entered. A photo was taken of each commercial building through the app at the end of the survey. Appendix D hosts a copy of the Wave 4b survey.

3.4. Wave 4a Survey Response Rates

Despite the multiple modes and effort made to recruit businesses for the survey, response rates were very low. Table 3-1 summarizes the response rate for completed surveys from Wave 4a, also taking into account previous occupancy status from Wave 3c, postcard return information from USPS, and web search. Despite the multiple modes and effort made to recruit businesses for the survey, response rates were very low.

Table 3-1. Wave 4a response rates for the business sample.

n=461	Completed Surveys	Possibly Closed - online search and Wave 3c status)	Possible Closed - returned from USPS citing vacancy	No Response (Out of full sample, n=461)	No Response (Out of presumed open, n=334)
Count	19	89	59	442	315
Percent	4.1%	19.3%	12.7%	95.9%	94.3%

Overall, 19 businesses completed the Wave 4a survey. Of those, 9 (4.1 %) were from the refreshment sample, 9 were from the original longitudinal sample, and one did not provide their PIN and could not be tracked. Of the 461 businesses in the sample, 89 (19.3 %) were deemed potentially closed as a result of the web search and their Wave 3c status. A total of 154 postcards were returned from USPS, of which 59 (12.7 % of the full n=461 sample) were labeled “vacant.” Table 3.2 summarizes the reported reasons for all USPS postcard returns. There were 21 businesses that were both returned as vacant and deemed possibly closed. That left 334 businesses presumed open. The response rate across the full sample for Wave 4a was 4.1 % and 5.7 % for the sample that was presumed to be open. The decision was made not to summarize the survey results of Wave 4a given that the low response rates made it unlikely that the results would generalize to the larger sample and population.

Table 3-2. Wave 4a postcard return reasons as cited by USPS.

Reason	Count (No.)	Percent (%)
Insufficient address	7	4.5
No mail receptacle	34	22.1
No such number	8	5.2
Not deliverable as addressed	44	28.6
Refused	2	1.3
Vacant	59	38.3
Total	154	100.0

3.5. Wave 4b Observation Rates and Visual Observations

Almost all businesses were visited in Wave 4b. The overall completed survey rate for the sample was 69 %, with the majority of the visits reaching the original longitudinal sample and the priority 1 and 2 businesses. Table 3.3 breaks down the businesses that were visited by sample and visitation priority.

Table 3-3. Wave 4b businesses by sample and visitation priority.

Sample Category and Priority	Count (No.)	Percent (%)
<u>Sample</u>		
Original longitudinal	187	89.0
Refreshment - floodplain	55	67.9
Refreshment - outside floodplain	65	42.4
<u>Priority</u>		
1 - Responded in both Wave 2 and Wave 3	87	95.6
2 - Responded in either Wave 2 and Wave 3	100	84.0
3 - Refreshment sample	120	51.1
Total Sampled	307	69.0

Similar to previous waves (see Chapter 3 in Sutley, Dillard, and van de Lindt [4]), sample data cleaning was necessary as ineligible businesses were found during web search, mailing, and phone calls to the businesses. In Wave 4, 27 businesses were removed from the floodplain and non-floodplain refreshment samples due to being a duplicate with another business, ineligible (e.g., nonprofit or government organization), or having no locatable address. The Wave 4b data were already standardized due to the electronic data collection method, so minimal data cleaning was needed. Some businesses were home businesses, which led to a few cases where the occupancy information was entered for a housing unit. These businesses are not reported in the results. In addition, some occupancy indicators were entered under “other” which were re-categorized into themes as needed for the discussion of the results.

The Wave 4b observational data were critical to helping understand results in Wave 4a, as well as to gather information relevant to conducting Wave 5. Wave 4b information can aid in understanding how much response rates in 4a might have been affected by changes to businesses’ operational statuses and establishes a baseline of operational status for the refreshment sample. Because the housing survey and business survey were combined and Wave 4b relied solely on observational information, the language of the survey related to occupancy. In general, this section will discuss occupancy with respect to commercial building units (e.g., suites, floors, or offices). Businesses in the sample occupy a commercial building unit. The operational status of a business does not map directly to the concept of occupancy of the commercial unit, since businesses can move, work remotely, or conduct online-only sales permanently or temporarily. Though this has the potential to overestimate vacancy, this is unlikely given that the survey used many indicators of occupancy that would indicate an operating or non-operating business. In the case of this particular field study, and given the metrics chosen for Wave 4b, the terms can be considered interchangeable. For clarity, however, language relating to occupancy will be used for the remainder of the report.

Table 3-4 summarizes the occupancy status information for the Wave 4b sample.

Table 3-4. Wave 4b commercial building occupancy status.

Occupancy Status	Count (No.)	Percent (%)
Occupied	259	83.8
Probably occupied	7	2.3
Vacant	30	9.7
Probably vacant	5	1.6
Unsure	8	2.6
Total	309	100.0

Most commercial units were reported as occupied or probably occupied by a business, representing 86.1 % of the Wave 4b sample in total. Approximately 10 % of the commercial units were vacant and 1.6 % were probably vacant. Only 2.6 % of the commercial units had an

occupancy status that was unable to be determined. Some businesses that are not public-facing, such as some industrial sector businesses, or businesses with limited operating hours may not have obvious and observable indicators that they are occupying a commercial structure.

Commercial structures were determined to be occupied if one of the following criteria was met: 1) the business was open for business at the time of visitation, customers or staff were inside, and/or the parking was lot in use; 2) The business was empty, but was visited outside of posted working hours and there was no sign of non-occupancy; and/or 3) other reasons (see below for further explanation). These reasons were cited in 88.9 %, 8.8 %, and 9.9 % of the occupancy determinations, respectively, as shown in Table 3-5. Other reasons cited included a sign posted on the business or the business being under renovation/repair. It should be noted that more than one reason could be selected; two reasons were cited for 20 determinations and all others cited one. The number of times each reason was cited was divided by the total determinations rather than total reasons, therefore the percentages will add up to over 100 %.

Table 3-5. Reasons for occupancy determination.

Cited Reason(s) - Occupancy	Count of Determinations (No.)	Percent of Total Determinations (%)*
Open for business/Customers or staff inside/Parking lot in Use	233	88.9
Empty, but visited outside of posted working hours and no sign of non-occupancy	23	8.8
Other	26	9.9
Total Businesses	262	-

*Note: More than one reason could be selected so percentages total over 100 %.

Similarly, commercial structures were determined to be non-occupied if one of the following criteria was met: 1) the interior was empty; 2) there was a permanently closed/moved sign; 3) the windows were covered with brown paper; 4) there were no customers or workers or an empty parking lot despite visiting during posted working hours; 5) there was mail stacked in front of the door; and/or 6) some other reason(s). The frequency that these reasons were cited is displayed in Table 3-6. The other category was used more frequently than in occupied structures and was cited in 67.7 % of all non-occupancy determinations. Other reasons included obvious disrepair and neglect or having a visible “For Sale” or “For Lease” sign. Having no customers or workers present was the second most common reason, appearing in 48.4 % of non-occupancy determinations. The interior being empty was cited in 29 % of cases. Having a sign, having covered windows, and having stacked mail were less common, appearing in 9.7 %, 9.7 %, and 3.2 % of all determinations. Like in Table 3.5, the number of times each reason was cited was divided by the total determinations rather than total reasons. Four reasons were cited for one determination, three were cited for four of the determinations, two were cited for ten determinations, and all other determinations cited one reason.

Table 3-6. Reasons for non-occupancy determination.

Cited Reason(s) - Non-Occupancy	Count of Determinations (No.)	Percent of Total Determinations (%)*
Interior empty	9	29.0
Permanently closed/moved sign	3	9.7
Windows covered with brown paper	3	9.7
No customers or workers/empty parking lot and visited during posted working hours	15	48.4
Mail stacked in front of door	1	3.2
Other	21	67.7
Total	31	-

*Note: More than one reason could be selected so percentages total over 100 %.

During Wave 4a data collection, the best estimate of the name of the occupying business was generated for each commercial unit. This was informed by the business status in previous waves, the business’s web presence, and phone calls as described in Section 3.3.1. During Wave 4b, the data collection team was able to check whether the posted business name on the commercial structure matched the estimated name collected in Wave 4a. Those results are provided in Table 3-7. Only 64.2 % of addresses had business names observed in Wave 4b that matched the business name in Wave 4a, 29.4 % were not a match, and 6.4 % were marked as “other.” Businesses were marked as other if there was no sign, if it was a home-based business, or if the name was very similar but not exactly the same as the Wave 4a name. Table 3-8 shows the number of businesses that had a posted business name in place of the Wave 4a name. Most commercial structures, more specifically 88.1 %, had a posted name whereas 11.9 % did not.

Table 3-7. Business name verification.

Name matched	Count (No.)	Percent (%)
Yes	190	64.2
No	87	29.4
Other	19	6.4
Total	296	100.0

Table 3-8. Business name replacements.

New name	Count (No.)	Percent (%)
Yes	74	88.1
No	10	11.9
Total	296	100.0

There are three reasons why the name on the commercial unit might not match the name in the sample. 1) the business in the sample permanently closed or moved and removed the sign, which might explain the lack of a name replacement; 2) the business in the sample permanently closed or moved and a new business moved in, which might explain a new name; and 3) the original name is an error in the original sample database. The third reason is specific to the fact that the refreshment sample had not been visited in person prior to Wave 4 (this issue occurred the first time in the field in Wave 2). The Wave 4 data collection alone does not lend itself to differentiating between these reasons, but explanations can be teased out in the future through previous wave information, imagery data, subsequent waves, and secondary data. Given the need for triangulation using multiple sources of data, the Wave 4 effort will be a valuable source of evidence towards this effort. Collecting this information, given the likelihood of business turnover during COVID-19, will be useful for future waves in terms of determining when closure or moves took place in the longitudinal sample or what error exists in the refreshment sample.

3.6. Longitudinal Analysis

Although occupancy status was the principal metric collected during Wave 4 given the low response rates to the survey effort, there are still some longitudinal observations that can be made from previous waves. First, the data collected in Wave 4b can be compared to the postcard returns in Wave 4a to examine the reliability of the postcard return information in determining potential non-occupancy. Table 3-9 shows the eventual Wave 4b occupancy status determination for the returned postcards in Wave 4a. Surprisingly, 70.7 % of returned postcards were from occupied or probably occupied units. Only 8.1 % of postcard returns were from vacant or probably vacant units. The second largest occupancy category for returned postcards was “unsure” at 17.2 %.

Table 3-9. Wave 4b occupancy status by Wave 4a postcard returns.

Occupancy Status	Count (No.)	Percent (%)
Occupied	70	70.7
Probably occupied	4	4.0
Vacant	17	3.0
Probably vacant	3	5.1
Unsure	5	17.2
Total	99	

Figure 3-3 looks more specifically at the overlap between occupancy status and postcard return reason. There appears to be a relationship between commercial units that were ultimately determined to be vacant, and postcards returned citing vacancy. However, there were quite a few commercial units that were determined to be occupied that had postcards sent back citing vacancy. Given that many businesses had different names than the original sample indicates (see Table 3-8), it is unclear without conducting a full survey whether this is postal error or whether a new business was established between waves.

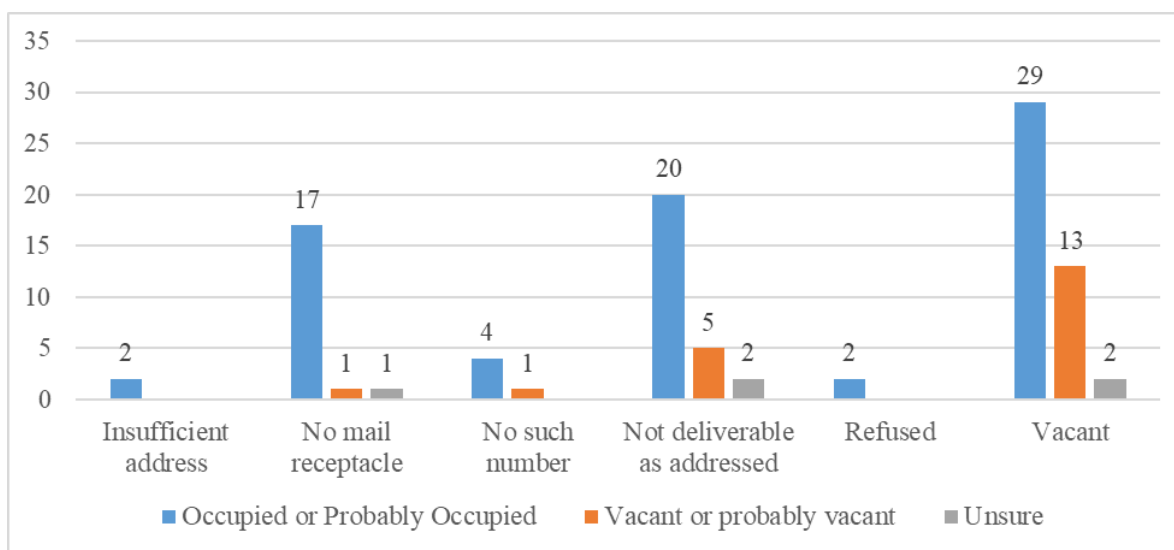


Figure 3-2. Wave 4b occupancy status by Wave 4a postcard return reason.

Figure 3-4 shows how occupancy status changed from Wave 2, to Wave 3c, to Wave 4b. Because Waves 2 and 3c looked at the operational status of each business rather than occupancy of the structure per se, commercial units were coded as occupied in Waves 2 and 3c if a business was open and operating in that unit regardless of whether it was a new business for that wave. Commercial units were coded as unoccupied if the business was permanently closed or had moved from that unit and no new business had moved in. The figure shows that, perhaps surprisingly, there were few commercial units in the longitudinal sample that went from occupied to unoccupied between Wave 3c and Wave 4b. However, there were some that were not assessed or for which the occupancy status was uncertain. In general, the occupancy rate of commercial structures appears to be of similar magnitude, compared with prior waves.

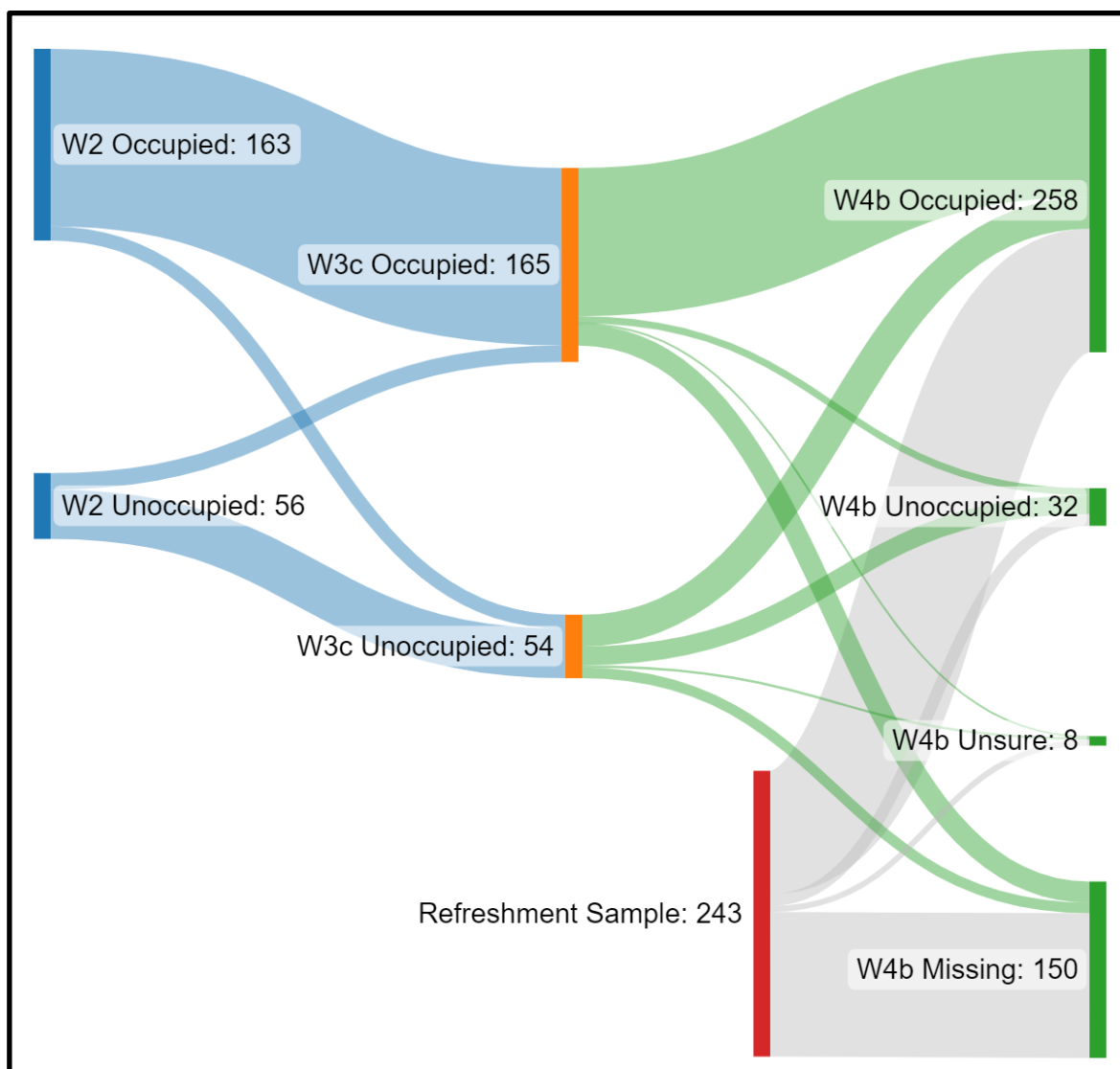


Figure 3-3. Longitudinal Occupancy.

4. Summary and Next Steps

4.1. Summary for housing impact and recovery

The Wave 4a housing survey attempted to capture resilience capacity in Lumberton through remote data collection. Several actions were taken to improve the outcomes of the electronic survey data collection, including (a) mailing multiple rounds of postcards reminding the longitudinal sample to complete the survey; (b) supplementing the original sample with a convenience sample to leverage relevant networks from previous years of data collection (e.g., faith-based groups, city government); (c) sending the longitudinal sample mailed surveys with addressed and stamped return envelopes in case the online surveys created a barrier for some respondents; and (d) keeping the online survey open as long as practical to obtain as many responses as possible.

Ultimately, these efforts still did not produce a meaningful outcome for Wave 4a. Only a few completed surveys were returned, and thus no Wave 4a housing survey data were presented here. Low response rates could have been a result of the emotional burden of the pandemic, survey fatigue, changes in responsibilities at work or home, or other factors unknown to the team. Many postcards (over 40 %) were either returned with no explanation, labeled as undeliverable, the address was associated with a vacant unit, or otherwise. The high number of returned postcards motivated the team to perform a Wave 4b in person. To protect the health and safety of the team, as well as the residents of Lumberton, human subjects were not part of Wave 4b. Instead, Wave 4b captured basic information on whether the housing unit was still physically in existence, and the occupancy status to the extent possible. Wave 4b confirmed that 2.6 % of the longitudinal sample did not have a building present, and 64.6 % were occupied with an additional 7.6 % of housing units that were probably occupied.

Looking at the longitudinal comparisons on occupancy status, the proportion of housing units occupied has increased, and the proportion of housing units that are vacant has decreased since Wave 3c, providing some hope towards the positive longitudinal recovery of Lumberton residents. Even still, approximately 20 % of housing units in our longitudinal sample are vacant, presumably as an outcome of 2016 Hurricane Matthew and continued impacts caused by 2018 Hurricane Florence and the COVID-19 pandemic. There was occasional evidence of mitigation actions being undertaken by households and the City of Lumberton, including demolished properties (presumed to be part of the buyout program) and construction to raise the first-floor elevation of homes.

4.2. Summary for business impact and recovery

The Wave 4a business survey used many of the same approaches as the housing survey, including (a) mailing multiple rounds of postcards reminding the longitudinal sample to complete the survey; (b) supplementing the original sample with a refreshment sample anticipating low response rates; (c) calling businesses over the phone to encourage survey completion; (d) sending the longitudinal sample mailed surveys with addressed and stamped return envelopes to the most updated business names based on online search; and (e) keeping the online survey open as long as practical to obtain as many responses as possible.

However, like the housing survey, the Wave 4a business effort yielded only 19 completed surveys for a response rate of 4.1 %. Although this response rate is not uncommon for mailing surveys to businesses [11], the total number of surveys was insufficient to provide meaningful conclusions on any ongoing recovery. Though there were fewer postcards returned in the business sample compared to the housing sample that cited vacancy—specifically 12.7 % of the total business sample—there were concerns about the impact COVID-19 was having on the economy and the closure of small and minority-owned businesses [12]. It was important to establish the operating statuses of businesses in the sample in Wave 4b, particularly for the refreshment sample which had never been visited, to capture any closures and new openings during the pandemic period ahead of a future wave.

Wave 4b found that most commercial units in the sample were reported as occupied or probably occupied by a business, representing 86.1 % of the Wave 4b sample in total. Approximately 11 % of the commercial units were vacant or probably vacant. Only 2.6 % of the commercial units had an occupancy status that was unable to be determined. Although similar in scale to the

vacancy percentages in the USPS postcard returns, many postcards returned as vacant were mailed to commercial units with an operating business and vice versa. Many businesses (approximately 29 % of the Wave 4b sample) also had new names. These findings illustrate the value of Wave 4b to the business longitudinal effort, as these vacancy changes and new business names can potentially indicate business closures and re-openings or indicate errors in the database for the refreshment sample that would have created issues for future in-person fieldwork.

Wave 4b had some optimistic results in terms of longitudinal recovery. There were fewer unoccupied commercial units (and assumed permanently closed or moved businesses) in Wave 4b than in both Waves 2 and 3c. Several commercial units that were unoccupied in Wave 3c became occupied in Wave 4b. Future waves will be critical in understanding these changes and confirming the observational assessments of business recovery from Hurricane Matthew, Hurricane Florence, and the COVID-19 pandemic.

4.3. Recommendations for the Lumberton Longitudinal Field Study

The field deployment in Wave 4b gave important confirmation on occupancy and operational status for housing units and businesses in Lumberton. However, despite the team's best efforts, Wave 4 produced minimal information on the status of Lumberton's longitudinal recovery and resilience. This outcome speaks to the imperative nature of in-person surveys, particularly for longitudinal efforts in areas with compounding disaster events.

The Lumberton longitudinal field study is planned to continue. The next wave will continue to prioritize field team safety and respondent safety, with a secondary goal of conducting the data collection in-person. As the longitudinal recovery dataset is built over time, it is anticipated that the field study will make major contributions to community resilience and recovery modeling efforts that are generalizable to other communities. To accomplish the team's long-term objectives outlined in Chapter 1, the following steps are recommended:

1. Both housing and business survey collection should continue in-person every 12 to 16 months. In-person surveys have better response rates than web-based surveys, particularly where internet access may not be available to all respondents [13]. Wave 4 established that Lumberton is not an exception. Similarly, the surveys should not be lengthened to maintain response rates and minimize burden and survey fatigue on respondents. Additional strategies to minimize burden and maintain or improve response rates should continue to be identified by the team.
2. Key questions or sections should be replicated throughout surveys to ensure comparability across timeframes, particularly given delays caused by the COVID-19 pandemic. This repetition is critical for improved power in longitudinal analyses which depends upon having multiple time points for each sample unit (i.e., housing unit or business).
3. Interviews with key community stakeholders should continue every 12 to 16 months to provide context for the findings of the field observations and structured data collections through surveys. This schedule of continued interviews and data collection aligns with the long-term nature of community recovery and resilience planning (e.g., [14, 15]). Specifically, these interviews should follow-up on observations during Wave 3c of

capital improvement projects planned or underway, as well as progression of disaster recovery and mitigation funds received.

4. Longitudinal temporal analyses should be conducted comparing results over time, advancing the cross-wave comparisons made in this report and past reports. This is a critical approach that aligns with the recovery, learning, and change experienced by communities after extreme events and planning for future events (e.g., Albright and Crow, [16]). The interconnectedness the infrastructure systems, housing, and businesses in community resilience is best served through longitudinal data collection and analysis [2].
5. Ongoing analysis, with regular feedback from NIST and COE researchers, should continue to ensure the field study continues to align with what is needed for measurement and modeling of community resilience, particularly for the advancement of IN-CORE and the Lumberton testbed. Interdisciplinary community resilience research requires developed plans and procedures that can be applied across study waves and transferred to improve future interdisciplinary studies (e.g., Peek et al., [17]).
6. Housing and business survey instruments, IRB protocols and supplemental documents, and de-sensitized collected data should continue to be published and receive Digital Object Identifier (DOI). This ensures that the current longitudinal effort advances other comparable data collection efforts across the fields engaged in disaster research. The publication of these products enables data collection instruments and protocols for measurement of community resilience and recovery to be applied in other communities. The on-going collection can be found on *DesignSafe-CI*:

<https://www.designsafeci.org/data/browser/public/designsafe.storage.published/PRJ-2656>

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Appendix A. Housing Convenience Sample Recruitment Email

Dear <insert name of individual and/or organization>,

We understand that the COVID-19 pandemic is disrupting your community. We are gathering information to learn how households like yours are adapting to the circumstances and how this situation may or may not be connected to broader weather-related stressors households in your community may face of have faced.

The *Center for Risk-Based Community Resilience Planning* is based at Colorado State University in Fort Collins, Colorado, and includes collaborations with researchers from universities across the United States. The National Institute of Standards and Technology's Community Resilience Program is based in Gaithersburg, Maryland and includes engineers, economists, and sociologists. Collectively, we are working to understand what makes a community "resilient" – or able to bounce back – in the face of disaster.

Our research in Lumberton focuses on community recovery following the flooding that occurred due to Hurricanes Matthew and Florence. We are virtually returning to Lumberton for our fourth year to follow up on progress with recovery and understand the impact of COVID-19. We will be collecting information from households to learn from their experiences and help communities better prepare for similar events in the future.

Will you send the email below to your members requesting they complete our 10-minute online survey? If you agree, we will follow-up in two weeks requesting that a reminder be sent out to increase our response rates.

Thank you so much for your time and help.

Sincerely,

<insert sender name>

Dear member,

We are sharing a survey with you from the *Center for Risk-Based Community Resilience Planning* is based at Colorado State University in Fort Collins, Colorado. The purpose of the 10-minute online survey is to understand how the COVID-19 pandemic is disruption your household, particularly during on-going recovery from Hurricanes Matthew and Florence. Please consider filling out their survey, which should only take 10 minutes, to help them better inform policies for future disasters.

Best regards,

<insert sender name>

Appendix B. Wave 4a Survey

OMB # 0693-0078

We understand that the COVID-19 pandemic is disrupting your household. We are gathering information to learn how households like yours are adapting to the circumstances and how this situation may or may not be connected to broader weather-related stressors your household may face or have faced.

We realize your time is at a minimum with the current situation. We sincerely appreciate your participation and our efforts will be greatly enhanced if you can spend a few minutes filling out this survey. We ask for no sensitive information and we will not identify you or your household at any time.

We would like to know how your household is being impacted by COVID-19 and how it has affected your household's recovery from Hurricane Matthew and Hurricane Florence. We are also interested in learning more about practices taken that have helped reduce the impact of future hazard events.

If you feel uncomfortable answering any of the questions, you can skip them, or exit the survey at any time. This survey should take less than 10 minutes to complete. Thank you for your time and participation.

[If you would like to download an information sheet on the project, please click here.](#)

Please confirm you are a Lumberton resident above 18 years of age, and consent to participate in this survey.

☐ I am above 18 years of age and consent to this survey. (1)

If you received a postcard, please insert the ID number found on your postcard:

Dear Residents, We are conducting our annual survey. This year we are hoping to learn about disaster preparedness and COVID-19 impacts on your household. Please fill out our short (10 minute) online survey and access more information about this study. Placeholder for the QR code or QR code on the postcard. Survey ID number.

Place Stamp Here

Broomfield, CO 80020-1372
Colorado State University
Fort Collins, CO 80523-1372

Please enter your current home address:

These first set of questions are about your household in general.

How many adults (18 years or older) live in your household?

0 2 3 5 6 8 9 11 12 14 15

Adults (≥ 18) ()



How many children (younger than 18 years) live in your household?

0 2 3 5 6 8 9 11 12 14 15

Children (< 18) ()



How many years have you lived in Lumberton? (if less than one year, insert 1)



When month and year did you move into your current home? (MM/YY)

Was your home damaged by either Hurricane Matthew or Florence?

☐

Yes, by Matthew (1)

☐

Yes, by Florence (2)

☐

Yes, both Matthew and Florence (6)

☐

No, neither hurricane damaged my home (3)

☐

DK (4)

Next, the questions are going to ask about your household's perceived preparedness now.

Do you rent or own your home?

☐ Rent (1)

☐ Own (2)

☐ Other, please specify (3) _____

Display This Question:

If Next, the questions are going to ask about your household's perceived preparedness now. Do you re... = Rent

Do you have renter's insurance?

- ☐ Yes (1)
 - ☐ No (2)
 - ☐ DK (3)
-

Display This Question:

If Next, the questions are going to ask about your household's perceived preparedness now. Do you re... = Own

Do you have flood insurance?

- ☐ Yes (1)
 - ☐ No (2)
 - ☐ DK (3)
-

Display This Question:

If Next, the questions are going to ask about your household's perceived preparedness now. Do you re... = Own

Do you have homeowner's insurance?

- ☐ Yes (1)
- ☐ No (2)
- ☐ DK (3)

Display This Question:

If Do you have renter's insurance? = Yes

Or Do you have flood insurance? = Yes

Or Do you have homeowner's insurance? = Yes

Do you believe you have adequate insurance coverage for another flood event?

☐ Yes (1)

☐ No (2)

☐ DK (3)

Display This Question:

If Next, the questions are going to ask about your household's perceived preparedness now. Do you re... = Own

Do you have a mortgage?

☐ Yes (1)

☐ No (2)

☐ DK (3)

How has your participation with neighborhood and/or community groups changed since the COVID-19 pandemic?

☐ Decreased (1)

☐ Stayed the same (2)

☐ Increased (3)

☐ Don't know (4)

How has your contact with neighbors and/or extended family and friends changed since the COVID-19 pandemic?

- ☐ Decreased (1)
- ☐ Stayed the same (6)
- ☐ Increased (7)
- ☐ Don't know (8)



How many major floods or hurricanes have you experienced first-hand (in your lifetime)?

How likely do you think your home is to be damaged during a major flood event, similar to Hurricane Matthew or Florence?

- ☐ Extremely unlikely (1)
- ☐ Unlikely (5)
- ☐ Neutral (6)
- ☐ Likely (7)
- ☐ Extremely likely (8)

If given evacuation orders, how likely is your household to evacuate your home during a future major flood event, similar to Hurricane Matthew or Florence?

- ☐ Extremely unlikely (1)
 - ☐ Unlikely (6)
 - ☐ Neutral (7)
 - ☐ Likely (8)
 - ☐ Extremely likely (9)
-

Please explain your evacuation decision:

The next set of questions look at mitigation and preparedness strategies used by your household now or that you plan to put in place in the next six months.

Has your household:

	Yes (1)	No (2)	Don't know (3)
Elevated hot water heater and/or HVAC (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Re-routed ductwork from below floor to attic space (3)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Developed an emergency plan with household members (5)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Gathered supplies to last 3 or more days (7)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sought information on mitigation or preparedness (9)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Attended a local meeting or training on preparedness (11)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Set money aside for recovery or repairs (13)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Anything else (15)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

In the next 6 months, does your household plan to:

	Yes (1)	No (2)	Don't know (3)
Elevate hot water heater and/or HVAC (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Re-route ductwork from below floor to attic space (2)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Make an emergency plan with household members (3)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Gather supplies to last 3 or more days (4)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Seek information on mitigation or preparedness (5)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Attend a local meeting or training on preparedness (6)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Set money aside for recovery or repairs (7)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Anything else (8)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Do you have the option to provide any utility services, even if temporarily, for your household?
(Please select all that apply.)

- ☐ Yes, power generator (1)
 - ☐ Yes, solar panels (4)
 - ☐ Yes, water storage tanks (5)
 - ☐ Yes, gas tanks (6)
 - ☐ Yes, community wi-fi (7)
 - ☐ Yes, community information hub (8)
 - ☐ Yes, other, please explain (9)
-

- ☐ No (10)
- ☐ Don't Know (12)

The next set of questions are intended to capture the impacts of COVID-19 on your household.

How has COVID-19 impacted repairs to your home?

- ☐ No impact (1)
 - ☐ Minor impact (6)
 - ☐ Neutral (7)
 - ☐ Moderate impact (8)
 - ☐ Major impact (9)
 - ☐ Don't know (10)
-

How has COVID-19 impacted your household's recovery from Hurricane Florence?

- ☐ No impact (1)
 - ☐ Minor impact (6)
 - ☐ Neutral (7)
 - ☐ Moderate impact (8)
 - ☐ Major impact (9)
 - ☐ Don't know (10)
-

Were members of your household unable to work because of COVID-19?

- ☐ Yes (1)
- ☐ No (2)
- ☐ Don't know (3)

Were members of your household reduced to part-time work because of COVID-19?

- ☐ Yes (1)
- ☐ No (2)
- ☐ Don't know (3)

Display This Question:

If Were members of your household unable to work because of COVID-19? = Yes

How long was your household member unable to work (please enter the number of days)?

Display This Question:

If Were members of your household were reduced to part-time work because of COVID-19? = Yes

How long was your household member reduced to part time (please enter the number of days)?

Display This Question:

If Were members of your household unable to work because of COVID-19? = Yes

Were you or other household members unable to work or reduced to part-time because of:

- ☐ Temporary closure of place of employment (1)
- ☐ Permanent closure of place of employment (2)
- ☐ Childcare issues (3)
- ☐ Health issues (4)
- ☐ Other (5) _____

Display This Question:

If Were members of your household unable to work because of COVID-19? = Yes

Would you say the disruption to your household's income has been:

- ☐ Significant (1)
 - ☐ Moderate (2)
 - ☐ Minimal (3)
 - ☐ None (4)
 - ☐ Don't know (6)
-

Finally, there are six questions about your household in general.

Do you have any individuals with special electricity-dependent medical needs in your house?
(Examples include individuals who require power wheelchairs, ventilators, oxygen concentrators, CPAP and other sleep apnea devices.)

- ☐ Yes (1)
- ☐ No (2)

When considering all members in your household, what is the highest level of of schooling completed?

- ☐ Less than High school (1)
 - ☐ High School diploma (2)
 - ☐ Associate's degree (3)
 - ☐ Bachelor's degree (4)
 - ☐ Master's degree or higher (5)
-

While we often ask about each member of a household, in general, when considering your household, how would you characterize its racial makeup? (Select one or more.)

- ☐ White or Caucasian (1)
 - ☐ Black or African American (2)
 - ☐ American Indian or Native American (3)
 - ☐ Asian (4)
 - ☐ Native Hawaiian or Pacific Islander (5)
 - ☐ Other, please specify (6)
-

Are members of your household Hispanic or Latino?

- ☐ Yes (1)
- ☐ No (2)

Do you consider your household a female-headed household?

- ☐ Yes (1)
- ☐ No (2)
- ☐ Don't know (4)

Finally, we do not want to know the exact amount but can you identify the letter associated with the category that best captures your household's combined annual income?

- ☐ \$1 to \$3,999 (1)
- ☐ \$4,000 to \$5,999 (2)
- ☐ \$6,000 to \$7,999 (3)
- ☐ \$8,000 to \$9,999 (4)
- ☐ \$10,000 to \$11,999 (5)
- ☐ \$12,000 to \$14,999 (6)
- ☐ \$15,000 to \$19,999 (7)
- ☐ \$20,000 to \$24,999 (8)
- ☐ \$25,000 to \$29,999 (9)
- ☐ \$30,000 to \$39,999 (10)
- ☐ \$40,000 to \$49,999 (11)
- ☐ \$50,000 to \$74,999 (12)
- ☐ \$75,000 to \$99,999 (13)
- ☐ \$100,000 to \$149,999 (14)
- ☐ \$150,000+ (15)

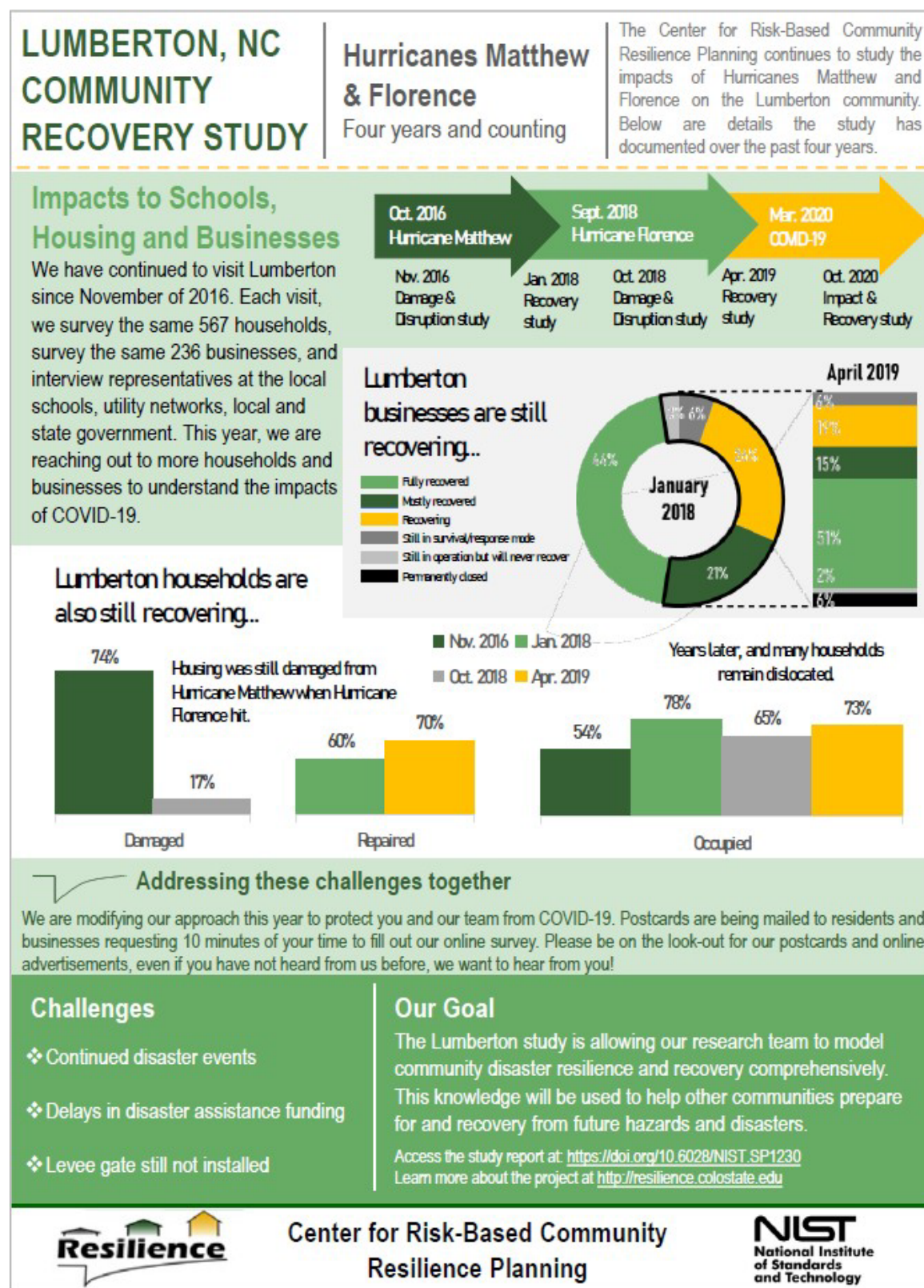
Are there any additional comments you would like to share?

Thank you for completing our survey.

For more information about the study, please visit <http://resilience.colostate.edu>.

To read our first report on the initial impact and disruption from Hurricane Matthew, please visit:
<https://doi.org/10.6028/NIST/SP1230>.

Appendix C. Project Informational Flier



Appendix D. Wave 4b Survey

Survey title not set

Description content for the survey

1

Location

Find address or place

NORTH AMERICA

SOUTH AMERICA

EUROPE

AFRICA

ASIA

AUSTRALIA

Esri, USGS | Esri, FAO, NOAA, USGS

No geometry captured yet.

2

Date & Time*

B/16/22

3:33 PM

3

Car Number*

4

Building Type*

12 11 9 8 7

☐ House

☐ Business

☐ No Building Present

☐ Other

59

6

Building Occupancy*



4 

7

Housing Indicators of Occupancy

☐ People present inside or outside house

☐ Lights on/Activity inside

☐ Vehicle in driveway

☐ Holiday decorations present

☐ Pet in yard

☐ Trash or recycling bins at end of driveway (for pickup)

☐ Other

4 

8

Housing Indicators of Non-Occupancy



☐ Foreclosure/condemned posting on door

☐ Visibly abandoned (e.g. doors & windows open, house empty or gutted)

☐ Landscaping not maintained

☐ Mail piled at doorstep






☐ Other

9	<div>4 </div> <div>10 </div> Does Business Name in Field Maps Match Name on Building?
---	--

☐ No

☐ Yes

☐ Other

	<input type="checkbox"/> No customers or workers/empty parking lot and visited during posted working hours
	<input type="checkbox"/> Mail stacked in front of door
	<input type="checkbox"/> Other
13	Photo 1 <div>Select image file </div>
14	Photo 2 <div>Select image file </div>
15	Photo 3 <div>Select image file </div>
16	Photo 4 <div>Select image file </div>
17	Photo5 <div>Select image file </div>
<div>Submit</div>	

Appendix E. Business Survey Recruitment Email

Dear Lumberton business owner,

My name is _____ and I am a professor/graduate student with the Center for Risk-Based Community Resilience Planning.

We understand that the COVID-19 pandemic is disrupting your business. We are gathering information to learn how businesses like yours are adapting to the circumstances and how this situation may or may not be connected to broader weather-related stressors your business may face or have faced. This is our third year talking to businesses in Lumberton, and although we can't come in person like usual, we want to know how you are doing.

We realize your time is at a minimum with the current situation. This survey should take **less than 15 minutes to complete**. We ask for no sensitive information and we will not identify you or your business at any time. If your business has more than one location, please answer for only one location. An Information sheet is available for download at the start of the survey if you want more details on the project.

[Please click here to take the survey.](#)

Your de-identified pin number for the survey is: [PIN]

If you feel uncomfortable answering any of the questions, you can skip them, or exit the survey at any time.

Thank you for your time and participation.

Appendix F. Wave 4a Business Survey

Hurricane Matthew Community Recovery Study for Lumberton, NC
Center for Risk-Based Community Resilience Planning
A U.S. National Institute of Standards and Technology-funded Center of Excellence

The Center for Risk-Based Community Resilience Planning is based at Colorado State University in Fort Collins, Colorado, and includes collaborations with researchers from universities across the United States. The National Institute of Standards and Technology's Community Resilience Program is based in Gaithersburg, Maryland and includes engineers, economists, and sociologists. Collectively, we are working to understand what makes a community "resilient" – or able to bounce back – in the face of disaster.

Our research in Lumberton focuses on community recovery following the flooding that occurred due to Hurricanes Matthew and Florence. We are virtually returning to Lumberton for our fourth year to follow up on progress with recovery and understand the impact of COVID-19. We will be collecting information from businesses like yours to learn from your experiences and help communities better prepare for similar events in the future.

This research is part of a five-year project that will be carried out by experts from engineering, the social sciences, economics, and many other disciplines. Lumberton is one of five research locations around the country that we hope to learn from.

Because NIST is part of the federal government, this research was reviewed through a special process. This collection of information contains Paperwork Reduction Act (PRA) requirements approved by the Office of Management and Budget (OMB). Notwithstanding any other provisions of the law, no person is required to respond to, nor shall any person be subject to a penalty for failure to comply with, a collection of information subject to the requirements of the PRA unless that collection of information displays a currently valid OMB control number. For this collection, the OMB Control number is: 0693-0078 with an expiration date of July 31, 2022.

Public reporting burden for this collection is estimated to be up to 15 minutes per survey, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed and completing and reviewing the collection of information. Send comments regarding this burden estimate or any aspect of this collection of information, including suggestions for reducing this burden, to the National Institute of Standards and Technology, Attn: Dr. Jennifer Helgeson, NIST, 100 Bureau Drive, MS 8603, Gaithersburg, MD 20899-1710, telephone 301-975-6133, or via email: jennifer.helgeson@nist.gov

If you have more general questions about the project or the Center for Risk-Based Community Resilience Planning, please contact: Dr. John van de Lindt at 970-218-4076 or via email: jvw@engr.colostate.edu.

Please fill out this survey, and return in the pre-addressed stamped envelope. Please read each question and answer choice carefully before responding.

If you prefer to take the survey online, please scan this QR code with your phone or type in the following weblink to access an online version of the survey.

Weblink: <http://www.tinyurl.com/lumberton-biz>



Please confirm you are a Lumberton resident above 18 years of age, and consent to participate in this survey by marking the circle: ☐ I am above 18 years of age and consent to participate in this survey.

What is the name of the business you are responding for?*

What is the physical address of the business? *

*If you prefer not to answer the previous questions, please enter the Survey ID number provided on the address label of the mailing envelope?

PANDEMIC IMPACT AND RECOVERY (This survey section asks about direct effects of COVID-19 (coronavirus) on your business. The COVID-19 Pandemic was declared a National Emergency on March 13, 2020. Please answer the following questions considering the period since then.)

1. What is your role with this business?

☐ Owner ☐ Manager ☐ Owner and Manager ☐ Senior Employee (5+ years at the business) ☐ Other

2. If there were any public health restrictions (e.g., stay-at-home orders, movement limitations, limits on public gatherings, or requirements for social distancing), is/was your organization designated as:

☐ Essential ☐ Some segments were essential, some were not ☐ Non-essential ☐ Not sure/don't know

3. Compared to before the pandemic, what is the % capacity at which you are currently operating? ____%

[note: this does not relate to occupancy capacity. For "capacity," consider aspects of the business that are most important to you, like the quality and/or quantity of service or product offerings. For example: 50% for reduced capacity, 110% for increased capacity, or 0% for businesses that have not resumed operations.]

4. How has the pandemic impacted this business in terms of revenue, customers, and operation? Please check the months the business experienced a change in these items, even if only part of that month.

	2020												2021											
a. Lower revenue	<input type="radio"/> Mar.	<input type="radio"/> Apr.	<input type="radio"/> May	<input type="radio"/> Jun.	<input type="radio"/> Jul.	<input type="radio"/> Aug.	<input type="radio"/> Sep.	<input type="radio"/> Oct.	<input type="radio"/> Nov.	<input type="radio"/> Dec.	<input type="radio"/> Jan.	<input type="radio"/> Feb.	<input type="radio"/> Mar.	<input type="radio"/> Apr.	<input type="radio"/> May	<input type="radio"/> Jun.	<input type="radio"/> Jul.	<input type="radio"/> Aug.	<input type="radio"/> Sep.	<input type="radio"/> Oct.	<input type="radio"/> Nov.	<input type="radio"/> Dec.		
b. Higher revenue	<input type="radio"/> Mar.	<input type="radio"/> Apr.	<input type="radio"/> May	<input type="radio"/> Jun.	<input type="radio"/> Jul.	<input type="radio"/> Aug.	<input type="radio"/> Sep.	<input type="radio"/> Oct.	<input type="radio"/> Nov.	<input type="radio"/> Dec.	<input type="radio"/> Jan.	<input type="radio"/> Feb.	<input type="radio"/> Mar.	<input type="radio"/> Apr.	<input type="radio"/> May	<input type="radio"/> Jun.	<input type="radio"/> Jul.	<input type="radio"/> Aug.	<input type="radio"/> Sep.	<input type="radio"/> Oct.	<input type="radio"/> Nov.	<input type="radio"/> Dec.		
c. Loss of customers	<input type="radio"/> Mar.	<input type="radio"/> Apr.	<input type="radio"/> May	<input type="radio"/> Jun.	<input type="radio"/> Jul.	<input type="radio"/> Aug.	<input type="radio"/> Sep.	<input type="radio"/> Oct.	<input type="radio"/> Nov.	<input type="radio"/> Dec.	<input type="radio"/> Jan.	<input type="radio"/> Feb.	<input type="radio"/> Mar.	<input type="radio"/> Apr.	<input type="radio"/> May	<input type="radio"/> Jun.	<input type="radio"/> Jul.	<input type="radio"/> Aug.	<input type="radio"/> Sep.	<input type="radio"/> Oct.	<input type="radio"/> Nov.	<input type="radio"/> Dec.		
d. Gain in customers	<input type="radio"/> Mar.	<input type="radio"/> Apr.	<input type="radio"/> May	<input type="radio"/> Jun.	<input type="radio"/> Jul.	<input type="radio"/> Aug.	<input type="radio"/> Sep.	<input type="radio"/> Oct.	<input type="radio"/> Nov.	<input type="radio"/> Dec.	<input type="radio"/> Jan.	<input type="radio"/> Feb.	<input type="radio"/> Mar.	<input type="radio"/> Apr.	<input type="radio"/> May	<input type="radio"/> Jun.	<input type="radio"/> Jul.	<input type="radio"/> Aug.	<input type="radio"/> Sep.	<input type="radio"/> Oct.	<input type="radio"/> Nov.	<input type="radio"/> Dec.		
e. Temporary closure	<input type="radio"/> Mar.	<input type="radio"/> Apr.	<input type="radio"/> May	<input type="radio"/> Jun.	<input type="radio"/> Jul.	<input type="radio"/> Aug.	<input type="radio"/> Sep.	<input type="radio"/> Oct.	<input type="radio"/> Nov.	<input type="radio"/> Dec.	<input type="radio"/> Jan.	<input type="radio"/> Feb.	<input type="radio"/> Mar.	<input type="radio"/> Apr.	<input type="radio"/> May	<input type="radio"/> Jun.	<input type="radio"/> Jul.	<input type="radio"/> Aug.	<input type="radio"/> Sep.	<input type="radio"/> Oct.	<input type="radio"/> Nov.	<input type="radio"/> Dec.		
e. Increase in staffing	<input type="radio"/> Mar.	<input type="radio"/> Apr.	<input type="radio"/> May	<input type="radio"/> Jun.	<input type="radio"/> Jul.	<input type="radio"/> Aug.	<input type="radio"/> Sep.	<input type="radio"/> Oct.	<input type="radio"/> Nov.	<input type="radio"/> Dec.	<input type="radio"/> Jan.	<input type="radio"/> Feb.	<input type="radio"/> Mar.	<input type="radio"/> Apr.	<input type="radio"/> May	<input type="radio"/> Jun.	<input type="radio"/> Jul.	<input type="radio"/> Aug.	<input type="radio"/> Sep.	<input type="radio"/> Oct.	<input type="radio"/> Nov.	<input type="radio"/> Dec.		
e. Decrease in staffing	<input type="radio"/> Mar.	<input type="radio"/> Apr.	<input type="radio"/> May	<input type="radio"/> Jun.	<input type="radio"/> Jul.	<input type="radio"/> Aug.	<input type="radio"/> Sep.	<input type="radio"/> Oct.	<input type="radio"/> Nov.	<input type="radio"/> Dec.	<input type="radio"/> Jan.	<input type="radio"/> Feb.	<input type="radio"/> Mar.	<input type="radio"/> Apr.	<input type="radio"/> May	<input type="radio"/> Jun.	<input type="radio"/> Jul.	<input type="radio"/> Aug.	<input type="radio"/> Sep.	<input type="radio"/> Oct.	<input type="radio"/> Nov.	<input type="radio"/> Dec.		

5. How profitable was your business prior to the pandemic?

☐ Highly Profitable ☐ Profitable ☐ Breaking Even ☐ Unprofitable ☐ Highly Unprofitable ☐ Closed

6. Where do you feel your business is in the process of recovery from the pandemic?

☐ Still in survival/response mode ☐ Recovering ☐ Mostly recovered ☐ Fully recovered

☐ Still in operation but will never recover (please explain) _____

7. Have any employees* reported issues working due to any of the following issues during the pandemic?

*please include yourself

a. children not back to school? ☐ Yes ☐ No

- b. children not back to daycare? ☐ Yes ☐ No
 c. pandemic-related physical health issues and/or risk? ☐ Yes ☐ No
 d. pandemic-related mental health issues and/or risk? ☐ Yes ☐ No
 e. other: _____

8. a. Immediately before the pandemic, how many full time and part time employees did this business have?

Before: Full time _____ Part time _____

b. What about now?

Now: Full time _____ Part time _____

9. Was this business damaged by Hurricane Matthew (September 2016) or Hurricane Florence (October 2018)?

☐ Yes, Hurricane Matthew ☐ Yes, Hurricane Florence ☐ Yes, Both ☐ No, neither

If you were damaged from either hurricane, proceed to Question 10. Otherwise proceed to Question 13

RECOVERY FROM MATTHEW AND FLORENCE

10. What kind of damage was caused by Hurricane Matthew and/or Hurricane Florence and how severe was the damage? See guide, below

	None	Minor	Moderate	Severe	Complete
Buildings	No damage; No contact to electrical or plumbing, etc. in crawlspace. No contact with floor joists. No sewer backup	Water touches floor joists up to minor water enters building; damage to carpets, pads, baseboards, flooring. Approximately 1" in the building but no drywall damage. Could have some mold in crawlspace. Could have minor sewer backup and/or minor mold issues.	Water level approximately 2 feet with associated drywall damage and electrical damage, water heater and other major equipment. Doors or windows may need replacement. Could have major sewer backup and/or major mold issues.	Water level 2 feet to 8 feet; substantial drywall damage, electrical panel destroyed, office cabinets or storage racks; lighting fixtures on walls destroyed; ceiling lighting may be ok. Studs reusable; some may be damaged. Could have major sewer backup and/or major mold issues.	Significant structural damage present; all drywall, cabinets etc. destroyed. Could be floated off foundation. Building must be demolished or potentially replaced.
Content/ Inventory	No damage	All reusable/usable easily once dried, with zero or slight value drop	About 60% reusable with drying and cleaning, and moderate value drop	About 30% reusable with drying and cleaning, and significant value drop	Non-reusable once dried and total loss
	No damage	All recoverable easily	About 60% recoverable	About 30% recoverable	Non-recoverable

Building damage (Matthew)	<input type="radio"/> None <input type="radio"/> Minor <input type="radio"/> Moderate <input type="radio"/> Severe <input type="radio"/> Complete
Contents damage (Matthew)	<input type="radio"/> None <input type="radio"/> Minor <input type="radio"/> Moderate <input type="radio"/> Severe <input type="radio"/> Complete
Building damage (Florence)	<input type="radio"/> None <input type="radio"/> Minor <input type="radio"/> Moderate <input type="radio"/> Severe <input type="radio"/> Complete
Contents damage (Florence)	<input type="radio"/> None <input type="radio"/> Minor <input type="radio"/> Moderate <input type="radio"/> Severe <input type="radio"/> Complete

11. Where do you feel your business was in the process of recovery from the hurricanes immediately prior to the pandemic?

☐ Still in survival/response mode ☐ Recovering ☐ Mostly recovered ☐ Fully recovered

☐ Still in operation but will never recover to pre-hurricane levels (please explain):

12. How much has the pandemic affected your on-going recovery from Hurricane Matthew and/or Hurricane Florence?

- ☐ Not at all ☐ A little ☐ Moderately ☐ Severely ☐ N/A (already fully recovered)
☐ The pandemic helped my business

L Skip here if the business circled 4 in Question 12

RESPONSE, MITIGATION AND PREPAREDNESS

13. Did the business take any of the following adaptive actions in response to the hurricanes or the pandemic? Does the business plan to take this action in the future? (Please mark ALL time periods that apply with an X)

Action	No Adoption	Adopted for Hurricane Matthew or Florence	Adopted for the Pandemic	Plan to Adopt for a Future Event
a. Changed product or service offering (new product/service, or limited quantity or variety of product/service)				
b. Changed product or service delivery (contactless pick-up, e-commerce)				
c. Changed store policies (mask requirements, more frequent cleanings, limiting number of customers)				
d. Changed inventory management strategy				
e. Changed employee work strategy (work from home, alternating schedules)				
f. Shared resources with suppliers or other businesses				
g. Other: _____				
h. Other: _____				

14. Did this business previously have, currently has, or will have any of the following insurance coverage?

Insurance Coverage	For Hurricane Matthew or Hurricane Florence	For the Pandemic	Plan to for future event
a. Business property insurance on contents			
b. Flood insurance on contents (NFIP)*			
c. Business income interruption insurance			
d. Business liability insurance			

15. Please indicate your level of agreement with the following statements:

a. This business's experience during Hurricane Matthew and/or Hurricane Florence has helped me handle challenges related to COVID-19.

- ☐ Strongly disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly Agree

b. The strategies this business has taken during COVID-19 will help me during or after a future hurricane/flood event

- ☐ Strongly disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly Agree

c. COVID-19 impacted this business's preparation for the 2020 hurricane season

- ☐ Strongly disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly Agree

SOCIAL AND INSTITUTIONAL NETWORKS

16. How has your business supported local people/organizations during COVID-19? (Check all that apply)

- ☐ Donated to local charities (1)
- ☐ Supported (other) local businesses (2)
- ☐ Offered additional income/paid leave to non-working employees (e.g. Laid-off, furloughed, sick) (3)
- ☐ Provided customer financial relief/delayed payments (4)
- ☐ Offered discounts to healthcare workers/essential workers (5)
- ☐ Assisted local government pandemic response (6)
- ☐ Set different hours for vulnerable populations (e.g. Senior-only hours) (7)
- ☐ Other (8) _____
- ☐ None of the above (9)

17. What community support has the business received during COVID-19? (Check all that apply)

- ☐ Local government (e.g. Loans, parking space for curbside pick-up, sidewalk dining, signs about COVID-19, etc.) (1)
- ☐ Customer support (e.g. Gift card purchases, shop local website) (2)
- ☐ Support from other businesses (e.g. Discounts, technical support, environmental cleaning, etc.) (3)
- ☐ Rent or mortgage relief (4)
- ☐ Other (5) _____
- ☐ No support received (6)

18. What financial support has the business applied for and received during COVID-19? (Check all that apply)

Assistance Description	Applied (If yes, provide the month, otherwise mark "No")?	Received (If yes, provide the month, otherwise mark "No")?
a. Federal assistance (e.g. Paycheck Protection Program) specify: _____	<input type="radio"/> Yes: ____ <input type="radio"/> No	<input type="radio"/> Yes: ____ <input type="radio"/> No
a. State assistance (e.g. North Carolina COVID-19 Rapid Recovery Lending program) specify: _____	<input type="radio"/> Yes: ____ <input type="radio"/> No	<input type="radio"/> Yes: ____ <input type="radio"/> No
c. Local assistance: specify: _____	<input type="radio"/> Yes: ____ <input type="radio"/> No	<input type="radio"/> Yes: ____ <input type="radio"/> No
d. Other: _____	<input type="radio"/> Yes: ____ <input type="radio"/> No	<input type="radio"/> Yes: ____ <input type="radio"/> No
e. Other: _____	<input type="radio"/> Yes: ____ <input type="radio"/> No	<input type="radio"/> Yes: ____ <input type="radio"/> No

BUSINESS INFORMATION

19. In what year was this business established at this location? _____ (Year)

20. Does this business own or rent the building?

- ☐ Own (including buying the building with mortgage) ☐ Rent
- ☐ Other (please specify) _____

21. What was the business ownership structure before the flood?

- ☐ Single owner ☐ Partnership (multiple owners) ☐ Corporation or franchise ☐ Cooperative

☐ Other (please specify): _____

22. How many years have you worked as a business owner/manager? _____ (years)

23. What is your age? _____ (years)

24. What is your number of years of schooling? Enter number of years _____ and indicate type of diploma or degree:

☐ Some High School ☐ High School ☐ Associates Degree ☐ Bachelor's Degree

☐ Master's Degree or higher

25. How would you describe your ethnicity? ☐ Hispanic or Latino ☐ Not Hispanic or Latino

26. What is your race? (select one or more)

☐ White ☐ Black or African American ☐ American Indian or Alaskan Native ☐ Asian

☐ Native Hawaiian or Pacific Islander

27. Is this business a minority-owned business, woman-owned business, or veteran-owned business? (select none, one, or more)

☐ Minority-owned business ☐ Woman-owned business ☐ Veteran-owned business

☐ Other _____

28. Would you be interested in or willing to participate in a phone interview about your experience?

☐ Yes ☐ No

We would like to get some additional information from you in order to make future surveys easier and at your convenience. Would you be willing to provide your first name and email address? **YOU WILL NOT RECEIVE ANY EMAILS BEYOND OUR REQUEST FOR ADDITIONAL CLARIFICATION ON THIS SURVEY.**

Name: _____

Business Email: _____

If you have any final comments about the survey and/or business recovery after the flood and/or pandemic, please write them down in the space below.

THANK YOU VERY MUCH FOR COMPLETING THE SURVEY!