Assessing Environmental Justice & Historical Transportation Impacts in North Carolina

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16. Abstract

Transportation decisions can either deepen environmental, socioeconomic, and health inequalities or serve to improve quality of life. This is particularly true for communities of color and low-income communities, who have been disproportionally impacted by historical transportation and land use policies that have furthered structural inequality and deepened spatial inequity in North Carolina. These communities are often more vulnerable to adverse weather, socioeconomic insecurity, and illness. In an effort to support NCDOT's goal of providing an equitable transportation system to all North Carolinians, this project developed multiple tools NCDOT can use to identify and address transportation inequity at the community level. Tools delivered through this study include a national State of the Practice review, nine case studies from across the state, Story Maps that communicate the impacts of historical transportation decisions, and implementation framework that can be leveraged to enact best practices, and other resources such as a presentation. Ultimately, this study is designed to help NCDOT achieve the goal of providing equitable transportation systems for all North Carolinians.

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Executive Summary

The North Carolina Department of Transportation (NCDOT) has sponsored this research project in an effort to identify, mitigate, and limit socioeconomic and environmental justice impacts of transportation decisions on communities. Understanding opportunities to improve transportation equity and avoid inequitable impacts related to transportation investments is critical for realizing a transportation system that effectively serves all North Carolinians. The current research project complements the federal Bipartisan Infrastructure Law (2021), the Inflation Reduction Act (2022), and the Justice40 Initiative (2021). Each of these includes an emphasis on reducing historical transportation inequalities and enhancing sustainable and resilient transportation infrastructure.

An overview summary of the research process and key research products are presented in the executive summary sections below. More detail is provided in the full report and the appendices that follow.

The research team conducted a comprehensive review of national literature and best practices for equity data, environmental justice (EJ) screening tools, and equity interventions in the transportation decision-making and investment process. The insight gained through the literature and the state of the practice review was synthesized into an implementation-focused best practice matrix. Peer-reviewed literature, resources created by reputable organizations, and state and federal agency guidance were explored to provide NCDOT with insights on identifying and mitigating inequitable impacts associated with transportation systems and the transportation decision-making process. The review also includes an extensive and comprehensive examination of data and screening tools associated with environmental justice and equity.

Knowledge gained through this effort and a community stakeholder workshop were leveraged to develop a series of best practices that were identified in the literature and state of practice review. A best practice matrix was developed to outline implementable approaches for identifying communities impacted by transportation and environmental inequity and offering implementation approaches to develop decision-making processes that are more explicitly focused on equitable outcomes. These best practices fall into three outcome-driven categories:

- Define inequities
- Identify disadvantaged communities impacted by past and reoccurring inequities
- Correct, eliminate and prevent inequities

The purpose of the best practice matrix is to highlight practices that can serve to prevent recurrence of past inequities and continuation of current inequities. The goal of these best practices is to eliminate inequities and create a transportation system that provides equitable access and mobility for everyone. The best practices and outcome-driven categories reflect the research focus on community inequity.

Many best practices incorporate more than one outcome-driven category. Best practices such as data and screening tool development often serve to both define inequity and identify disadvantaged communities. Defining inequity is often established by the data sets selected and screening thresholds established within a screening tool. Some of the outcomes focused on correcting, eliminating, and preventing inequities have embedded steps to define inequity and/or identify disadvantaged communities.

Nine North Carolina case studies were also developed to examine different types of before-and-after impacts of historical highway transportation decisions across the state. These cases also provided a means

for the research team to identify the variance and availability of historical data across the state. Cases included NC communities that are known to have disproportionately faced highway construction impacts and the harmful effects of inequitable transportation policies and investments. Three of these cases were documented through ArcGIS Story Maps.

Drawing from the comprehensive literature review, state of the practice assessment, data survey, and case studies the research team developed an implementation framework to highlight how NCDOT could implement emerging best practices. The research team worked with key NCDOT stakeholders to develop the framework in a manner that is most useful to the department. Although NCDOT is a leader in some practice areas, the agency has opportunities to integrate emerging best practices to remain a national leader. Additionally, while elements and aspects of the best practices are captured in the NCDOT transportation decision-making process, there are opportunities to enhance or improve upon some of these practices further to better serve North Carolinians, especially those in underserved and vulnerable communities.

Ultimately, the research team developed several resources NCDOT can use to identify, mitigate, and correct impacts to EJ and disadvantaged communities. These resources can be categorized as data and policy best practices, community case studies and engagement, and EJ mapping and presentation tools. The project and developed resources are documented in this final report and the attached appendices.

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Introduction

Transportation decisions have the power to improve quality of life. However, these decisions can also further environmental, socioeconomic, health, and other types of inequalities. Communities that have been disproportionally impacted by historical transportation and land use policies, such as communities of color and low-income communities, are particularly vulnerable to these negative effects. These same communities can also be at higher risk for adverse weather, socioeconomic insecurity, and illness (Martin, 2015). Many of these communities have experienced deep and long-lasting negative impacts due to transportation policies and projects of the past, which can limit their opportunities for socioeconomic mobility for generations (Archer, 2021).

During the mid-1900s, transportation and land use policies implemented across the United States furthered structural inequality and deepened spatial inequity in communities of color and socioeconomically disenfranchised communities. The Homeowner Loan Corporation (HOLC) surveyed these communities and delineated Black communities on maps as "hazardous" to investment with red lines. These "redlined" communities signaled to mortgage lenders that loaning to people in these areas was risky and excluded them from federal lending programs (Rothstein, 2017). Urban renewal land use policies, such as the Housing Acts of 1949 and 1954, combined with new federal highway programs, like the Federal-Aid Highway Act of 1956, led to the clearing of so-called "slum" housing and "urban blight" in these areas to make way for new highway infrastructure (Woods, 2012). Highway infrastructure was also designed through communities and neighborhoods designated as "blight". This would separate and fragment the community, resulting in a loss of community cohesion and prosperity. At the time, highway infrastructure was used as a tool to clear blighted neighborhoods.

These types of policies exacerbated inequalities in "redlined" neighborhoods and paved the way for highway infrastructure projects that often divided communities of color and displaced neighborhood residents (Woods, 2012). Redlining in North Carolina impacted numerous communities, including Asheville, Charlotte, Durham, Greensboro, and Winston-Salem (Nelson, et al., 2022). The effects of these policies are still experienced by North Carolinians today.

Although the federal government later enacted policies that helped enhance protections for disenfranchised communities and environmental justice impacts, like the National Environmental Policy Act of 1969 (NEPA), transportation and environmental inequities continue to persist. For example, people of color experience higher bike/pedestrian crash rates (HSRC), less access to personal vehicles (National Equity Atlas; U.S. Census Bureau), and increased commute time due to discrepancies between transit and personal vehicle travel time (National Equity Atlas). Disenfranchised communities are also often pushed to marginalized land that is more prone to extreme weather events and have higher concentrations of air and water pollution (EPA, 2021; NC Climate Risk Assessment and Resilience Plan, 2020). Historic disinvestment in redlined neighborhoods also included communities being intentionally excluded from streetscaping and tree planting efforts. This created urban heat islands, as increased impervious surface and reduced tree canopy cover created warmer street-level temperatures. With increasingly higher temperatures, the impacts of urban heat islands are becoming more dangerous to communities impacted by historical disinvestment. Exposure to increased air and water pollution, neighborhood flooding, and urban heat islands impact the health and quality of life for community residents. For example, the

Princeville community in North Carolina, which was located on land founded by freed slaves, has repeatedly experienced flooding, displacement, and illness.

Despite a recent increase in national guidance and practices related to examining impacts related to environmental justice, transportation agencies like NCDOT are still challenged to measure related impacts and improve approaches for addressing inequities. The limitations of these resources are that most are not designed to capture a deep before-and-after analysis of impacts at the community level and do not include tools for analyzing cumulative historical impacts. Another is the quality and availability of the data required to do such analyses is not always clear and can vary by region. Yet, assessing how transportation decisions impact communities, especially those that have been historically disenfranchised, is key to improving equity across North Carolina.

Consequently, NCDOT funded this study to examine past and present transportation decisions in an effort to identify and limit socioeconomic and environmental justice impacts in the future. In addition to supporting a more equitable transportation system in North Carolina, the results of this study can also be used to inform NCDOT's efforts to maintain sustainable and resilient transportation infrastructure, which can provide benefits for current and future generations.

Overall, the objectives of this research project are to:

1. Identify North Carolina communities that have been disproportionately impacted by inequitable highway transportation construction, policies, and investments.
2. Scan the literature, review national best practices, and identify opportunities to address and mitigate historical and current transportation inequity.
3. Investigate available data to identify disproportionally impacted communities and present opportunities for collecting new data to address coverage gaps.
4. Develop a methodology to identify North Carolina communities disproportionally impacted by transportation construction and investment and to limit socioeconomic and environmental justice impacts in the future.

The detailed results of this study are outlined in this report and the accompanying appendices, which are designed as implementation-ready resources to be used by NCDOT and its partners.

Working Definitions of Equality and Equity

Title VI of the Civil Rights Act of 1964 is a federal law that "prohibits discrimination on the basis of race, color, or national origin in programs and activities that receive federal financial assistance". For the purposes of this report, the definition of Equality was adapted from Title VI and is equal protection of all citizens under the law. The implication of the term equality is equal distribution of influence on decision-making, and the resources to mitigate the negative impacts of decision-making are equally allocated and reinforced. Another implication is that regardless of context, an equal distribution accounts for the diversity of socio-demographic contexts within which policies operate.

However, disparities exist in the negative impacts of transportation decision-making in communities across the state. Although operating within the context of laws demanding equal protection, some Black

and Brown communities as well as low-income communities have experienced a larger share of negative impacts than their demographic proportion in the state.

The definition of Equity for the purposes of this report was adapted from definitions from literature including the American Planning Association and Partnership for Southern Equity. Equity is the just and fair inclusion into a society in which all can participate, prosper, and reach their full potential. Equity assumes the need for policies to actively mitigate the disproportionate harm faced by communities. Equity is different from equality because it centers on proactive processes that constitute corrective actions specifically tailored to the needs of communities negatively affected by policy decisions. For the purposes of this report, the broader realms of equity considered included:

Structural Equity: Equitable impacts of policy decision making including transportation as a component of broader community development, policies affecting land use, land tenure, racial segregation, and cumulative effects on community cohesion.

Procedural Equity: Equitable impacts of policy decision making including community trust between agencies and communities, and collaborative decision making

Distributional Equity: Equitable impacts of policy decision making including increased access to goods, services, and opportunities to mitigate community harm.

Transgenerational Equity: Equitable impacts of policy decision making including public health outcomes, exposure risk to environmental hazards, and resources to mitigate risks to home ownership and home equity.

What is an Inequity Lens?

Inequity, barriers to equitable decision-making, were identified as a target for research presented in the case studies included in this report. An inequity lens highlights key processes that have not resulted in equitable transportation decision-making outcomes. This report focuses on inequitable access to participation in decision-making (procedural) and distribution of goods, services, and opportunities (distributional) associated with policy decisions. Procedural and distributional inequity operate within the context of the cumulative impacts of historical policy decisions (structural) which can impact community stability and prosperity over time (transgenerational).

For the purposes of this report, the broader realms of equity considered included:

Structural Inequity

Transportation decision-making process in the context of:

- Disproportionate community proximity to environmental hazards
- Disproportionate impacts of land tenure and land use legacy policies including “Redlining”
- Lacked community cohesion as a result of recurring historical and cumulative effects of legacy decisions on communities

Procedural Inequity

Transportation decision-making processes that:

- Lacked acknowledgement of the cumulative impact of legacy decisions on communities
- Lacked evidence of community trust building and collaborative decision making with communities

Distributional Inequity

Transportation decision-making processes that:

- Resulted in reduced access to goods, services, and opportunities that mitigate community harm due to policy decisions

Transgenerational Inequity

Transportations decisions that contributed to:

- Cumulative community harm including disproportionate exposure to environmental risks
- Lack of community stability resulting from the changing community character and housing cost increases.

State of the Practice

This study began with a state of the practice (SOP) review focused on understanding what other agencies across the United States are doing to examine historical transportation decisions that deepened inequities as well as the approaches they are applying to mitigate future inequities. This included a thorough literature review with a focus on best practices from across the country. Through the SOP review, the research team also identified communities impacted by transportation inequity in North Carolina as well as appropriate approaches for collecting data and community input, which can vary by geographic area and historical context (FHWA, 2016).

The full SOP review document, which was delivered and finalized by NCDOT previously through this study, is available in Appendix 1 and provides detailed information about what the research team learned. The review served as a foundational document for the research team and NCDOT that informed all subsequent tasks and deliverables.

Literature Review

The SOP developed through this project involved a national scan of available literature and publicly available resources. National and federal resources like Assessing Indirect Effects and Cumulative Impacts Under NEPA (2016) and the EJScreen: Environmental Justice Screening and Mapping Tool (2022) are designed to help transportation practitioners assess impacts related to environmental justice specifically and equity in general. This body of literature has grown rapidly in recent years as awareness of the value of examining the distribution of community impacts related to transportation projects has grown. For example, resources like the FHWA's Community Connections Innovations Handbook (2018) and new tools stemming from the USDOT's Justice40 Initiative (2021) offer updated guidance on how to mitigate the burdens and enhance the benefits of transportation projects through thoughtful and collaborative processes.

As part of the literature scan, more than 120 reputable sources were reviewed and summarized. Sources ranged from peer-reviewed journal articles to online guidance provided by federal agencies to public information about approaches used by state and planning agencies. Details about the results of the full literature scan, including key takeaways for NCDOT, are outlined in the SOP document in Appendix 1.

Engagement with National Experts and Community Stakeholders

Recognizing that literature and practice cannot replace human experience, the research team engaged with an advisory board of national experts and gained insights from North Carolina community representatives.

Advisory Board

The research team coordinated with an advisory board of national transportation equity experts to help ensure that the results of this task were comprehensive. This advisory group included Nicole Bennett, AICP, Principal and founder of N!Equity LLC; Diane Jones Allen, Ph.D., Principal Landscape Architect with DesignJones LLC; and Julian Agyeman, Ph.D., Professor of Urban and Environmental Policy and Planning at Tufts University. Their feedback informed the SOP, the best practice matrix, and other project activities. and provided a broader lens of expertise than what the research team and NCDOT alone could offer to this research project.

Community Representatives

In addition, the research team sought insights from North Carolina communities identified as being negatively impacted by past transportation decisions. The research team worked with NCDOT to identify North Carolina stakeholders to engage with throughout the research, including representatives from community organizations in disenfranchised areas. The research team facilitated a virtual community conversation with five community representatives to better understand their firsthand experiences with transportation decisions that furthered or led to inequities. Three reoccurring themes emerged during these discussions. Community members communicated they and/or many people in the area they lived in:

- Maintain a distrust of transportation projects and an awareness of the legacy of previous transportation decision-making engagement approaches
- Believe that community partnership capacity building and financial compensation of community partners as key to positive changes
- Need better mobility beyond automobiles

Community representatives involved in these transportation-based discussions communicated about opportunities to improve the current public involvement process, community safety and well-being, and local economic viability. They also shared the toll it can take to constantly defend and advocate for decisions that support equity. Further information is available in the SOP document in Appendix 1.

Best Practice Matrix

Knowledge gained through the project literature review, state of the practice review, the stakeholder engagement sessions, and the data review was leveraged to develop a best practice matrix. The best

practice matrix captures and builds upon emerging equity practices and highlights best practices from the literature on transportation decision-making and investment. These best practices are also informed by recent federal initiatives that are building the foundation for the next generation of federal guidance and policies.

The results were synthesized into a best practice matrix shown in Exhibit 1. This best practice matrix outlines implementable approaches for identifying and addressing communities impacted by transportation inequity, including opportunities to make infrastructure improvements and policy updates to address inequitable impacts. Additionally, the matrix provides best practices for identifying historical causes of transportation inequity and a current set of best practices for mitigating these historical impacts.

The purpose of the best practice matrix is to highlight practices that can serve to prevent recurrence of past inequities and continuation of current inequities. The goal of these best practices is to eliminate inequities and create a transportation system that provides equitable access and mobility for everyone. The best practices and outcome-driven categories reflect the research focus on community inequity. These best practices fall into three outcome-driven categories:

- Define inequities
- Identify disadvantaged communities impacted by past and reoccurring inequities
- Correct, eliminate and prevent inequities

Many best practices incorporate more than one outcome-driven category. Best practices such as data and screening tool development often serve to both define inequity and identify disadvantaged communities. Defining inequity is often established by the data sets selected and screening thresholds established within a screening tool. Some of the outcomes focused on correcting, eliminating, and preventing inequities have embedded steps to define inequity and/or identify disadvantaged communities. The best practice matrix is presented thematically with the outcome-driven category of each best practice highlighted in the matrix.

The best practices presented here focus on roadway infrastructure with a broad understanding that roadway infrastructure impacts bicycle, pedestrian, public transportation, and shared-mobility transportation modes. Highway-related inequity among all of these modes is captured in some capacity within the project scope focusing on historic and reoccurring inequity in highway investment and decision making. The research team also recognizes inequalities of highway infrastructure go beyond transportation and impact community cohesion, physical and mental health, social mobility and economic prosperity.

The best practices captured in the matrix were used to inform NCDOT internal stakeholder interviews, which were designed to help identify where these practices are currently being implemented in the current NCDOT process and where opportunities exist to enhance current processes to capture cutting-edge and emerging best practices. The result is a framework NCDOT can use to enhance their current processes and practices to further align with the approaches outlined in the best practice matrix. The framework is further discussed in the Implementation Framework section of this report.

Exhibit 1: Best Practice Matrix

Category	Best Practice	Define Inequity	Identify Disadvantaged Communities	Correct, Eliminate and Prevent Inequities
Data and Screening Tools	Develop Comprehensive Screening Tools	✓	✓	
	Public Participation and Field Verification	✓	✓	
Planning and Project Development Process Improvements	Improve Community Social and Health Impact Assessments		✓	✓
	Develop Data for Household Transportation Cost and Travel Time Cost	✓	✓	
	Re-Connect Communities	✓	✓	✓
Funding	Prepare and Apply for Future Federal Funding for Disadvantaged Communities	✓	✓	✓
	Link Screening Tools Designation with Funding Opportunities		✓	✓
Workforce Development	Provide Job and Training Opportunities for Impacted Communities			✓
	Maximize Workforce Development and Disadvantaged Business Enterprise (DBE) Funds			✓
Public Engagement Processes and Community Partners	Community Engagement Plan with Virtual and In-Person Meetings	✓	✓	✓
	Treat Community Stakeholders Like Full Partners			✓
Environmental Quality and Health Impacts	Mobile Source Air Emissions Reduction		✓	✓
	Zero Emission Vehicles to Improve Air Quality			✓
	Storm Water Infrastructure Improvements			✓
Roadway, Bicycle and Pedestrian, and Shared-Mobility Facility Planning and Design	Increase Bicycle and Pedestrian Connectivity			✓
	Implement Traffic Calming and Roadway Design Measures			✓

The best practice matrix is discussed further in the SOP review document in Appendix 1.

Data Availablity and Review

In conjunction with the national State of the Practice Review discussed in the previous section, the research team conducted a comprehensive review of existing data that can be used in identifying communities that have disproportionally negative impacts associated with transportation policies and investments. This data review includes an exploration of relevant data used by NCDOT, additional data sources uncovered through the SOP, and other data known based on the research team's experience. These data sources were inventoried and reviewed to identify opportunities for potential application as part of this research project as well as opportunities for NCDOT in the future.

To understand the potential benefits and limitations of these data sources, a gap analysis was conducted. This analysis focused on assessing the uniformity of statewide coverage, historical availability of data, and other factors that may limit NCDOT's use of the data. Beyond a review of data available at the statewide scale, the research team conducted a review of the available data for case study communities, which are described in subsequent report sections. These cases represent different types of geographic

coverage from across North Carolina, different types of environmental injustices, and different types of data availability. Diverse case studies were selected to provide a more complete picture of community impacts and needs across the state.

While the results of these case studies and key takeaways are detailed in other sections of this report, the SOP document in Appendix 1 provides additional information about different data sources investigated through the data review. These insights may highlight opportunities to fill gaps in NCDOT's current historical data repository.

The research team also mapped potentially underserved communities (PUCs) to analyze their relationship to certain characteristics of highway assets. To demonstrate how roadway quality and safety may differ in underserved and vulnerable communities, the research team sought to connect select local transportation asset data to community characteristic data.

PUCs were explored at the census tract and block group level using the North Carolina Department of Environmental Quality (NCDEQ) formula based upon race and poverty. Key data sources used for this analysis include pavement and structures data already produced and maintained by NCDOT.

This analysis provides examples of how roadway characteristics (such as pavement and structure state-of-repair) could be mapped with PUCs at the local level. PUCs were used for this analysis as a spatial boundary that identifies where people live who may have experienced, or are at risk for experiencing, environmental injustice based on race and poverty. The analysis presented in Appendix 2 highlights transportation system quality and safety issues as a form of environmental justice assessment.

A brief description of the mapping and analysis presented for each geodatabase, followed by database contents, is available in Appendices 2 through 5.

Quantitative Data

Data that can be mapped, referred to as geospatial data, can be a powerful resource for identifying where underserved and vulnerable communities live as well as the benefits and burdens these communities may experience related to transportation projects. As such, the research team endeavored to identify quantitative data that is or could be mapped to examine the characteristics and impact of transportation decisions on communities. This data is discussed within the context of scale and utility.

The SOP document described many existing and emerging tools, methods, and data for describing and quantifying disadvantage and vulnerability within communities and the environmental burdens that communities face. An essential component of many tools and analyses is a consistent definition of disadvantaged communities that can be used to assess spatial relationships between elements of the transportation system and disadvantaged areas. These definitions typically rely heavily on socioeconomic data sourced from the U.S. Census, and consequently disadvantaged communities are typically defined and mapped at a census geography such as the block group or tract. The analysis presented in greater detail below employs a definition already in use by NCDEQ. As further described below, this definition uses race/ethnicity and poverty factors, to succinctly assess disparate environmental exposures and effects.

The SOP document also described the many sources of environmental data that are commonly employed in environmental justice screening tools. These environmental factors can be broadly separated into

categories of environmental exposures (pollutants that come into direct contact with people) and environmental effects (negative environmental conditions that result from pollutants that pose indirect burdens in communities). The case studies demonstrate how datasets that describe the geography of these environmental impacts can be coupled with spatial community data to describe environmental justice issues. For example, the Durham: NC-147/Hayti Community study includes an in-depth air quality analysis, and the Princeville: US-64/Princeville Community study includes a detailed flood hazard analysis. Studies such as these can provide a guide for leveraging environmental datasets in other areas of analysis.

Finally, the analysis presented here also highlights transportation system quality and safety issues as a form of environmental justice assessment. Key data sources used for this analysis include pavement and structures data already produced and maintained by NCDOT.

The remainder of this section documents the key data sources employed by the research team for conducting its analyses of environmental issues at a statewide scale, with a focus on community and infrastructure data. This data was used to produce the analysis provided here and to construct the geodatabases described in Appendices 2 through 5. Data for key environmental hazards are documented more fully in the case studies sections of this report.

KEY DATA FOR IDENTIFYING COMMUNITY HISTORY, CHARACTERISTICS, AND IMPACTS

Identifying the characteristics of a community in current and historical context can be a complex task that requires the incorporation of numerous types of data. As such, additional sources were considered in addition to data required for identifying Potentially Underserved Communities (PUCs). These sources can help address gaps and may require ad hoc methodologies to incorporate in the future analysis of equity issues. To support possible future applications, the research team inventoried such sources, with results briefly described in the following sections. More information about these data sources can be found in the SOP document in Appendix 1

1. COMMUNITY DATA AVAILABLE NATIONWIDE

2. American Community Survey/US Census - for archival data and estimates of demographic data at multiple scales
3. ATSDR Environmental Justice Index - Agency for Toxic Substances and Disease Register, useful for high level screening on disparities in exposure to specific substance
4. CEJST - Climate Economic Justice Screening Tool, similar factors as EJScreen with addition of climate risk factors and federally designated disadvantaged communities by census tract
5. EJSCREEN - the first free and online environmental justice screening tool for the entire United States; enables searches based on health, demographics, and other indicators
6. Google Earth – a source of aerial photography for most of the United States; “time machine” function allows seeing different eras of aerial photography for the same area, useful for visualizing changes in land use, environment, transportation, etc.
7. Google Street View – a source of eye-level photography of places, limited by time and scope of photography
8. RWJF Life Expectancy - Robert Wood Johnson Foundation analysis of epidemiological environmental factors contributing to life expectancy by zip code; high level screening tool to associate regions with public health impacts

9. USDA Historic Aerial Photography - Some of the oldest aerial photographs of US communities dating back to the 1940s; inconsistent coverage
10. USDOT ETC Explorer - the most sophisticated free online environmental justice screening tool available for transportation, aligned with Justice40 language on disadvantaged communities and burdens; lacks race as a demographic indicator which constrains environmental justice considerations
11. US EPA Interactive Air Quality Monitor - online monitoring tool for high-level air quality mapping; low resolution and large scale
12. US EPA Health Impact Assessment Resource and Tool Compilation - a toolkit of data and methods to document health impacts of community planning projects

COMMUNITY DATA AVAILABLE STATEWIDE

1. NC Department of Environmental Quality Community Mapping System – an online mapping tool for high-level screening of different environmental indicator
2. NC Department of Environmental Quality Animal Facility Map – a high-level screening of permitted animal facilities across the State of North Carolina
3. NC One Map - State and local repositories of imagery and mapping associated with property, streams, and other features

COMMUNITY DATA AVAILABLE LOCALLY

Local community scale data is most appropriate for identifying community history, characteristics, and impacts. The research team used the following sources to support this effort:

1. Redline Maps - Federal Government's Homeowners Loan Corporation (HOLC) in the 1930s, specifically communities that were "redlined" (excluded from Federal funding at that time); official HOLC coded maps were retrieved via the Mapping Inequality website for review.
2. Urban Renewal/Redevelopment Plans - In cases where transportation planning and decision-making happened in accordance with mid-20th century urban renewal/redevelopment plans, those plans were solicited from local community planning departments.
3. Sanborn Fire Insurance Maps - in cases where analysis required an understanding of pre–World War II community development patterns; Sanborn Fire Insurance Maps were acquired through the digital archive via the UNC Library System.

Qualitative Data

Quantitative data alone is not sufficient for assessing the full breadth of EJ and historical transportation impacts; to fully understand the impacts to people and communities, qualitative data is required. This project also highlighted the need to incorporate the use of qualitative data in decision-making. Communities that have lived through transportation decisions often have local residents with oral histories and narratives that have not been documented. Local media including newspaper articles, photographs, and recordings can exist in different archives and collections. Collaboration with local communities is essential for establishing trust with and having access to qualitative data.

Generally, qualitative data comes from two sources: archival data and engagement with stakeholders. Finding, retrieving, and communicating qualitative data is time and labor intensive. In the case of engaging with stakeholders, the process requires direct engagement and trust between the investigators and community members. All of these factors will require intentional strategies that often go beyond established community engagement practices, particularly when working with communities that have

endured the negative impacts of transportation decision making. Strategies may include aligning qualitative research with community priorities and goals like gathering and packaging local histories for the community and not just research project use. Communities are increasingly requesting fair compensation for their time and efforts, including for meetings, associated with data gathering. Collaborating with community stakeholders and qualitative data specialists as well as allocating sufficient time and resources for this intensive work is recommended for future practitioners as they research available qualitative data for community engagement efforts.

QUALITATIVE DATA AVAILABLE NATIONWIDE

1. National Archives and The Library of Congress – These institutions are valuable resources if local and state-level resources do not include historic resources that provide community context. This may include access to historic media (newspapers, etc.), oral histories, and other resources. There is a searchable database and the potential for scheduled appointments with librarians for special collections.
2. National Register of Historic Places - The US Department of Interior manages a national database of federal historic designation applications. For any federally designated historic place, the accompanying application provides detailed information about historic context. This may be relevant for communities where transportation decisions impacted historic resources.
3. US Department of the Interior (USDI) African American Historical newspapers Archive - This online and searchable database focuses exclusively on African American newspapers from the 20th century. Where transportation decisions affected historically African American communities in the early-mid 20th century, these newspapers offer a lens and perspective that may not have been captured by other media sources.

QUALITATIVE DATA AVAILABLE STATEWIDE

1. State Historic Preservation Office (HPO) - HPO Web 2.0 is an interactive map that documents all local, state, and nationally designated historic places in NC.
2. Duke Oral History Projects - This resource, accessed through Duke University, collects and archives oral histories from across the south with a focus on North Carolina. Some of their themed collections include:
    a. Behind the Veil: Documentation African-American Life in the Jim Crow South
    b. Duke University Oral History Program Collection
    c. African American Oral Histories in Rubenstein Library
    d. Student Nonviolent Coordinating Committee (SNCC) Digital Gateway
3. NC African American Heritage Commission - This statewide commission includes technical assistance and access to existing statewide networks of stakeholders focused on history and cultural heritage in NC. This group can support identifying and developing relationships with local stakeholders in communities impacted by transportation decisions.
4. UNC Chapel Hill Wilson Library Southern Historical Collection - This resource, accessed through UNC Chapel Hill, collects and archives oral histories from across the south with a focus on North Carolina.

QUALITATIVE DATA AVAILABLE LOCALLY

1. Local Community Organizations - Community organizations can support the identification of key stakeholders and connect to local networks of history and knowledge keepers that may not be documented through other data sources. Establishing trust and relationships with arts and culture,

religious, and other groups in communities affected by transportation decisions can offer unique insights.

Case Studies

North Carolina case studies were developed to examine different types of before-and-after impacts of historical highway transportation decisions across the state. These cases also provided a means for the research team to identify the variance and availability of historical data across the state. Cases included NC communities that are known to have disproportionately faced highway construction impacts and the harmful effects of inequitable transportation policies and investments.

As shown in Exhibit 2 and Exhibit 3, the case study pool included nine communities of different sizes in different parts of the state that experienced different types of impacts that can stem from transportation projects. Potential cases were identified through the aforementioned literature review as well as discussions with NCDOT stakeholders and past research team experience. For three cases, the research team developed comprehensive studies that included the development of geospatial Story Maps, while a higher-level analysis was conducted for the other six cases.

Exhibit 2: Case Study Communities

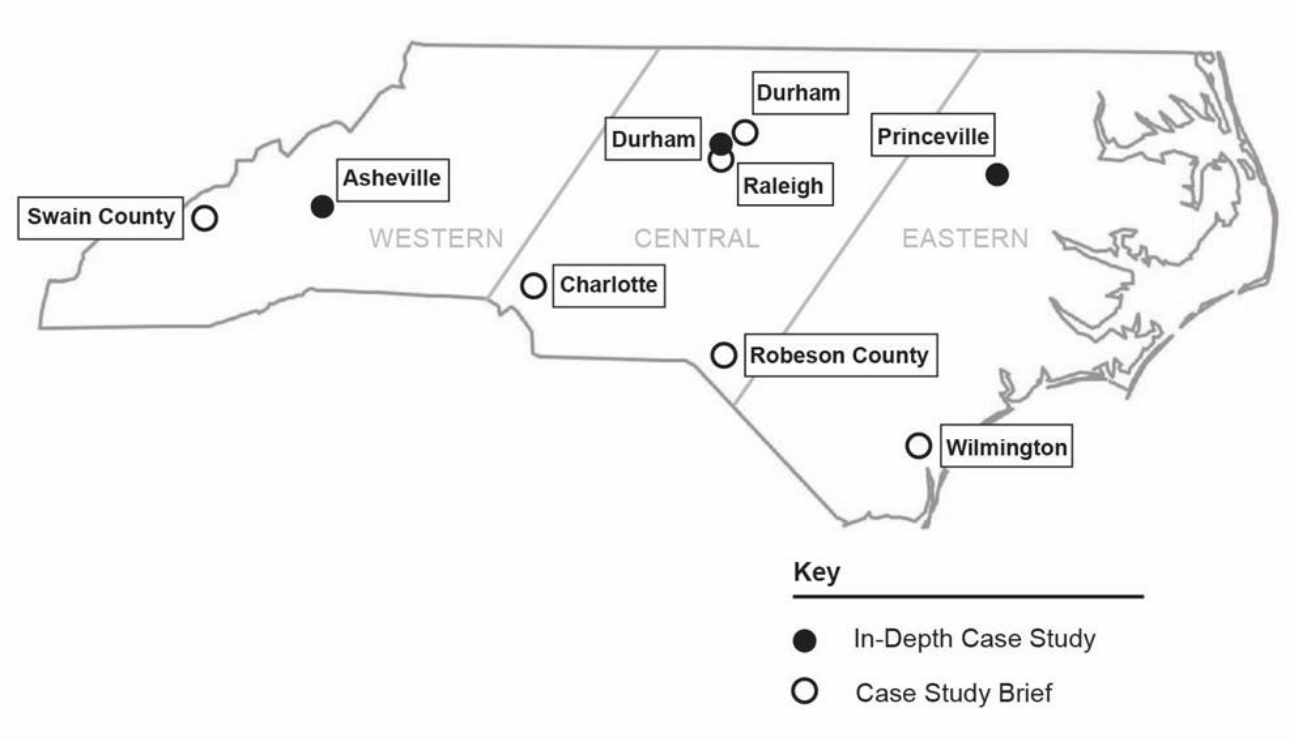


Exhibit 3: Case Study Community Details

Area	Region	Area Type	Community Impacted	Transportation Period
Asheville	Western	Urban	Historically Black Community, I-26 connector impacts on Burton Street Neighborhood	1960s-present
Charlotte	Western	Urban	Historically Black Community, I-77 impacts on West End community	1960s-present
Durham	Central	Urban	Historically Black Community, NC 55/Alston Avenue widening impacts on Northeast Central Durham, Impacts of freeway construction and expansion on community connectivity and cohesion	2000s-present
Durham	Central	Urban	Historically Black Neighborhood, NC-147/Durham Freeway impacts on the Hayti Community	1950s-1970s
Princeville	Eastern	Rural	Historically Black Community, US 64 impacts on flooding in the Princeville Community	1990s-2010s
Raleigh	Central	Urban	Historically Black Community, I-40 impacts on flooding in Rochester Heights Community, Inadequate flood protection measures, reduced connectivity	1950s-1990s (revise to reflect construction period of I-40)
Robeson County	Central	Rural	Native American and low income communities, air quality and respiratory disease risks	I-95 construction period
Swain County	Western	Rural	Low income rural communities, displacement, loss of connections to burial grounds and ancestral lands	1930s-2000s
Wilmington	Eastern	Urban	Historically Black Community, Wilmington Bypass, displacement, sound and other freeway impacts	1990s

North Carolina In-Depth Case Studies and Story Maps

The team produced in-depth case studies for three (3) communities in part due to an abundance of available data but also because of their abilities to provide thick descriptions of overall study themes. In-depth case studies required mixed methods including quantitative and qualitative analysis tools. All data and tools were identified due to their availability to NCDOT researchers for future similar efforts. However, for future work, the relationship building with local community stakeholders as well as time dedicated to pursuing archival research would not be replicable without additional resources and/or policy directives.

Quantitative data sources considered include:

1. ACS and US Census - case study communities were correlated with their associated census tracts and key demographic indicators were identified to describe pre and post NCDOT demographic changes. Unless otherwise noted, census tracts were selected within a one (1) mile radius of each project area.
2. EJSCREEN - EJSCREEN was used to identify current (since 2010) documented exposure risks to disadvantaged communities at the census tract level. This tool was relevant in cases where air, water, or other forms of contamination have been reported to federal agencies.
3. HOLC Maps - in cases that were in the context of communities coded by the Federal Government's Homeowners Loan Corporation (HOLC) in the 1930s, specifically communities that were "redlined" (excluded from Federal funding at that time), official HOLC coded maps were retrieved via Mapping Inequality for review.
4. NCDOT and USDOT archival research - where applicable, project files associated with each case study were acquired and reviewed.

5. NC One Map/FEMA FIRM Maps - in cases where the current locations of floodplains and flooding were integral to understanding community impacts, blue line streams, floodways, and floodplains (100 and 500 year) were identified.
6. State Historic Preservation Office archives - in cases where officially documented historic and cultural features were relevant, archival research was conducted through the State SHPO office including review of local, state, and National Register of Historic Places applications.
7. Redevelopment/Urban Renewal archival research - in cases where NCDOT decisions coincided with mid-20th century urban redevelopment plans, reports and data were retrieved from local and state archives
8. USDA Historic Aerial Photography - these were useful for case studies reflecting significant land use and built environmental shifts over the duration of NCDOT projects. Photography dating back to 1939 where available was accessed via the UNC library system.
9. USDOT ETC Explorer - ETC Explorer, a new online tool created by USDOT during the process of this study, was used in the context of cases that were currently federally designated as being in disadvantaged communities. This new tool documented most of the factors found in EJSCREEN, with additional risk factors associated with disadvantaged communities per Justice40.

Qualitative data sources considered include:

1. Informal semi-structured interviews with technical experts - this included current and former NCDOT staff, engineers, planners, and others associated with selected case studies.
2. Informal semi-structured interviews with community stakeholders - this included current and former residents from case study communities.
3. Media archival research - this included newspaper articles, community organization newsletters, audio and video recordings associated with the case study context.
4. Key informants - In the initial proposal direct engagement with local stakeholders in case study communities was proposed. However, due to barriers including a perceived distrust by communities of NCDOT decision-making, this process was not pursued. It is proposed in future NCDOT engagement with the caveat that trust building is necessary for adequate participation.

Through case study analysis, the project investigated the impacts of historical NCDOT projects on several EJ communities throughout the state (the nine case studies previously noted). The stories of these cases were developed into ArcGIS StoryMaps (referenced as Story Maps in this report) that combine images, maps, video, and text to describe these communities' past, present and future: Hayti (Durham), Princeville, and Burton Street (Asheville). These Story Maps, developed by the research team, are being delivered to NCDOT through this study and provide interactive experiences with the narrative of each community affected by NCDOT decision-making. In addition to the Story Maps, these cases are also documented in briefs available in Appendix 6.

All three communities documented in the Story Maps were predominantly African American at the time that transportation decisions led to significant impacts. The stories reveal historical practices that resulted in destruction within these communities as examples of lessons to be learned. In addition to the community stories, the site includes a link to NCDOT's current EJ practices that address some past decisions and help move forward in ways that are equitable and community inclusive. The links to the stories are found on an introductory page, termed the Landing Page as shown in

Exhibit 4. The following sections provide an overview of these three cases and the related Story Map content.

Exhibit 4: Landing page providing links to in-depth case study story map



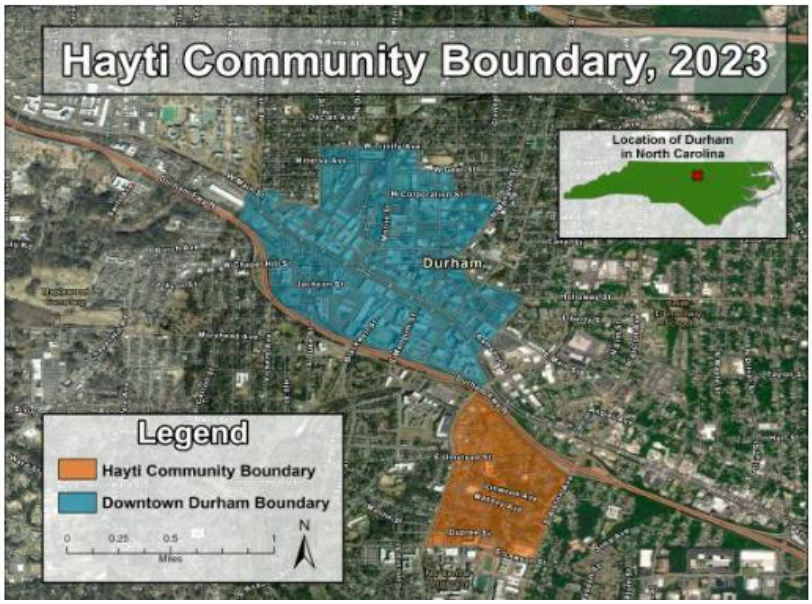
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Durham: NC-147/Hayti Community

Hayti, shown in Exhibit 5, was a once-flourishing African-American community in Durham, North Carolina. It was founded by Freedmen soon after the end of the American Civil War and was the home of many successful Black business, faith, education, and political leaders dating back to the late 19th century. It is the location of NC Central University. It was the home of James Shepard who helped found North Carolina Mutual Life Insurance Company. That company, along with Mechanics and Farmers Bank, was headquartered on Parrish Street (in Downtown Durham), also known as "Black Wall Street." Hayti emerged during the Jim Crow Era and developed as a segregated community. It was described by early 20th century residents as a self-sufficient community containing a range of locally-owned housing, businesses, and services.

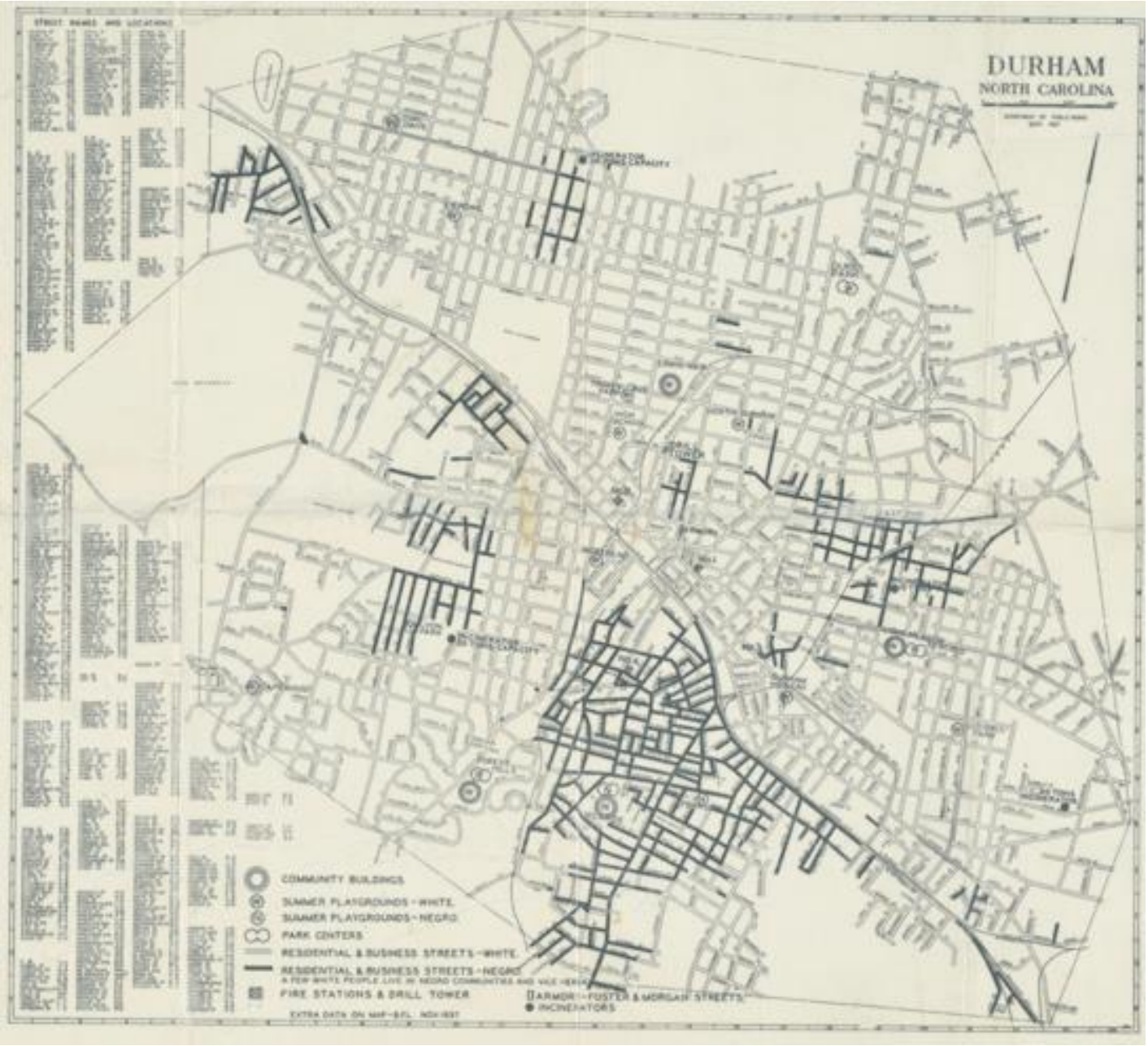
The Hayti case study offers an in-depth look into the impacts policy, planning, and infrastructure have had on a historically significant community. The Hayti community suffered serious upheaval due to redlining and the construction of the Durham Freeway or NC-147 during urban renewal efforts in the 1960s (Bullcity150, 2024). These actions led to the displacement of thousands, and severed connections between the community and Downtown Durham, resulting in economic and social decline. Recent attempts at redevelopment have often bypassed community input, which further raises concerns about gentrification and future displacement.

Exhibit 5: Hayti Community Boundary in Durham, NC



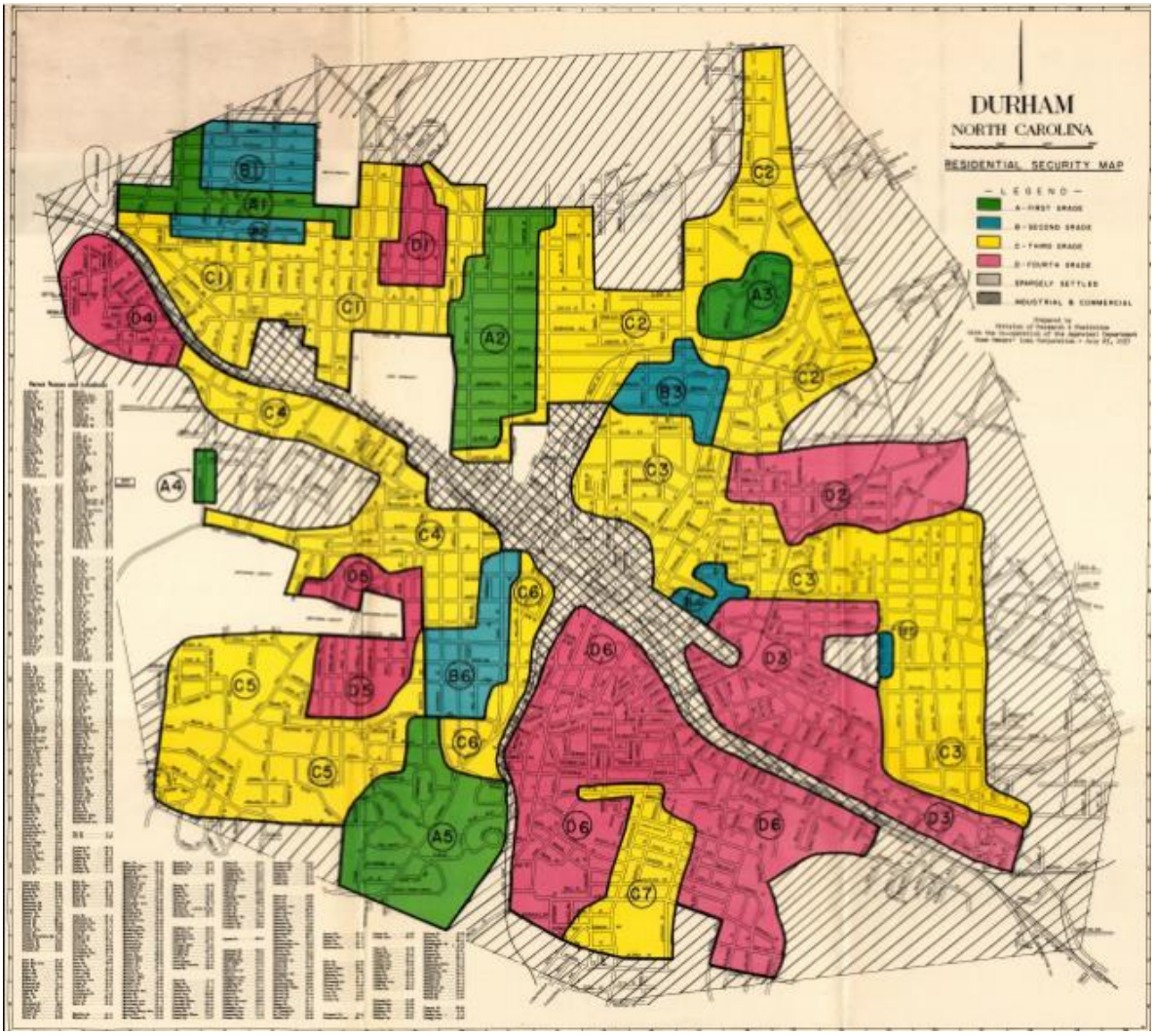
The accompanying Story Map describes the thriving nature of Hayti, and how redlining enabled the reclassification of this community as "blighted" so as to be funded for urban renewal. Exhibit 6 shows the preliminary redlining map of the community developed during the planning process in the 1960s. The streets in bold are those earmarked at the time as "predominantly minority' residences.

Exhibit 6: Historical Redlining Map for Durham's Hayti Community Boundary



During this period of "urban renewal," neighborhoods like Hayti were color-coded on maps: green for the "Best," blue for "Still Desirable," yellow for "Definitely Declining," and red for "Hazardous." The areas identified by bold in the preliminary redlining map are all shaded in red (Mitchell & Franco, 2018). Exhibit 7 presents the historical map of this type for the Hayti community.

Exhibit 7: Residential Security Map Durham's Hayti Community



Through these types of deceptive tactics, the Hayti community was framed as one that was not worth preserving. Consequently, the construction of NC-147, which cut through the community, was approved. In addition to reducing community cohesion, this transportation project resulted in the destruction of significant community landmarks and a loss of connectivity between Hayti and downtown where Black Wall Street was located. Thousands of residents and businesses were displaced and numerous businesses closed, leading to the loss of the community as a whole over time.

These effects are demonstrated by the images within the slider maps from the Story Map in Exhibit 8 and

Exhibit 9, which shows a comparison of Hayti during pre-and post-NC-147 construction. In around a decade, Hayti went from a thriving, connected community to an empty, fractured one. As seen through the sliders, almost every home or business was demolished to make room for the Durham Freeway and other Urban Renewal projects.

Exhibit 8: Hayti Community Slider: Existing Land Use vs Proposed Land Use (1960).

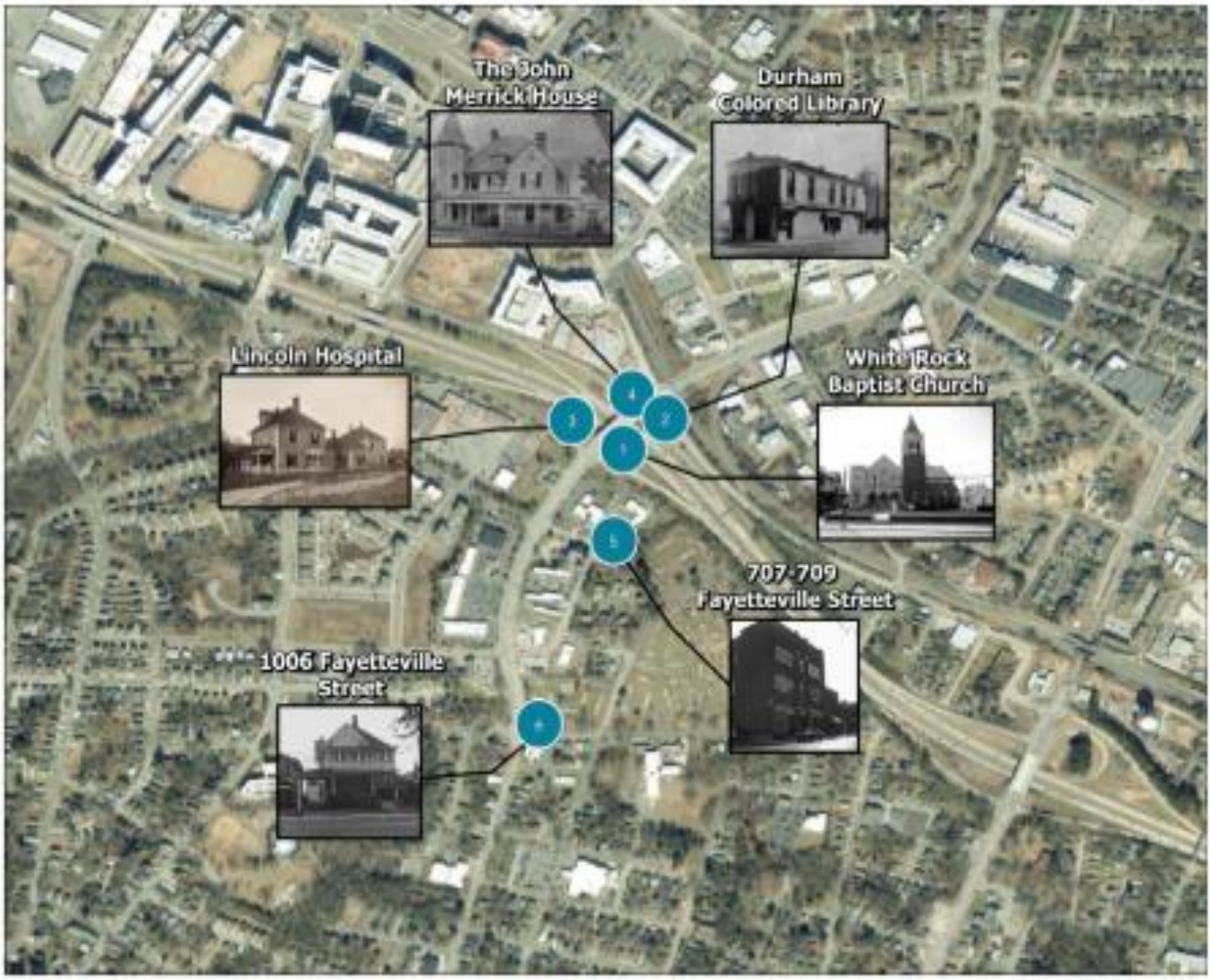


Exhibit 9: Durham's Hayti Community Pre- and Post-NC-147



Through a series of "then and now" images at locations designated on the location map in Exhibit 10, the Story Map shows the drastic changes that took place with freeway construction.

Exhibit 10: Location Markers for Durham's Hayti Community in the Online Story Map



The White Rock Baptist Church is one example of a foundational community space that was lost with the development of NC-147. Originally established in the home of Mrs. Margaret Faucette, the church would grow into one of the largest churches in Durham. In Exhibit 11, a 1950s photograph on the left depicts the church before its demolition for "Urban Renewal" to make way for the Durham Freeway/Fayetteville Street Interchange. The photo on the right shows the current state of the land where this landmark once stood upon.

Exhibit 11: Site of Durham's White Rock Baptist Church Before and After NC-147



The Hayti Story Map also includes a video (compliments of "Be Connected") that includes the experience of four community members who describe their heartfelt sentiments on how NC-147 and related community demolition and fragmentation impacted the lives of Hayti's residents by displacement and loss of connectivity. An example is shown in Exhibit 12.

Exhibit 12: Example of Community Voices Video in Hayti Story Map



A brief section on risk for gentrification and displacement describes Hayti's current and potential future situation is included in the Story Map. Discussion includes developments like the South Redevelopment Project, the Hayti Reborn initiative, Fayetteville Place housing, and Heritage Square. Mention is made of the need for equitable treatment across all communities in future endeavors, with a link provided to NCDOT's current initiatives to advance equitable treatment.

The Story Map concludes with mention of two online mapping platforms - Tree Equity Score and ETC Explorer where viewers can learn more about environmental justice related issues in Durham and around the state.

AIR QUALITY ANALYSIS

In addition to the content included in the NC-147/Hayti Community Story Map, the research team evaluated exposure to air pollutants in Hayti and demonstrated disproportionate exposure and risk for related adverse human health effects among the most vulnerable (low-income and minority) residents.

Nitrogen oxides (NO_x) is a criteria air pollutant regulated by National Ambient Air Quality Standards, mainly coming from transportation sources (EPA, 2014). Short-term exposure to NO_x can cause adverse health effects on the human respiratory system (EPA, 2015). NO_x is also a key pollutant of concern to communities overburdened with environmental exposures that contribute to environmental justice concerns. Using an EPA-regulated emissions model, Motor Vehicle Emission Simulator (MOVES), coupled with a regional travel forecast model, Triangle Regional Model, NO_x emissions were estimated in the Hayti community study area for 2023 during evening rush hour, when traffic volume is at its peak (EPA, 2023; Institute for Transportation Research and Education, 2023). The demographic index, developed by EPA, is an indicator of socioeconomic status, with higher values indicating more low-income and minority residents (EPA, 2024). Detailed information about the methodology of emission estimation and results for other key air pollutant emissions are provided in the Appendix.

Results show that census block areas with a high demographic index, especially those around the Durham Freeway NC-147, have high NO_x emissions, as illustrated in *Exhibit 13*. Although NC-147 only covers 7% of roads in Hayti, it contributes to 25% of traffic flows and 35% of NO_x emissions during evening rush hour. Road link-based NO_x emissions rates for NC-147 are among the highest, falling within the top 10^{th} percentile of NO_x emission rates in the Hayti Community. Areas around NC-147 have high demographic index values (80%-90%), indicating high proportions of low-income (75%-88%) and minority residents (84%-99%). Area-based NO_x emissions during the evening rush hour vary up to 20 times across different census blocks (*Exhibit 13*). This leads to a substantial disparity in short-term NO_x exposure among different areas, with emissions varying greatly between census blocks. Particularly noteworthy is the impact of NC-147, which significantly contributes to NO_x emissions in areas characterized by high minority and low-income populations. The area-based emissions are valuable for identifying regions with potential environmental justice concerns and highlighting disparities in exposure.

The trends in other key air pollutant emissions, such as carbon dioxide (CO_2) and particulate matter (PM), by road link and by census block area are similar to NO_x, showing elevated emissions in census block areas covering NC-147. The emissions analysis was also conducted to assess the environmental justice implications in the future. Exhaust air pollutant emissions are projected to significantly decrease by 2050; for example, area-based NO_x emissions in Hayti are estimated to be reduced by an average of 65% by 2050. This reduction is primarily attributed to the retirement of older vehicles in the fleet, the

implementation of increasingly stringent vehicle emission standards, and the growing adoption of electric vehicles (EVs) in the future.

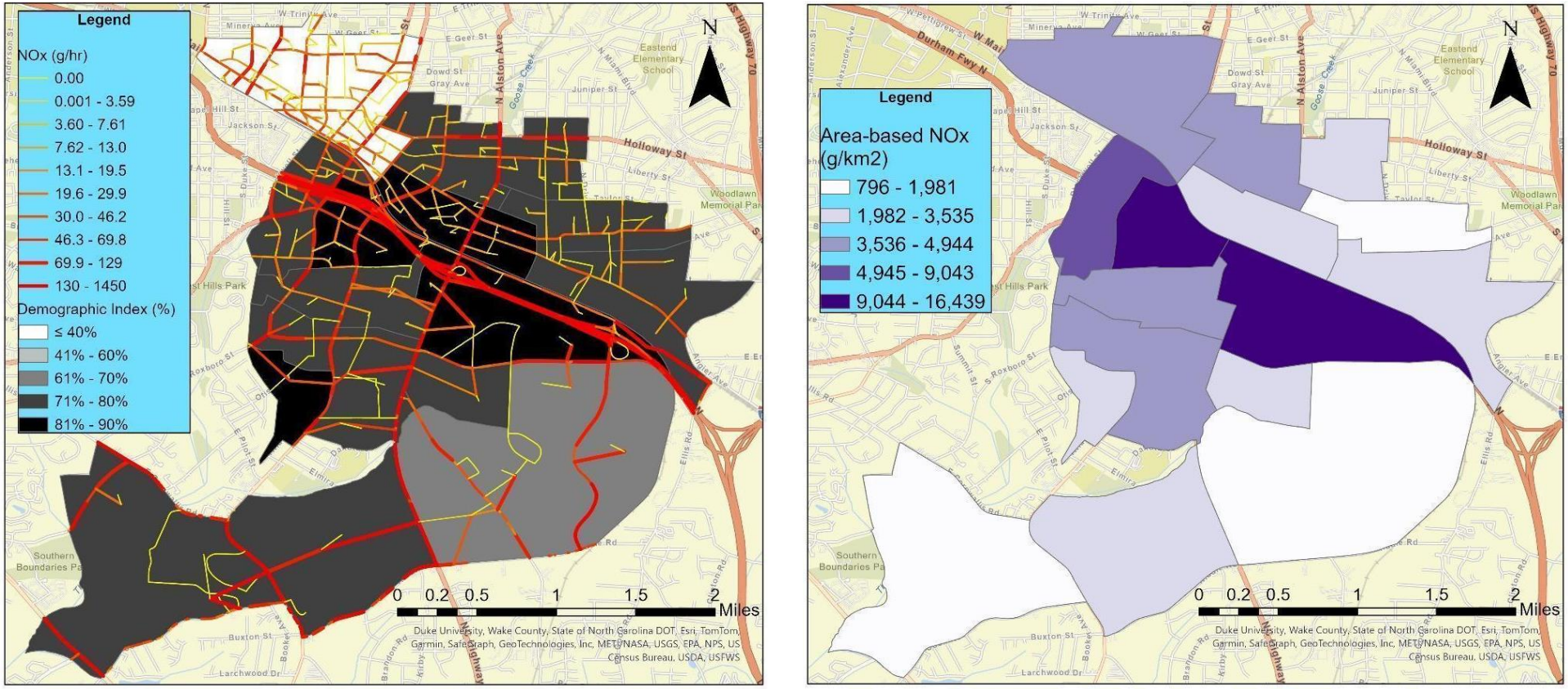
However, transitioning to EVs may also pose challenges related to environmental justice concerns in air pollutant emissions. EVs may produce more non-exhaust PM emissions, such as tire wear emissions, compared to non-EVs due to their heavy batteries, which could result in increases in PM exposure (Timmers and Achten, 2016). Additionally, transitioning to EVs may involve a tradeoff of reducing and relocating emission-impact areas rather than completely eradicating emission impacts (Peters et al., 2020). Encouraging the adoption of EVs can mitigate mobile source emissions along high-volume corridors (such as NC-147) and improve air quality near transportation facilities.

Nevertheless, EVs currently have higher upfront costs compared to conventional gasoline vehicles, which may make them less accessible to lower-income residents. As a result, the low-income communities are more likely to continue using gasoline vehicles for a longer period, potentially delaying the benefits of lower emissions associated with EVs. While much of the traffic on NC-147 is through traffic rather than local neighborhood traffic, the slower adoption of EVs in low-income communities could result in these areas experiencing less reduction in air pollutant emissions compared to higher-income communities where EV adoption is more rapid.

Additionally, the increased demand for electric power generation for EVs may lead to elevated air pollutant emissions from power plants, which are often located near disadvantaged communities. Therefore, while EVs can help alleviate impacts on disadvantaged communities to some extent, they should not be viewed as a cure-all solution for eliminating all impacts on these communities.

Consequently, air quality effects should continue to be considered by NCDOT in the future as part of transportation planning and implementation. The air quality analysis demonstrated here for the NC-147 area could be replicated by NCDOT in other areas of the state to understand past effects of emissions and project what air quality may look like in the future under different scenarios. Appendix 7 provides detailed information about the air quality data and analysis.

Exhibit 13: Estimated evening rush hour nitrogen dioxide (NOx) emissions in the Hayti community in 2023: (a) NOx emission rates in grams per hour (g/hr) by 1,065 road links; and (b) NOx emission rates in grams per square kilometer per hour (g/km2-hr) by 16 census block areas.



(a) Road link based NO_x emissions; (b) Census block area based NO_x emissions

Note on Exhibit: Demographic index, an indicator of socioeconomic status, by census block area is also illustrated in *Exhibit 13* (a)

KEY TAKEAWAYS

Hayti, Durham, North Carolina offers many insights that could be considered in future transportation decision making.

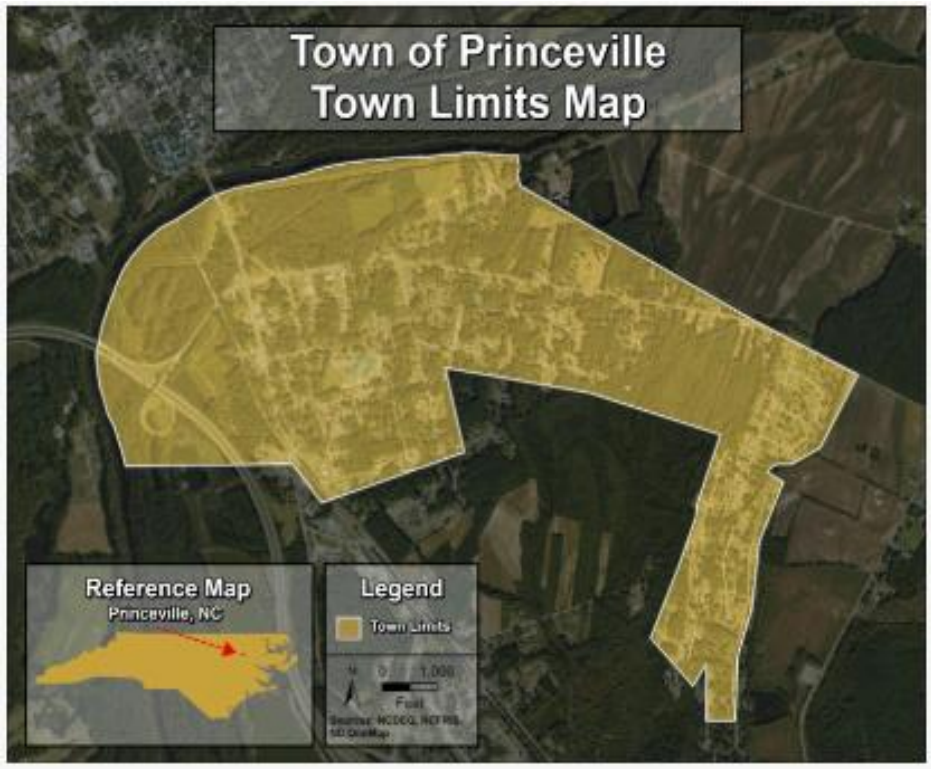
1. Acknowledging cumulative policy impacts: NC-147/The Durham Freeway did significant harm to the Hayti Community. The freeway route resulted in 4000 residents permanently displaced, as well as the loss of over 500 local businesses. However, the routing of the freeway was based on the effects of previous eras of policies that undermined the economic and political capacities of the community. Redlining in the early 20th century excluded Hayti from participating in federal loan programs that could have been used to invest in homes and businesses. Decades later, urban renewal policies determined that portions of Hayti were slums and targeted for clearance and redevelopment. Recognizing the impacts of previous eras of policies on communities as a part of the planning process can support reparative strategies that can identify opportunities for transportation decisions to support community stability and repair.

2. Investing in community engagement throughout the process: The Durham Freeway began before NEPA and Title VI of the Civil Rights Act were enforced in federal freeway construction. Although there were records reflecting some community engagement as a part of the decision-making process, little is known about the level of community understanding of the impacts of the freeway, or the impacts of the freeway on other factors such as housing and business retention, walkability, and health. The lack of effectively communicating these impacts can contribute to a lack of community trust in subsequent decision-making. In the case of Hayti and the Durham Freeway, current City-led efforts to envision a new Durham Freeway (Reimagine Durham Freeway Study, 2024) reflect best practices in community engagement. A range of different engagement methods is being used and deployed in different venues. The community is being asked to provide their visions and insight before a plan is developed. And the engagement activities are being led by local stakeholders. These strategies attempt to build community trust and empower local voices in advance of a transportation project, not in response to it.

Princeville: US-64/Princeville Community

Princeville, North Carolina, shown in Exhibit 14, occupies a significant place in American history as one of the first towns founded by free African Americans post-Civil War. Throughout its 150-year history, the residents of Princeville have endured racism, economic and social isolation, and increasingly severe environmental hardships, including chronic flooding and frequent hurricanes. These challenges, compounded by poor infrastructure decisions, threaten the community's stability and growth. The exhibits presented in this section are shown in the Princeville case study Story Map as well.

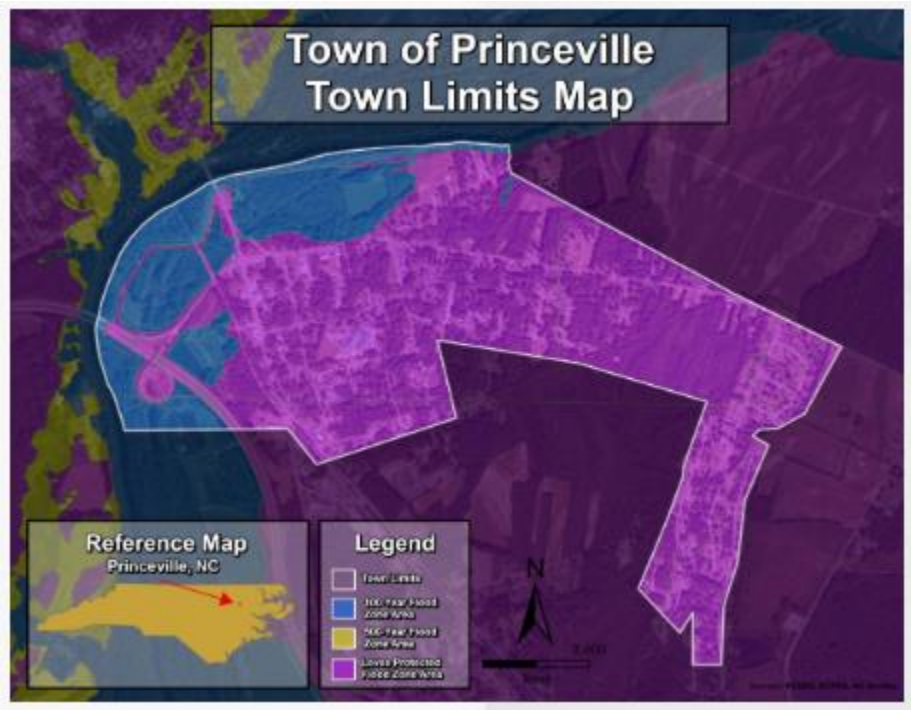
Exhibit 14: Princeville, NC Town Limits



In 1865, freed African Americans settled on the swampy, flood-prone terrain along the Tar River, establishing what was originally known as "Freedom Hill" to commemorate the spot where a Union soldier announced the Emancipation Proclamation to the local African American population (dncr.nc.gov, 2016). The local white population in nearby Tarboro, did not initially oppose this settlement because the swampy land was seen as undesirable.

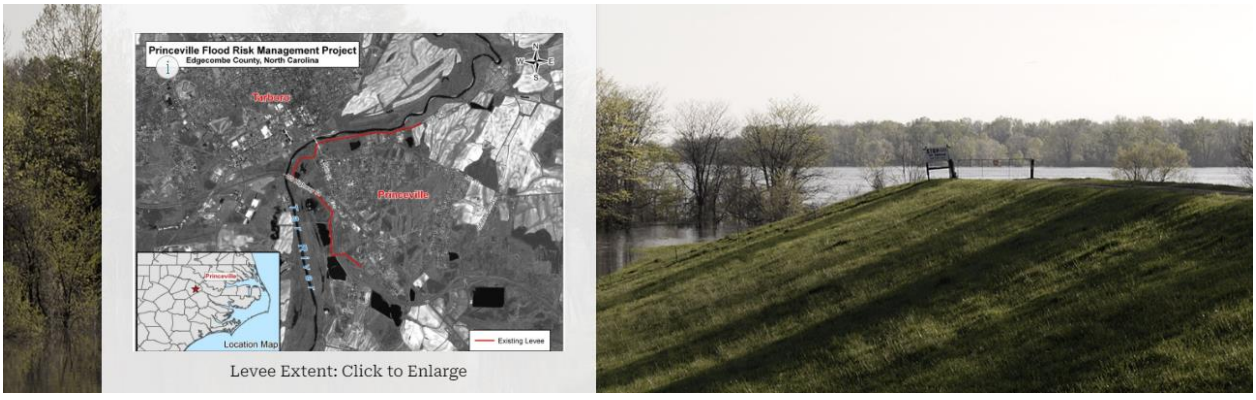
Exhibit 15 shows Princeville's flood zones: blue for the mandatory insurance 100-year floodplain, and purple for levee-protected areas since the 1990s.

Exhibit 15: Princeville Flood Zones



In response to the threat of flooding, the construction of a levee system by the U.S. Army Corps of Engineers occurred in the 1960s. The levee, rising almost 37 feet from the water's edge, was designed to protect Princeville from 100-year storm events. Exhibit 16 presents a map detailing the original extent of this levee. For almost three decades this levee protected Princeville, until 1999 when Hurricane Floyd devastated the town, and revealed some underlying deficiencies with the levee.

Exhibit 16: Princeville Levee Construction



In the early 1990s, construction began on US Highway 64, with plans to integrate the highway with Princeville's existing levee system. However, as shown in Exhibit 17, several points along the southern edge of Princeville's levee were replaced with a series of ungated culverts (MacConnell & Associates, 2017). Ungated culverts in essence created an opening in the levee along the freeway and enabled the

breaching of the levee from Hurricane Matthew flood waters. How the decision was made to uncouple the highway from the levee is unclear. Research revealed references to interagency communication between NCDOT and US Army Corps of Engineers officials but no documentation of that decision process was found (MacConnell & Associates, 2017).

Exhibit 17: US Highway 64



The decision to interrupt the continuous levee with ungated culverts would be revealed in 2016 to have brought down the effectiveness of the levee in managing 25-year storm events in several areas (USACE, 2014). Exhibit 18 is an updated flood risk potential map. Following the addition of culverts, almost the whole town was at flood risk of 1.33% or a 100-year storm event.

Exhibit 19 shows the depth of flood at 1% chance flood event, which was earlier shown to affect almost the entire town. This displays the risk of devastation for the town, whereby almost the entire town is at risk of 3+ feet of flooding during a 100-year storm event.

Exhibit 18: Princeville Risk Management Project

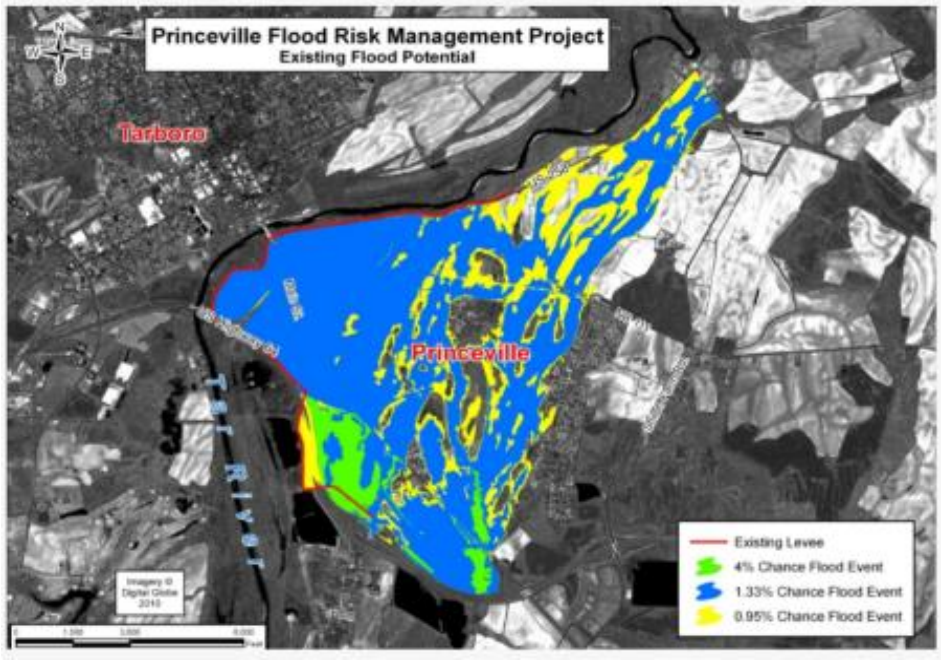
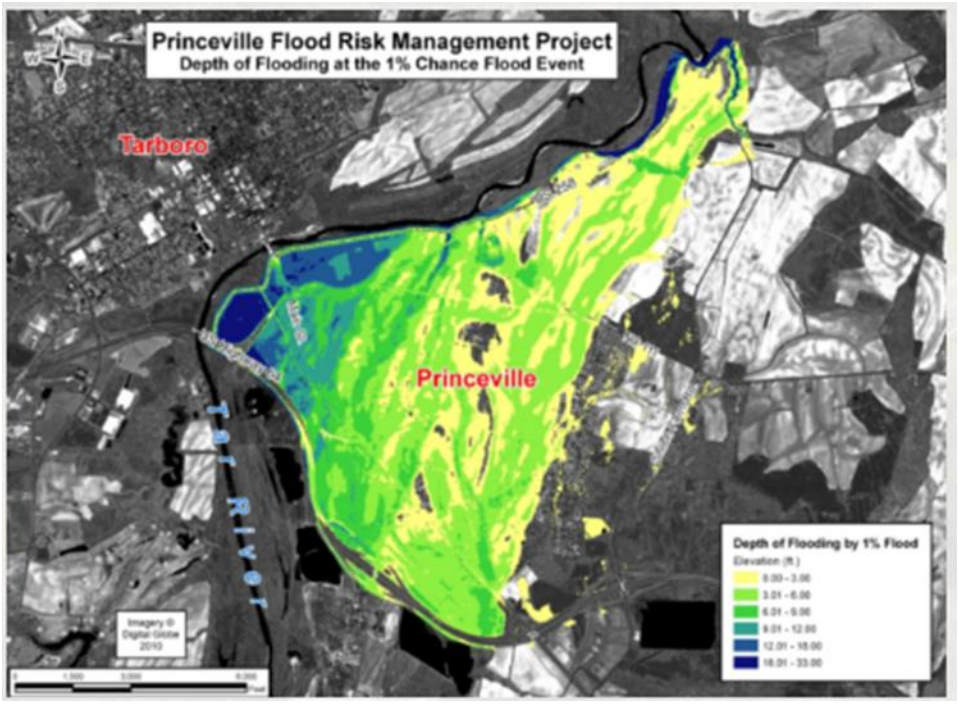


Exhibit 19: Princeville Flood Management – 1% Risk Map



The map in Exhibit 20 highlights the 2021 racial dot density in Tarboro and Princeville, showing Tarboro's Black population at 51.3%, with Princeville hosting a significantly higher minority population—93% Black and Hispanic at 5.1%. Tarboro has a much larger land area with a larger population. Additionally, dot density mapping in ArcGIS places dots randomly across a given space, such as block groups. The Tarboro dot map, thus, does not illustrate whether neighborhoods are segregated or fully integrated as would appear on the map. This is a limitation of computerized dot mapping. Princeville is by far predominantly Black, thus its dot map is more reflective of communities of color.

Exhibit 20: Racial Dot Density in Tarboro and Princeville

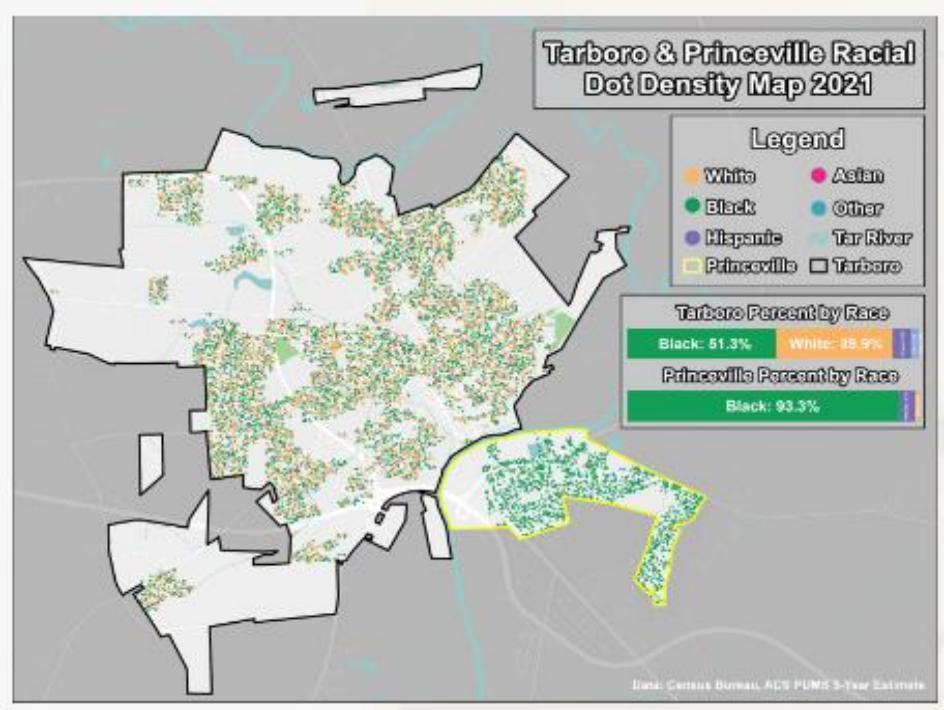
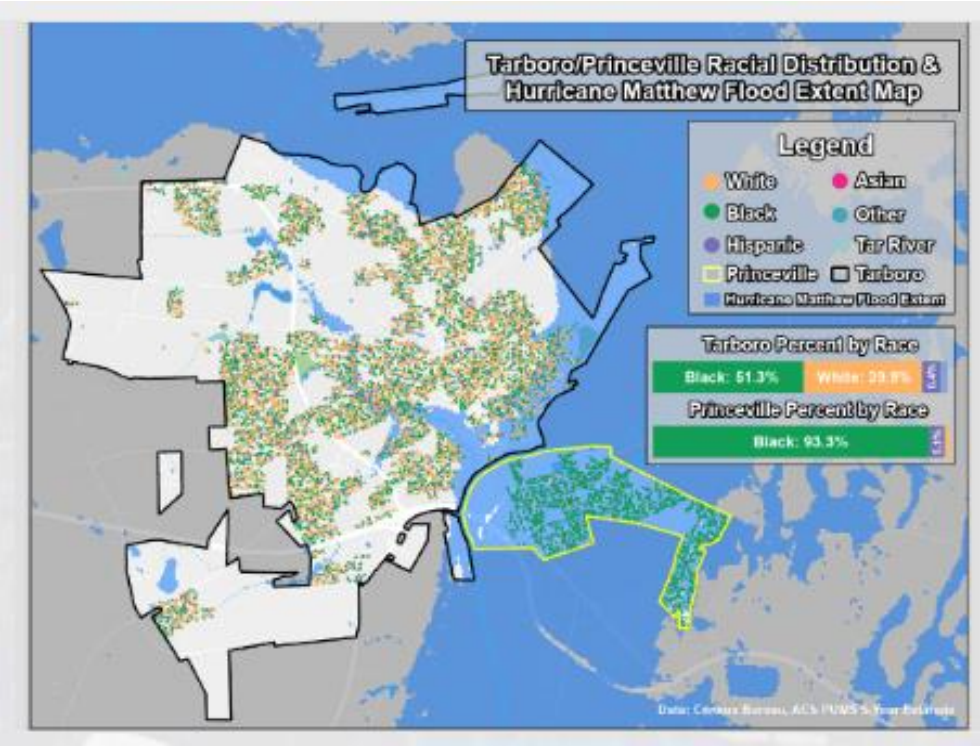


Exhibit 21 provides context for the disadvantage of living in flood-prone Princeville, where the entire community was flooded during Hurricane Matthew. In comparison, only small segments of Tarboro were flooded. These appear to be primarily in areas that are not populated. There are a few small segments where residents were flooded along the eastern side of the town.

Exhibit 21: Hurricane Matthew Flood Extent/Racial Dot Density Map of Tarboro & Princeville



HURRICANE FLOYD

Several years after the construction of US Highway 64, the Town of Princeville was struck by Hurricane Floyd in 1999, a Category 2 hurricane that made landfall off of Cape Fear, NC. It was considered a 1000-year storm, something that far exceeded the levee's original 100-year protection design, and significantly surpassed the reduced 25-year protection. The town was inundated with over 30 feet of water, and over 600 homes were destroyed.

Within days of the hurricane's landfall, Princeville's situation captured national attention, even drawing the focus of President Bill Clinton. FEMA arrived shortly thereafter, presenting the town with two choices:

1. Raise the levee walls and rectify the issues with the existing system, such as the culvert.
2. Facilitate a buyout of a significant portion of the homes, offering residents an opportunity to relocate.

Ultimately, the community chose not to relocate, driven by various factors including the community's historical significance and attachment to the town, a lack of affordable housing options, and a mistrust in federal agencies caused by a history of underinvestment in flood protection.

Exhibit 22: Video inserted into story map describing Hurricane Floyd



HURRICANE MATTHEW

Over the next 17 years, the Army Corps of Engineers made slow progress in strengthening the levee, the project culminated in the final report presented in the spring of 2016. Six months after the report's release, disaster struck again as a Category 1 hurricane made landfall, inundating the town with more than 12 inches of rain. This storm caused the destruction of 450 homes, with roughly 80% of the town submerged. Unlike previous floods, the water this time didn't overtop the levee; instead, it surged through a gap around the railroad tracks. The image below illustrates the extensive damage inflicted by Hurricane Matthew's floods on the town.

Exhibit 23: Images from before (left) and after (right) Hurricane Matthew



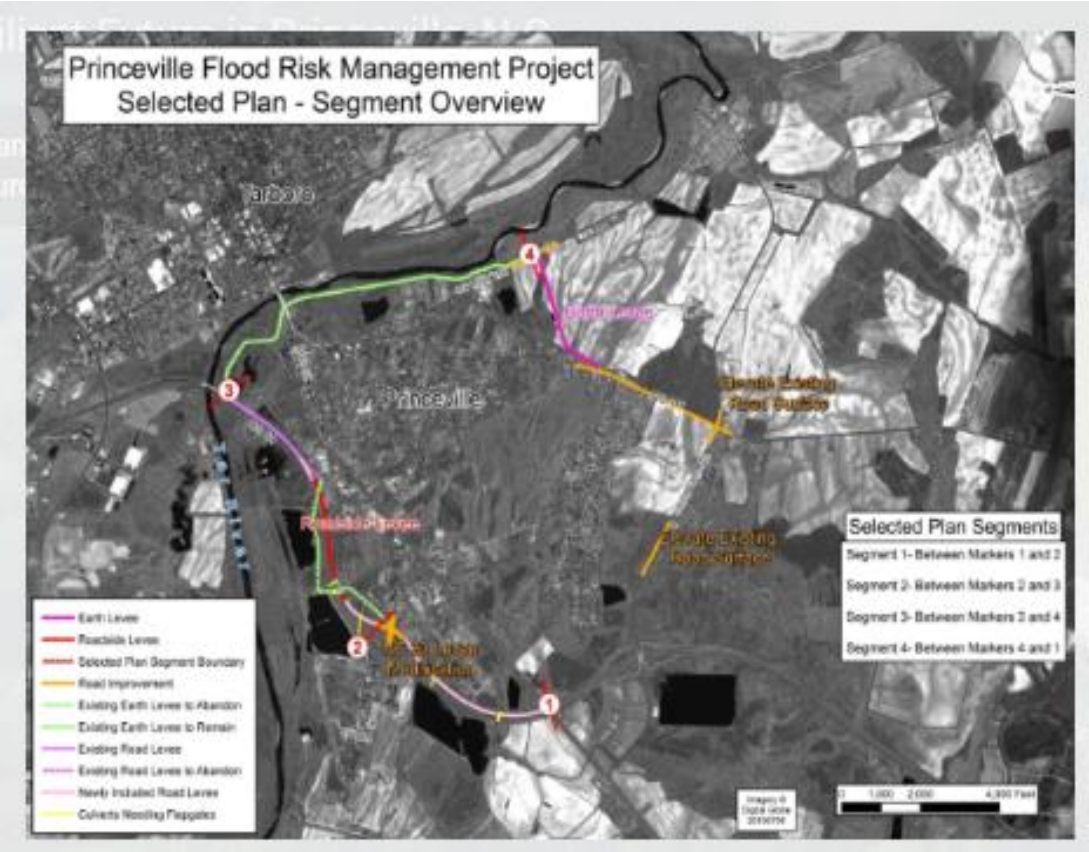
The Mayor, Bobbie Jones, advocated for rebuilding rather than accepting the buyouts, however, the town board voted to allow residents to decide individually on accepting buyouts. Soon after, an agreement was made between the state and the town. A 53-acre subdivision would be built on higher ground, providing essential services such as fire and new homes. At the same time, the historic downtown would be rebuilt allowing for people to return to their homes. The plan for this project is shown in Exhibit 24.

Exhibit 24: Proposed 53-Acre Rebuilding Site with Roads



In 2020, federal funding totaling nearly $40 million was allocated to support the construction of a new levee aimed at protecting Princeville (Fain, 2020). However, in 2023 the Army Corps reported that revised modeling revealed the new levee would threaten thousands of buildings in Tarboro, as well as throughout the river basin (Fox, 2024). This leaves the project unable to be completed at the moment. This proposal is presented in Exhibit 25.

Exhibit 25: US Army Corp of Engineer Levee Strengthening Proposal



The story ends with a brief description of community and non-profit initiatives to strengthen Princeville's resilience and resistance to flooding.

Exhibit 26: Website for Conservation Trust for North Carolina's Princeville Collaborative Project



KEY TAKEAWAYS

Princeville, North Carolina offers many insights that could be considered in future transportation decision making.

1. Interagency collaboration: The decision-making process that forced a separation between the levee and Highway 64 is still a mystery. No levee system would have been capable of protecting Princeville from Hurricane Floyd, a 1000-year storm. However, some of the Hurricane Matthew flooding in Princeville has been attributed to the ungated culverts between the levee and Highway 64. There is a need for more effective, transparent, and well documented decision making between NCDOT and US Army Corps of Engineers, especially in communities at extreme risk of flooding.

2. Investing in community resilience: Since Hurricane Matthew, NCDOT has added backflow preventers to the ungated culverts, and raised several intersections to improve Princeville's resilience. There is a need for environmental modeling to forecast increased climate related threats (like flooding) and consider the contributions transportation infrastructure can play in increasing community resilience. In the case of small rural towns like Princeville, this may also mean rethinking benefit-cost ratios used to justify the costs of infrastructure improvements. Highway 64 is a key hurricane evacuation route and its ability to function in storms is essential for regional security and sustainability.

Asheville: I-26 Connector/Burton Street Neighborhood

The Burton Street Neighborhood is a historically Black neighborhood in West Asheville, North Carolina, as shown in Exhibit 27. The neighborhood was founded in the early 1900s on land that, due to the valley along the French Broad River, was isolated from the heart of Asheville. This topographic isolation reinforced racial segregation and a lack of connectivity to the rest of the city since its founding. It is home to an important piece of Asheville's cultural history. Throughout this history, the neighborhood has been targeted by policies and development projects resulting in economic and social isolation. The associated Story Map developed through this research serves to educate on these struggles, examine the current state of the community, and explore future responses to social and environmental burdens.

Exhibit 27: Burton Street Community's Extent and Relation to Downtown Asheville

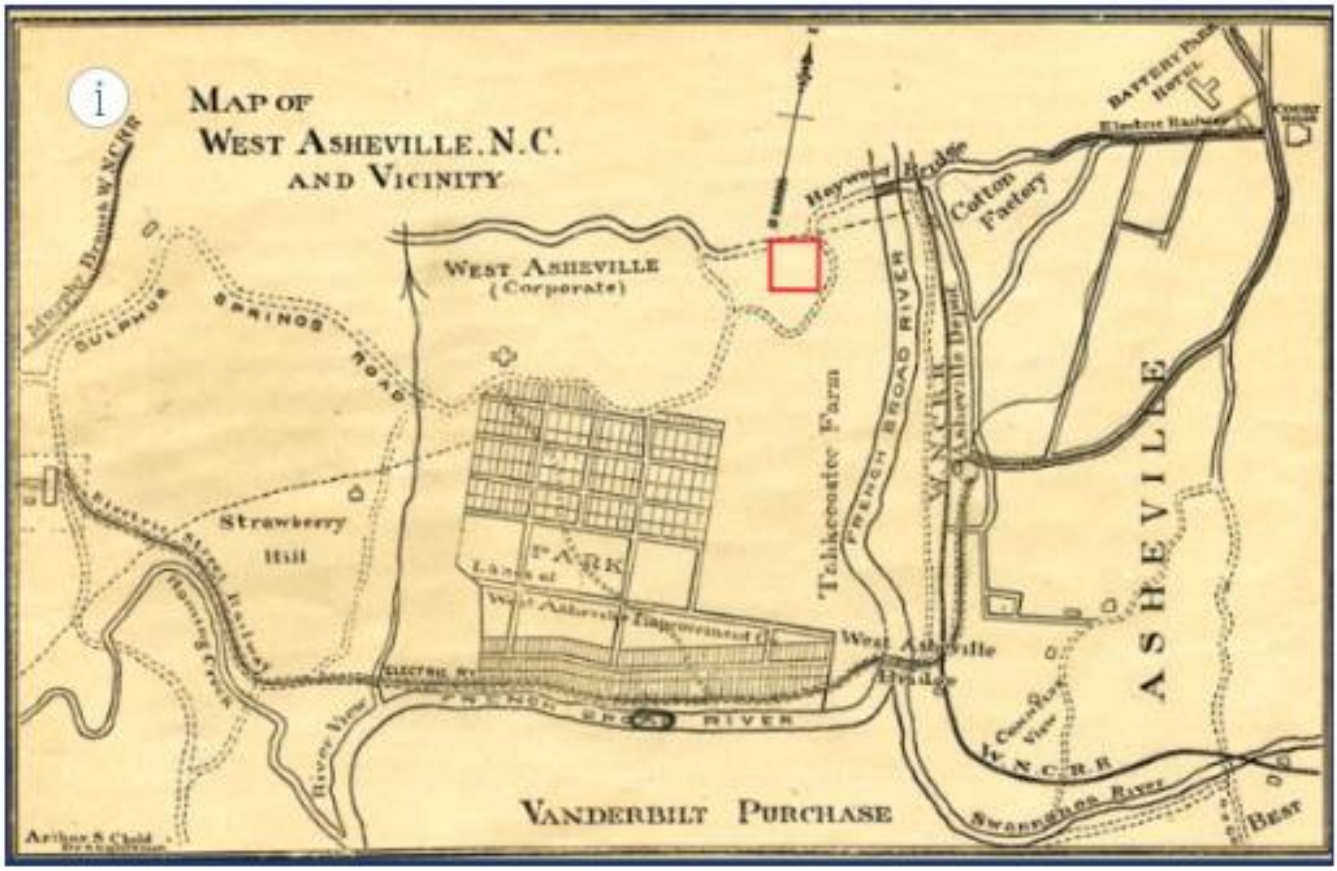


The Burton Street Community was established in 1911 by renowned civic leader and businessman E.W. Pearson, often referred to as the "Black Mayor of West Asheville" (Asheville Black Cultural Heritage Trail, 2024). Through numerous initiatives and activities, he established a strong sense of cultural identity for Burton Street, which sparked growth.

This growth was further supported by the development of a streetcar line along Haywood Road, which connected Downtown Asheville, the French Broad River, and the West Asheville Communities. This connectivity enabled the development of many unique businesses that added to the community character.

In a map of West Asheville shown in Exhibit 28, the red square roughly depicts the Burton Street Community. The Burton Street Community borders Haywood Road, which had an electric streetcar network. A series of examples of local architecture attest to Burton Street's unique character. A few of these are shown below.

Exhibit 28: Historical Map of West Asheville



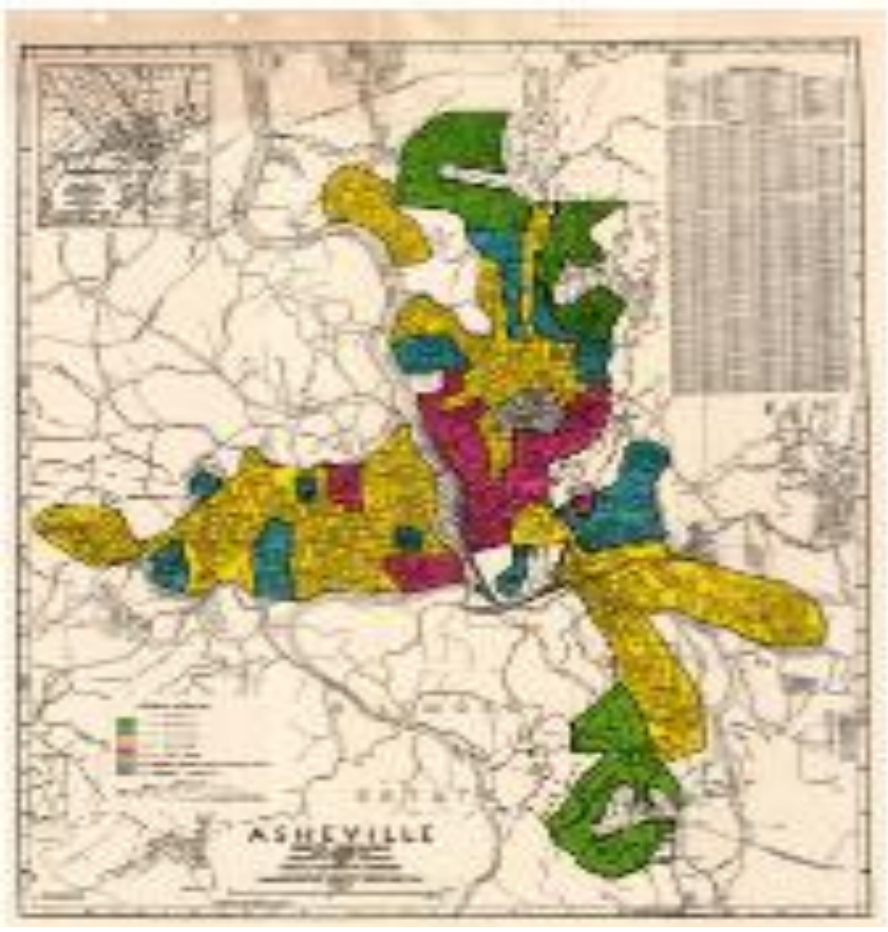
As with the other places, Burton Street was adversely affected by redlining. In 1937, the Home Owners Loan Corporation (HOLC) program (Rothstein, 2017) conducted a survey of the Burton Street Community. They noted that the community was "100 percent negro, common laborers and tannery workers, and negro railroad laborers." The area received a D+ Grade, indicating that it was "hazardous" and not recommended for home and business loan access (HOLC, Burton Street Community,1929) [1] Exhibit 30 provides examples of what homes in the area would have looked like at the time. This exclusion from investment slowed community growth and development throughout the following decades. In the mid-20th century the Burton Street Community was described as having large amounts of undeveloped parcels (Asheville Design Center, 2010). Community stakeholders in Asheville have connected the effects of redlining in the 1930s to community vulnerability to urban renewal in the 1950s and freeway impacts in the 1960s and 1970s (Forbes, 2014).

Exhibit 29: Examples of Burton Street Neighborhood Architecture from 1910s-1920s



Exhibit 30 shows the 1937 HOLC 'Redlining Map' depicting the Burton Street Community, indicated by the D3 label as 'Hazardous.'

Exhibit 30: Redlining Map depicting the Burton Street Community, 1937



In the 1960s, construction of Interstate 240 began along the eastern portion of the Burton Street Community, as shown in Exhibit 31. I-240's location, largely in the valley separating West Asheville from Downtown Asheville, impacted the eastern edge of the Burton Street Community (Burton Street Community Association, 2018). The community lost residential and commercial structures, including the former E.W. Pearson Grocery Store, and reinforced the physical separation created by a valley between the Burton Street Community and the Westwood Place Community (below). The interstate plans did not result in a response by local transportation agencies that incorporated bus services, sidewalks, or other mobility infrastructure to mitigate the negative mobility impacts on community members without access to an automobile.

Exhibit 31: Bisection of Burton Street and Westwood Place Communities by I-240



By the 1970s/1980s, there were cumulative effects of the community's physical isolation due to the community's location, the negative impacts of policies excluding the community from investment (like redlining), as well as the loss of many of the community's founding families who had left or passed away. Drug-related crimes increased in the community. It was not until the mid-2000s, fueled by community activism and funding from the Weed and Seed program, that the community began to recover (Asheville Design Center, 2010). The area began seeing an increase in policing, community center renovations, small home repairs, community cleanups, creation of drug abuse treatment programs, arts education, and afterschool activities.

The Interstate-26 Connector project was proposed in 1989 to reduce traffic congestion, enhance regional commerce, and provide a more efficient gateway into Asheville. During the early 2000s, the project was expanded to include an interchange connecting I-26, I-240, and I-40. This newly expanded project would see interstate expansion into the already burdened Burton Street Community. Local community members, including those from the Burton Street Community, expressed concerns about the impacts of this new interstate development, given the community's existing isolation and the impacts of I-240. From this, the Burton Street Community Plan was written in 2010 (Asheville Design Center, 2010). This plan included recommendations for landscape buffers, compatible land uses, and mobility strategies. A subsequent plan, The Burton Street Neighborhood Plan, included the Burton Street Community Association, the City of Asheville, NCDOT, and other stakeholders (Burton Street Community Association, 2018). The 2018 plan was designed to meet the standards of local policies and was ultimately adopted by the City of Asheville and incorporated into Asheville's Comprehensive Plan. Slow progress of the project, however, led to significant community frustrations, as documented in the case study Story Map.

Over time, NCDOT responded to the frustrations expressed by the community. In 2022, construction began on the $1.2 billion I-26 Connector (NCDOT, 2024), with NCDOT agreeing to the following conditions in the Burton Street Community: fewer property relocations (approximately eight homes), significant noise reduction, reduced floodplain impacts, and fewer land use impacts (USDOT, 2023). NCDOT has also made several Environmental Justice commitments to the Burton Street Community: investing in sidewalks; providing a bridge to Patton Avenue; paving the Community Center parking lot; acquiring land for Asheville to develop a public park with pedestrian paths, transit stops, public art; and enhancing the tree canopy in the area (USDOT, 2023).

KEY TAKEAWAYS

The Burton Street Neighborhood in Asheville, North Carolina offers many insights that could be considered in future transportation decision making.

1. Mitigating the impacts of extended planning processes: The extended planning processes associated with I-26 widening impacted the Burton Street Neighborhood. The extended planning timetable, including a major reset leading to the current approved Environmental Impact Assessment process, did produce a plan that significantly reduced community impacts post-project completion. However, the duration of the planning process caused uncertainty and hindered community stakeholders from development efforts. These included challenges in attracting investment in local homes and businesses, and investments in infrastructure like sidewalks and open spaces. Future planning efforts would benefit from collaboration with other agencies and organizations to identify and respond to community needs that may be delayed due to the impacts of eventual freeway development.

2. Enabling community capacity building: In the final EIS process NCDOT agreed to support a list of significant community benefits. These ranged from sidewalk and neighborhood infrastructure improvements to commissioning an architectural survey to document historic structures. These

were developed relatively late in the process. Future planning efforts could consider opportunities to elicit and respond to community needs prior to transportation plan development.

3. Recognizing cumulative impacts: The Burton Community Plan (2010) and The Burton Street Neighborhood Plan (2018) described the cumulative impacts of the community's isolated location, policies like redlining, and other factors that negatively impacted the area prior to freeway development. The documentation, acknowledgement, and proposed mitigation of these impacts (for example, Environmental Justice Commitments made for the I-26 Connector project) occurred in reaction to community concerns about freeway planning. They also occurred late in the freeway planning process. There is an opportunity to more explicitly address the cumulative impacts on communities earlier in freeway planning processes. Communicating cumulative impacts faced by communities, and working with communities on mitigation strategies earlier in planning processes, could result in increased community trust and collaboration.

North Carolina Case Study Briefs

The in-depth case studies documented through the Story Maps present scenarios in which there is sufficient availability of historic records and data to conduct such analysis. However, the depth of information used to develop these cases is not available for many communities and historic transportation projects in North Carolina. Consequently, the research team also demonstrated how smaller-scale historical impact analysis can be conducted through six case study briefs in addition to the three in-depth case studies. The results of each of these case studies are described in the following sections.

Charlotte: I-77 Impacts on West End Community public health and community cohesion

The West End Community is a historically Black community in Charlotte, North Carolina. In the early 20th century, The West End was "redlined" through the HOLC program and suffered decades of disinvestment. In the 1960s, I-77 was proposed and its preferred route resulted in the destruction and displacement of dozens of homes and businesses. Emissions due to automobile and truck traffic have resulted in poor air quality, leading to high instances and risk of respiratory disease. The West End is in the USDOT Reconnecting Communities pilot program and attempting to repair the harm done by the freeway and its emissions.

Key takeaways include:

- Recognition of how infrastructure decisions can compound existing land use and development decisions that impact current equitable development opportunities - Urban renewal in the 20th century combined with the construction of I-77 resulted in the demolition and displacement of hundreds of local households and businesses. Current EIA and EJ protocols require NCDOT to engage affected communities and document community history. Moving forward, NCDOT should consider how infrastructure can support community-driven equitable development strategies, in this case, how infrastructure improvements can enhance promoting and expanding affordable housing access, ownership, and local business development.

- Opportunity for partnerships to monitor public health impacts of infrastructure - Air quality directly impacts community respiratory health. Increased automobile traffic has contributed to increased toxic emissions. In this case, citizen science and community engagement were essential to providing evidence of poor air quality. Continued monitoring using collected data as a baseline could help determine long-term impacts and inform the development of plans to mitigate impacts.

Additional details about this case are available in a case study brief in Appendix 6.

Durham: NC-55/Alston Avenue widening impacts on housing and local small businesses

The Northeast Central Durham Community is a historically Black community in Durham, North Carolina. In the early 20th century, Northeast Central Durham was "redlined" through the HOLC program and suffered decades of disinvestment. In the 2010s Alston Avenue widening was proposed to improve traffic flow connecting to the Durham Freeway. The proposed widening would have displaced dozens of homes and businesses including a significant non-profit organization and the only local grocery store in a "food desert". Interagency cooperation at the local level included leveraging a local HOPE VI redevelopment project to offset removed housing, rerouting of the widening alignment to preserve the local grocery, and real estate development to enable the non-profit to remain in place. Additionally, acknowledgement and engagement with Spanish-speaking stakeholders was essential to more effective community engagement and feedback on decision making.

Key takeaways include:

- The value of effective community engagement - NCDOT pivoted from the results of an initial EIS that identified multiple environmental justice issues including the loss of multiple homes, businesses, and portions of the Durham Rescue Mission. Part of the pivot was changing community engagement approaches, engaging the local Spanish-speaking Latino community, and working to redesign to preserve Los Primos, the only local grocery store in the community (NOTE: Los Primos still closed due to increased property values and rents that displaced this business). Additionally, NCDOT worked with local property owners to acquire land that was taken from Durham Rescue Mission to enable their expansion plans.

- The value of interagency collaboration - Foremost amongst mitigation efforts was countering the loss of affordable housing caused by highway widening. NCDOT worked in coordination with Durham's Housing Authority to incorporate Hope VI funded redevelopment housing, which increased affordable housing in the community, to offset the loss of affordable housing due to highway widening.

Additional details about this case are available in a case study brief in Appendix 6.

Raleigh: I-40 flooding impacts on the Rochester Heights Community

The Rochester Heights Community is a historically Black community in Raleigh, North Carolina. It is the first post-World War II subdivision built by Black people on Black-owned land in Raleigh. That land is partially located in the floodplain of Walnut Creek. I-40 was proposed in the 1960s and coincided with rapid growth affecting the community. The increase in impervious surfaces, including paving, increased flood risk to the community. Community engagement revealed periodic flooding under I-40 overpasses that blocked community streets and reduced community connectivity. Continuing monitoring and community partnerships can help reveal and address flooding that is below the FEMA (Federal Emergency Management Agency) disaster threshold.

Key takeaways include:

- Community participation and citizen science - NCDOT could engage residents in post-construction monitoring of the effects of highway infrastructure on area flood risks in flood-prone communities. Evidence of recurring nuisance flooding affecting community access that did not reach FEMA disaster thresholds was undocumented before academic research studies.

- Partnerships to enhance green infrastructure and nature-based solutions in disadvantaged/underserved communities - NCDOT could increase partnerships with local agencies and communities to support and enable green infrastructure and nature-based solutions to flood protection and mitigation. In Rochester Heights, the creation of Walnut Creek Park and the Norm and Betty Camp Wetland Education Center both enhanced community resilience but were primarily community-driven and city-funded. No current efforts address nuisance flooding affecting community access and exacerbated by I-40 and the increase in impervious surfaces in the community.

Additional details about this case are available in a case study brief in Appendix 6.

Robeson County: Transportation, land use, and public health impacts

Robeson County is home to several American Indian tribes including the Lumbee; the largest tribe in the eastern United States. Robeson County residents suffer from many social and health vulnerabilities. Robeson County land uses transformed in the late 20th century and became home to an increasing number of Concentrated Animal Feeding Operations (CAFOs) and other industrial uses. These uses have attracted an increasing number of trucks into and out of the community. Citizen science and community engagement with air quality advocates report an increasing number of people living near highways with respiratory diseases that are exacerbated by air pollutants. This phenomenon is not documented in any state or national screening tool. More resources are needed to document this phenomenon and to understand the relationships between transportation, land use, and public health.

Key takeaways include:

- Assessing the impacts of infrastructure on land use changes - Highway construction is in part the result of benefit-cost analysis that rewards its impact on economic development. However, economic development that may compound existing environmental justice issues (truck emissions from travel,

layover, idling, etc.) does not currently have a mechanism to enable the mitigation of negative impacts. Including land use trends more explicitly in benefit-cost analysis could enable transportation decisions that reduce EJ burdens including exposure to air pollution.

- Interagency collaboration to coordinate equitable truck routing and layover locations - NCDOT could assess the locations of noxious uses and work with local communities to document currently undocumented air pollution generators to determine appropriate mitigation and buffer strategies.

Additional details about this case are available in a case study brief in Appendix 6.

Swain County: Impacts of Lakeview Drive East aka "The Road to Nowhere"

Swain County is home to American Indian tribes and other communities that lived from economies based on the resources of the local environment. In the 1940s, the US Department of Interior's Tennessee Valley Authority (TVA) used eminent domain to seize land for the creation of Fontana Dam. This land seizure, later incorporated into The Great Smoky Mountains National Park, resulted in the displacement of hundreds of homes and severed connections to burial grounds and ancestral lands. Lakeview Drive East was proposed as a means to provide access to these dislocated lands but was abandoned mid-development due to environmental constraints. In lieu of completion, the US Department of Interior has instead made cash payments to the State of North Carolina on behalf of Bryson City to further local economic development.

Key takeaways include:

- Building community trust after eminent domain - This was not an NCDOT project. It was a US Department of Interior proposal to connect communities displaced by the Tennessee Valley Authority (TVA) creation of Fontana Dam to their ancestral lands and villages. It is referred to as a "broken promise" due to its lack of complete implementation resulting in a cash payment held by the State of North Carolina on behalf of Bryson City. Rules affecting eminent domain have changed since the 1940s. But the significance of implementing mitigation to support community cohesion remains.

Additional details about this case are available in a case study brief in Appendix 6.

Wilmington: Wilmington Bypass/I-140 impacts on Rock Hill community cohesion

The Rock Hill Community was a historically Black community formed in the late 19th century on former plantation land near Wilmington, North Carolina. Residents currently face high levels of social and health vulnerability. In the 1990s, a highway bypass was proposed north of Wilmington. The initial preferred route was proposed to cut through the Wrightsboro community. However, political resistance which leveraged personal connections between local officials and the Governor's office blocked that route in favor of a route that would bisect the Rock Hill community as well as require higher environmental impacts. The process did not have formal structures to incentivize community engagement as well as document qualitative factors such as community values. I-140 resulted in the removal of dozens of structures and the displacement of dozens of residents. Also, the protection of a significant church, the

establishment of local historical markers, and the implementation of sound walls were indicative of ad hoc technical consultant initiatives and not policy mandates.

Key takeaways include:

- The need for equity in the route selection process - Low-income, Black, and Latino residents are disproportionately impacted by the preferred and selected alternative. Initially, the preferred alternative was through Wrightsboro. However, political power imbalances between Wrightsboro and Rock Hill, as well as Wrightsboro residents' influence on decision making favored the protection of wealthier communities and the selection of Rock Hill for freeway construction.

- The need for replicable qualitative data methods that can influence decision making - At the time there were not established best practices in documenting community values, particularly the value of Rock Hill AME Church (did not meet integrity standards for State Historic Preservation Office protection). Innovative community engagement efforts, including the development of memorial signage and a garden helped establish trust and provide a precedent for future community engagement efforts.

- The agency and effectiveness of technical experts in mitigating freeway impacts on communities - From the protection and interpretation of Rock Hill AME Church to the implementation of sound walls, the mitigation of freeway impacts was due to the impacts of effective technical experts who engaged with the local community. Since this project, some of their approaches have been encoded into policy (i.e. The FHWA Purple Book, etc.). However, the empowerment, effective evaluation, and communication of the effectiveness of these approaches can be more broadly included in upstream project identification, planning, and monitoring.

Case Study Limitations

The case studies (in depth and briefs) revealed many examples of community impacts across the many regions and types of neighborhoods across North Carolina. However, the research revealed gaps in data and methods. There were limitations to this study. Below are opportunities for future research.

1. Improve access to NCDOT project documentation: Some of the case studies featured projects that occurred before NEPA (National Environmental Policy Act) and the enforcement of Title VI of the Civil Rights Act. In those cases, research methods included archival research, informal semi-structured interviews, and reviews of local media. However, in some of the post-1971 cases, there were no available NCDOT records. There is an opportunity to develop an accessible archive of project reports in the future. This may be most important in under-resourced and rural communities that lack the capacity to have their own archives.

2. Develop pre-project environmental data: Demographic data comparing pre and post-project development was generally available for all case studies. However, environmental data was limited to

projects with EIS and other specific studies. This made comparisons of pre and post environmental impacts reliant on screening tools and assumptions based on models of air quality, water quality, urban heat islands, and other impacts. In the future, consistent use of EIS and other methods to establish baseline assessment of environmental factors that contribute to environmental justice issues could be implemented. As with several case studies presented, these may also engage local communities in citizen science practices that can build trust.

3. Develop pre-project human health data: Public health data was not equally available for all case studies. In some cases, county health assessments were referenced. But generally, inferences were made about current public health issues in case study communities based on existing screening tools. Data correlating environmental impacts on public health is central to addressing environmental justice. There is an opportunity to use Health Impact Assessment (HIA) methods and work collaboratively with others to supplement the lack of public health information in future projects. Baselining community health prior to project development and committing resources to monitoring health impacts is a way to build evidence of best practices and correct practices that are not producing healthy outcomes.

4. Model real estate impacts of infrastructure projects: The case studies presented a range of private property impacts due to policies including transportation decisions. In some cases, lower property values due to policies like redlining and urban renewal depressed private property values and that process contributed to the perception of affected communities as slums and of low value. In other cases, broader community growth trends disadvantaged local communities in their ability to access development capital and advantaged non-local investments fueling gentrification and displacement after transportation projects were completed. In future research developing models to simulate the potential economic impacts of transportation projects on their affected communities can help stakeholders understand the costs and benefits of different proposals. This economic modeling could include community values as well (retention of social networks, retention of institutions, etc.).

5. Commit to establishing community trust: The initial proposal for this research anticipated community stakeholder involvement throughout the process. However, after initial meetings, it became clear that there was reticence on the part of the community stakeholders to fully engage in the process due to a history of distrust with NCDOT and other government actions. In the case of Hayti in Durham, North Carolina, community stakeholders were not willing to fully commit due to a recently failed community-led redevelopment effort partially addressing the harm done by the Durham Freeway (Hayti Reborn). In Princeville, North Carolina, a recent US Army Corps of Engineers decision not to improve the levee soured their participation in the study. In the case of the Burton Street Neighborhood in Asheville, North Carolina, a legacy of uncompensated community engagement and some dissatisfaction with the community outcomes of the I-26 project dissuaded participation. In future work, there are opportunities to rebuild community trust through investment in more enhanced community engagement techniques. These may include community engagement in advance of projects instead of after projects have been developed, an emphasis on documentation and

communication of project impacts, interagency collaboration to address community issues not directly in NCDOT purview, and compensation for community stakeholder involvement.

National Case Studies: Reparative Justice

In addition to examining cases in which past transportation decisions may have negatively impacted communities, the research team investigated cases across the country where efforts are underway to address negative impacts experienced by communities. These activities, called "reparative justice" efforts, are increasingly occurring in the United States as government agencies, grassroots organizations, and other groups have identified opportunities to mitigate past harms. Leveraging online research and NCDOT expertise, the research team inventoried 15 reparative justice efforts ranging from the removal of past highway projects that harmed communities to more comprehensive community governance and development initiatives.

At the level of effective community-engaged governance, the Just Communities Protocol offers an approach to co-creating equity goals with communities. The protocol, developed by Partnership for Southern Equity and EcoDistricts, frames future policies in the context of racial equity and builds coalitions of stakeholders to assess current conditions, evaluate alternatives, and measure the outcomes of projects and the community scale. Referencing examples from across the United States, the protocol can offer insight on how to develop similar approaches to repairing the harm done by transportation planning before projects are proposed. South Carolina's Racial Equity Assessment and Twin Cities Racial Equity in Transportation Planning offer similar tools and methods.

With regards to continuity from community capacity building through project implementation, the 11th Street Bridge Park Equitable Development Plan offers insights into the timeline and level of engagement required for authentic community buy-in in a large infrastructure project. The 11th Street Bridge, connecting southwest Washington DC and southeast Washington DC (Anacostia) was decommissioned and a design competition proposed its reuse as a park. Community stakeholders knew that a development of this scale would increase adjacent property values and potentially displace existing residents. They developed a non-profit organization that authored an equitable development plan. The plan began 10 years before project development; that timeline was essential to building community capacity to build wealth and systems to resist displacement. The plan set goals for community growth in homeownership, workforce development, small business enterprise creation, and arts and culture all enabled by park development. The plan is monitored by an independent entity. Considering and enabling the many secondary benefits that transportation projects could provide to their communities is aligned with national best practices. Reconnecting Claibourne (a USDOT Reconnecting Communities pilot study) offers similar lessons.

Exhibit 32 presents a summary of these findings, including the specific types of reparative actions included in each effort. Note that this table is based on information that was publicly available at the time of the research team's investigation and it may not be exhaustive.

Exhibit 32: Reparative Justice Cases and Research Across the U.S.

		Reparative Actions						
Effort Name	**Location**	*Environmental Justice (key considerations clearly included)*	*Health (analyzed and considered in planning)*	*Governance/ Decision Making (oversight by impacted community)*	*Wealth Creation (plan includes)*	*Planning (clearly informed by meaningful community engagement)*	*Monitoring (accountability plan for future in place)*	*Government (support like grants, tax incentives, etc.)*
Metro Atlanta Racial Equity Atlas	Atlanta, Georgia	☐	☑	☐	☐	☑	☐	☑
Redline Planning	Baltimore, Maryland	☐	☑	☐	☑	☑	☐	☐
Silverline and Nubian Square Planning	Boston, Massachusetts	☑	☑	☐	☑	☑	☐	☐
Southern Gateway Park	Dallas, Texas	☐	☑	☐	☑	☑	☐	☑
I-375	Detroit, Michigan	☑	☑	☐	☐	☑	☐	☑
Twin Cities Racial Equity in Transportation Planning	Minneapolis & St. Paul, Minnesota	☐	☑	☑	☐	☑	☑	☐
Reconnecting Claibourne	New Orleans, Louisiana	☑	☑	☑	☑	☑	☐	☑
Fruitvale Station and Unity Village	Oakland, California	☑	☑	☐	☑	☑	☐	☐
I-579 cap	Pittsburgh, Pennsylvania	☐	☑	☐	☑	☐	☐	☑
West Savannah R/UDAT	Savannah, Georgia	☑	☑	☐	☑	☑	☐	☑
Seattle DOT Transportation Equity	Seattle, Washington	☐	☑	☐	☑	☑	☐	☐
Racial Equity Impact Assessment Guide	South Carolina	☑	☑	☑	☑	☑	☑	☑
Reconnecting Rondo	St. Paul, Minnesota	☑	☑	☑	☑	☐	☐	☑
EcoDistricts (Just Communities) Protocol	Various	☑	☑	☑	☑	☑	☑	☐
11th Street Bridge Park Equitable Dev. Plan	Washington, DC	☑	☐	☐	☑	☑	☐	☐

Implementation Opportunities

Drawing from the comprehensive literature review, state of the practice assessment, data survey, and case studies conducted in the previous tasks, an implementation framework NCDOT can use to better identify and address transportation inequity was developed. The research team worked with key NCDOT stakeholders to develop the framework in a manner that is most useful to the department. This framework incorporates findings from current NCDOT research projects to develop a methodology that provides a consistent synergy with the Department's ongoing efforts. This framework may be extended to future research or implementation efforts to support the integration of the recommended methods into different NCDOT processes. For example, the framework may also be implemented to incorporate the data and best practices outlined in the Comprehensive Transportation Plans (CTP) and Strategic Transportation Prioritization (SPOT) processes. The framework, and the results of this project in general, could also be used as a steppingstone for creating similar transportation inequity measurements for the other NCDOT modal divisions beyond the Division of Highways.

While the focus of this review was on highway impacts, the research team also captured relevant literature relating to other modes of transportation. The insight gained through the literature and the SOP review was synthesized into an implementation-focused best practice matrix. In addition to capturing sixteen national best practices in the matrix, the research team interviewed stakeholders across NCDOT involved in transportation investment decision making processes with the goal of identifying where and how these practices are currently being implemented at NCDOT. This information was documented and opportunities to enhance existing practices or to develop processes to capture cutting-edge and emerging new best practices were documented in the implementation framework.

The results and opportunities for implementing lessons learned and best practices from these efforts are presented here. Specifically, a focus on lessons learned from the case studies, the value of framing transportation infrastructure decisions through an equity lens and, an implementation framework highlighting opportunities to implement emerging best practices into the existing NCDOT process.

Case Study Applications

The case study research provided insight on the past, present, and potential future of NCDOT decision making. The following are some of the key takeaways.

Acknowledge that current and future projects operate in a historical context and can compound current inequities. Many of the case studies focus on communities that faced previous inequitable and unjust policy decisions ranging from residential segregation to disinvestment in the form of "redlining". The intention of *Executive Order 12898*- the first Federal policy requiring Environmental Justice analysis in decisions covered by NEPA, was to demonstrate that new uses would not compound existing burdens faced by communities of color. That process requires recognition of existing burdens prior to NCDOT actions. The case studies reflect an unevenness in how burdens have been acknowledged and documented. Developing policies to standardize and monitor how NCDOT will define and document pre-project burdens, especially in the context of Justice40 and ETC Explorer, is necessary to more effectively address the potential for disproportionate negative impacts on already burdened communities.

Enable and resource interdisciplinary and interagency collaboration. Some of the case studies feature the actions of key actors who were able to facilitate interdisciplinary and interagency collaboration, particularly with local agencies. Some of the most impactful actions associated with highway siting are their impacts on existing housing and local businesses. Working collaboratively and proactively with local stakeholders and decision-makers made a positive impact and effectively mitigated impacts in some cases. Working collaboratively, especially in the context of housing, economic development, and public health can reduce the need for NCDOT to develop that capacity internally and instead gain expertise in interdisciplinary deliberations.

Effective community partnerships, engagement, transparency, and accountability are essential to establishing community trust. Many case studies describe how trust between NCDOT and the communities receiving their projects and decisions had been eroded in several ways. Some communities began their engagement in resistance to NCDOT proposals and were subsequently frustrated by processes and procedures that did not acknowledge and respond to their concerns. Some communities

communicated key values that were not accounted for in standard methods and felt excluded from key decisions. Some communities were frustrated with the time frame and complexity of decision-making processes which put their neighborhoods in a sense of suspended animation with regards to economic development and stability. As reinforced by Justice40 initiatives and FHWA updates to Community Impact Assessment procedures, there should be more focus, resources, and accountability incorporated into community engagement procedures.

Embedding equity measures in "upstream" policies and procedures could build more sustainable and effective equity outcomes in "downstream" projects. Currently, there are no equity policies embedded in the MPO project nomination process, or the Integrated Project Delivery (IPD) project management guide. Equity training occurs in an ad hoc manner and lacks monitoring for its effectiveness. Equitable responses, at least in the case studies reviewed, reflect a pattern of a reactionary approach to equity that varies with the expertise and opportunities presented after a project has begun. Since the completion of the projects reviewed, there have been many innovations in embedding equity in policy decision making in corollary departments, disciplines, and agencies. NCDOT has an opportunity to learn from others and begin incorporating equity as an essential goal and outcome of project work.

In addition, Appendix 8 includes a presentation the research team developed that outlines some of the key results of the three case studies for which Story Maps were developed, as well as some related lessons learned.

Inequity Lenses

While all transportation projects have the potential to result in both benefits and burdens, the equity of how and where these occur across time is the focus of this project. Consequently, what inequity looks like is key to mitigating and preventing inequitable transportation decisions, particularly in underserved and vulnerable communities that are already overburdened.

Although the literature on defining "inequity" for this purpose is limited, there are frameworks that help define "equity." One of these is a set of thematic lenses developed by the Urban Sustainability Directors Network (USDN). These lenses are described by USDN (2014) as follows:

- **Distributional Equity**, or when programs and policies result in fair distribution of benefits and burdens across all segments of a community, prioritizing those with the highest need.
- **Transgenerational Equity**, or when decisions consider generational impacts and don't result in unfair burdens on future generations. This is also known as Restorative Equity.
- **Procedural Equity**, defined as inclusive, accessible, authentic engagement and representation in processes to develop or implement programs or policies.
- **Structural Equity**, or when decision-makers institutionalize accountability; decisions are made with a recognition of the historical, cultural, and institutional dynamics and structures that have routinely advantaged privileged groups in society and resulted in chronic, cumulative disadvantage for subordinated groups.

These four lenses can also be applied to define inequity, or the absence of these elements of equity, looks like. Exhibit 33 demonstrates the application of these "inequity lenses using examples from the

aforementioned stakeholder engagement. Note that these lenses are not mutually exclusive, as shown in these examples.

Exhibit 33: Inequity Lens with Examples from Stakeholder Engagement

Inequity Lens	Distributional	Transgenerational	Procedural	Structural
Example from Stakeholder Discussions	Initiation of highways projects that negatively impact the wellbeing of underserved communities instead of responding to their needs.	Impact of heir property rights on notification and awareness of transportation decision-making by rural property owners.	Lack of meaningful, impactful, and compensated community engagement in ongoing freeway development in participant's county.	Feeling that their participation in the process did not result in community benefits due to lack of consideration of community-voiced issues and absence of meaningful inclusion of community interests in final planning decisions.

NCDOT can apply similar lenses across the transportation decision-making process. For example, these lenses could be used to understand community experiences and needs during engagement activities or as part of community impact assessments. Similarly, these lenses could be considered when determining the type of data that needs to be collected and analyzed to assess the potential immediate and long-term impacts of transportation projects.

Implementation Framework

As part of the State of the Practice (SOP) review, the research team conducted a comprehensive review of the literature and best practices for equity data, environmental justice (EJ) screening tools, and equity interventions in the transportation decision-making and investment process. While the focus of this review was on highway impacts, the research team also captured relevant literature relating to other modes of transportation.

The insight gained through the literature and the SOP review was synthesized into an implementation-focused best practice matrix. Presented earlier in this report, the matrix captures and builds upon emerging equity practices and recommended best practices being implemented by transportation agencies across the country. This includes emerging federal initiatives that may inform the next generation of federal guidance and policies.

In addition to capturing sixteen national best practices in the matrix, the research team interviewed stakeholders across NCDOT involved in transportation investment decision making processes with the goal of identifying where and how these practices are currently being implemented at NCDOT. This information was documented and opportunities to enhance existing practices or to develop processes to

capture cutting-edge and emerging new best practices were documented. The result is a framework NCDOT can use to enhance their current processes and practices to further align with the approaches outlined in the best practice matrix.

NCDOT's Current Processes and Practices

To identify NCDOT's current processes and practices, leaders from the Transportation Planning Division, Public Involvement and Community Studies, the Office of Civil Rights, the Integrated Mobility Division, and the Project Management Unit were interviewed. Currently, NCDOT captures elements of most of the national best practices identified in the research at some point in the transportation decision-making process. In this context, "transportation decision-making and investment process" includes activities from long-range planning to project delivery. Based on the SOP review conducted through this project, NCDOT is among the leading wave of state transportation agencies that are working to build capacity and explore implementation options by developing equity plans, screening tools, and researching implementation strategies.

Although NCDOT is a leader in some practice areas, the agency has opportunities to integrate emerging best practices to remain a national leader. Additionally, while elements and aspects of the best practices are captured in the NCDOT transportation decision-making process, there are opportunities to enhance or improve upon some of these practices further to better serve North Carolinians, especially those in underserved and vulnerable communities.

Exhibit 34 highlights how elements of these best practices identified through the state of the practice review of this study are currently incorporated into the NCDOT transportation decision-making and investment process. The subsequent report sections capture the best practices that are currently included in the NCDOT process as well as opportunities to enhance these practices and/or adopt emerging best practices that the agency does not currently incorporate.

Exhibit 34: National Best Practice from the State of the Practice Review

National Best Practice	NCDOT Practices and Processes
Develop Comprehensive Screening Tools	NC Planning Geodatabase in Comprehensive Transportation Plan (CTP) Process American Community Survey (ACS) Demographic Data in Community Studies Process Atlas Community Screening Data Layers Forthcoming AI Tool to capture overburdened and underserved communities
Public Participation and Field Verification	Comprehensive Transportation Plan (CTP) maps are reviewed, and field verified by local planners and community-based CTP Steering Committee. Mapped Environmental Justice data is included in the CTP Public Participation Plan (PPP) Interagency Protocol requires circulating CTP mapping and documentation to state and federal partners at a minimum of two points in the process to solicit feedback. Demographic data is field verified in the Community Studies and Public Involvement processes. Project level community studies include Community Characteristics Report (CCR) and Community Impact Assessment (CIA).
Improve Community Social and Health Impact Assessments	Community Understanding Reports (CUR) capture EJ, Title VI; and local community information during the Comprehensive Transportation Plan (CTP). Health Impact Assessments (HIA) can be accepted by NCDOT as a local plan to incorporate during community studies and NEPA/SEPA environmental documentation process.

Develop Data for Household Transportation Cost and Travel Time Cost	Travel time impacts associated with project related construction detours are considered in community studies. Research project is underway to develop a tool to measure travel times associated with individual projects.
Re-Connect Communities	Previously disconnected communities are discovered on a case-by-case basis through the Comprehensive Transportation Plan (CTP), community studies and the NEPA/SEPA process.
Prepare and Apply for Future Federal Funding for Disadvantaged Communities	Support is provided to community, local and planning organization partners with federal grant applications. These discretionary federal grants are often designed for local and regional organizations to be the awardee (as opposed to state transportation agencies).
Provide Job and Training Opportunities for Impacted Communities	Disadvantaged Business Enterprises (DBE) target goals and requirements are included in the bid process and project contracts. Those targets are for all projects and not specific to disproportionately impacted communities. There are three workforce development focuses: (1) On-the-Job Training; (2) Human Resources support (3) HBCU Outreach.
Maximize Workforce Development and Disadvantaged Business Enterprise (DBE) Funds	There is a Disadvantaged Business Enterprises (DBE) program that oversees DBE processes. DBE targets are included in bid processes and project contracts.

Community Engagement Plan with Virtual and In-Person Meetings	Comprehensive Transportation Plans (CTP) use data and mapping from the Community Understanding Report (CUR) to develop community specific Public Involvement Plans (PIP). Community studies include extensive public involvement and community engagement. Public Involvement team provides community engagement support and expertise throughout NCDOT projects and processes. Public involvement efforts include both virtual and in-person engagement. A Statewide Public Involvement Process and Practitioner Guide supports the public involvement process (including the Resident's Guide to Transportation Decision Making and the Elected Official's Guide to Transportation). NCHRP pilot program to automate public involvement performance measures is being developed with NCDOT.
Mobile Source Air Emissions Reduction	Air Quality Conformity compliance for MPOs is administered through NCDOT
Zero Emission Vehicles to Improve Air Quality	The state's National Electric Vehicle Infrastructure (NEVI) Plan addresses electric vehicle charging infrastructure along alternative fuel corridors (Phase I) and community level charging infrastructure (Phase II). The NC Clean Transportation Plan also addresses ZEV efforts to improve air quality.
Storm Water Infrastructure Improvements	Storm water impacts are being considered in resilience studies and a pilot mapping study is underway. Transportation routes of concern are being screened in resiliency studies. Supporting Gold Leaf funding to make community storm water improvements NEPA/SEPA studies examine storm water and flooding impacts
Increase Bicycle and Pedestrian Connectivity	Complete Streets Process and Transportation Disadvantaged Index (TDI)
Implement Traffic Calming and Roadway Design Measures	Complete Streets Process and Transportation Disadvantaged Index (TDI)

Incorporating Best Practices into the Decision Making Process

All organizations and agencies must occasionally revisit and update their policies and practices. Existing practices can be updated and enhanced by developing process improvements that more closely align with benchmarked best practices. There is also the opportunity to implement new and emerging practices into an organization's process. As with any emerging practices, the approach to process implementation will need to be tailored to meeting the needs and regulatory context of each transportation agency that adopts the new practices.

NCDOT has the opportunity to develop both process improvements and implement emerging best practices. Based on the national best practices and the NCDOT stakeholder interviews, the following opportunities for both process improvements and implementing emerging practices are presented.

Opportunities for Current NCDOT Process Improvements

Key opportunities for current NCDOT process improvements include:

1. Enhanced communication and process clarity among units
2. Systematic processes in place of case-by-case analysis
3. Dedicated funding and a primary screening tool

Large public agencies like NCDOT face challenges to maintaining clear, consistent understanding of agency-wide processes across departments, divisions, units, and disciplines. The task becomes increasingly more difficult for public agencies that value process improvements and work to consistently enhance policies and processes. This is especially true for public agencies with leadership that can be shifted due to political appointments and other restructuring activities.

During the course of the stakeholder interviews, the research team noted some instances where there seemed to be a reoccurring need for additional process clarity. At times there were gaps in communication and shared understanding across units. Divisions and units had a great depth of knowledge about what was occurring in their unit. However, unsurprising in a large organization, there were also occasions where there was some misunderstanding about: (1) processes that were occurring in other units, (2) where certain screening processes and tools were situated in the Department's larger overall process, and (3) potential changes and process improvements being made in other units.

The point of confusion most often identified in the interviews was the lack of clarity around where Integrated Mobility Division (IMD) initiatives fit within the larger NCDOT process. Both the Transportation Disadvantaged Index (TDI) and the Complete Streets Policy were cited often by stakeholders when discussing screening tools and integrating multimodal infrastructure (such as bicycle and pedestrian infrastructure). While IMD provided clarity about how they implement these two processes, some stakeholders were unclear about exactly where in the process these touchpoints are embedded. Overall, stakeholders seemed to understand the Complete Streets policy and TDI screening

tool but tended to be unclear about where these 'live' in NCDOT's process and what projects are screened using the TDI tool.

This could be because the TDI or another tool has not been identified as the primary screening tool that is used across NCDOT to capture impacts to disadvantaged communities for all modes of transportation projects. Instead, different NCDOT units and processes use different tools as the primary source of information for transportation and investment decisions related to environmental justice and community impacts. Other tools and data sources similar to the TDI that are used by NCDOT include the NC Planning Geodatabase, the American Community Survey (ACS), and additional ATLAS GIS layers Ideally, NCDOT would designate one primary screening tool that could be used in context with other information. It is important to note that the primary screening tool would serve as a common starting point for EJ and disadvantaged community screenings but would not replace the need for additional analysis, field verification, and public involvement throughout the project planning and development process.

Assessments of current and historical inequities, specifically environmental burden and social vulnerability, are central to understanding how transportation policies and investments may affect communities. Screening tools can aid transportation agencies with the assessment of transportation project impacts by helping to identify projects that may have adverse impacts given their location relative to burdened communities. In addition to state transportation agencies, MPOs may use screening tools to identify communities of concern within project boundaries to ensure project compliance with EJ requirements tied to federal funding.

As a part of North Carolina Executive Order 292, the North Carolina Department of Environmental Quality (NCDEQ) is working with the North Carolina Department of Information Technology (NCDIT) to develop an EJScreening tool for use by all state agencies. The benefits to NCDOT of a singular screening tool include:

1. Providing process clarity
2. Establishing a tool to conduct a systemic review process at the start of the planning process
3. A consistent EJ touch point for all units at NCDOT

Currently, the NCDOT process relies on several EJ and disadvantaged community screening tools that are focused on their stage of the planning process (such as Comprehensive Transportation Plans (CTP), Community Impact Assessments (CIA), and NEPA/SEPA documents). Additionally, past transportation impacts on EJ communities are identified on a case-by-case basis in the NCDOT process. Historically, analysis that involved identifying EJ and disadvantaged communities (including communities that have been disconnected due to previous iterations of transportation infrastructure development), was a very time and labor-intensive process tailored to specific processes and planning outputs. However, the recent innovation in big data screening tools that focus on EJ and disadvantaged communities at the national and state scale have become more prevalent.

Federal, state, and local agencies have developed a variety of methods for identifying and comparing communities that have been disproportionally impacted by transportation policies and investments or that may be particularly vulnerable to the negative effects of future policies and investments. Recently, some

states have developed a state-wide EJScreening tool that is used across multiple state agencies to create a singular, statewide screening tool. One example is the CalEnvroScreen 4.0 tool in California, which includes the state's definitive, primary EJ and disadvantaged community assessment screening.

NCDEQ and NCDIT is currently developing a screening tool that serves as the singular EJ and disadvantaged communities screening standard for all North Carolina state agencies, similar to California's CalEnviroScreen. Incorporating the forthcoming North Carolina EJScreening tool into the existing NCDOT long-range planning process could serve as a primary EJScreening assessment for NCDOT planning processes.

It is important to affirm that, despite having a primary EJScreening tool, other EJ and community assessments will still need to occur. The primary screening tool would serve as a starting point for transportation planning and project development but would not absolve the agency of the need to conduct further community studies. Field verification would still need to happen during long-range transportation planning efforts such as CTPs. Community studies, public involvement processes, and EJ considerations within the NEPA/SEPA process would still need to be conducted in the project development process.

Beyond the process improvement of utilizing a primary EJScreening tool, NCDOT could also consider utilizing EJ community designation as an eligibility list for specific dedicated funding targeting EJ and disadvantaged communities. EJScreening results are currently used by NCDOT as part of the alternative criteria for funding outside the Strategic Transportation Investment (STI) process, such as CMAQ and Carbon Reduction funding. NCDOT includes EJScreening processes and TDI assessments as project criteria. MPOs also use EJScreening tools are part of their project identification and selection process for these funds.

Another opportunity for North Carolina is to implement the emerging best practices of setting aside dedicated funding to EJ communities that are identified through a common screening tool. Some states now link EJ and disadvantaged community screening tools directly to state agency funding to determine eligibility for community and transportation infrastructure funding. Rather than exclusively using transportation funds, some states utilize other sources of state funding to support transportation projects in identified EJ and disadvantaged communities. For example, New York and California use greenhouse gas reduction Cap-and-Trade funds to fund clean transportation projects. In those states, twenty-five percent of that funding is required to be used in EJ communities identified in the state-based screening tool. North Carolina does not have a Cap-and-Trade fund but could utilize other funding sources to develop a portion of dedicated statewide funding to further invest in EJ and disadvantaged communities impacted by transportation projects.

The USDOT Equity Action Plan (2022) proposes new federal discretionary grants for disadvantaged communities in urban and rural areas that have not been able to obtain funding grants in the past, noting that targeted competitive, discretionary funds for disadvantaged communities can be an important tool to address transportation equity. NCDOT pursues EJ associated USDOT discretionary grants and supports local and regional partners in applying for federal discretionary grants. Many of the recent federal discretionary grants that NCDOT has applied for are supporting infrastructure for EJ and disadvantaged communities. Another means of leveraging federal funding is to combine EJ mitigation funds, distributed

to EJ communities determined to be impacted during the NEPA processes, with other funding such as brownfield and flood prevention funds to take an interagency approach to community betterment associated with transportation projects.

Additional information about linking screening tools with dedicated funding opportunities is provided in Exhibit 35.

Exhibit 35: Best Practice - Link Screening Tools Designation with Funding Opportunities

Emerging Best Practice	Description	Implementation	Anticipated Outcome	Example
Link Screening Tools Designation with Funding Opportunities	Dedicate specific funding for transportation improvement projects in disadvantaged communities as identified by set criteria and a data-driven EJScreening tool.	Develop an EJScreening tool and set of criteria for communities being identified as disadvantaged. Identify a funding source and allocate funding to transportation improvement projects that directly benefit disadvantaged communities. Create some eligibility flexibility to fund not only new projects but also to mitigate existing burdens created by previous transportation infrastructure projects (such as impacts to environmental health, flooding, community cohesion and disconnected bicycle and pedestrian networks).	Develop a consistent funding mechanism to ensure that EJ and disadvantaged communities identified in the screening process can have dedicated funding for investing projects that mitigate and correct	California's SB 535 Communities that are identified by the CalEnviroScreen process. New York State's definition for disadvantaged communities within the domain of its 2019 Climate Act ensures that the Act's funding directly benefits historically underserved and vulnerable communities. The Colorado EnviroScreen tool, modeled on CalEnviroScreen, is intended to assist in the targeting of grants related to environmental justice.

Opportunities to Incorporate Emerging Best Practices

During the aforementioned state of practice review, the research team identified emerging community assessment and public engagement practices that are being recognized as national best practices. These emerging practices are reflected in updated federal guidance and process improvement documentation developed to encourage broader dissemination of these practices across the country. Some of these documents and practices are so recent they were released during the course of this project (see *USDOT Equity Action Plan*, 2022 and 2023, and *Promising Practices for Meaningful Public Involvement in Transportation Decision-Making*, 2023).

Between the state of practice and stakeholder interviews, two emerging practices were identified as potential practices that could be incorporated into the NCDOT transportation infrastructure planning, development, and decision-making process:

1. Implementing a comprehensive, cumulative, and consistent health impact assessment into the planning process, and
2. Treating community stakeholders as full partners including considering providing compensation for participation by overburdened and underserved communities.

The research team captured how these best practices are being implemented in other states, the context of related implementation, and how these practices may feasibly be incorporated into the current NCDOT transportation decision-making process. Below is a brief snapshot of opportunities that NCDOT could integrate to support the implementation of these emerging practices.

Health Impact Assessments

During stakeholder interviews, the implementation of comprehensive health impact assessments (HIAs) was often discussed as the clearest opportunity to incorporate new and emerging best practices into future NCDOT processes. Exhibit 36 summarizes details about this best practice, implementation opportunities, and potential outcomes.

Exhibit 36: Best Practice - Improve Community Social and Health Impact Assessments

Emerging Best Practice	Description	Implementation	Anticipated Outcome	Example
Improve Community Social and Health Impact Assessments	Establish a robust and consistently applied community social and health impact assessment in the transportation decision-making process that focuses on cumulative impacts on community social well-being, mental and physical health and quality of life	Utilize and consistently apply Social Impact Assessments (SIA) and Health Impact Assessments (HIA) as part of NEPA/SEPA environmental review processes and long-range multimodal transportation plans.	Improve physical, mental and community health by designing health-focused transportation investment	New EPA Cumulative Impact Assessments (CuIA)
		Use EPA Cumulative Impact Assessment recommendations to support in capturing the breadth of impacts and community well-being outcomes		
		Encourage Metropolitan Planning Organizations (MPO) and Rural Planning Organizations (RPO) to utilize similar assessment tools in establishing local plans, developing projects and project prioritization processes.		

Currently, NCDOT accepts existing, locally produced HIAs as a plan that is documented and considered through all of the agency's planning efforts. In this case, the documents are produced by a local government or planning organization and NCDOT is made aware of the local plan so it can be included in the NCDOT CTPs. The projects are also assessed for consistency in the Community Impact Assessment (CIA). Examples areas in which HIAs may be documented are Community Understanding Reports (CURs) and Comprehensive Transportation Plans (CTPs).

There is an opportunity for NCDOT to strengthen its understanding of community health needs and hazards in transportation project areas by developing a consistent HIA approach. Doing so can help NCDOT better capture and evaluate transportation infrastructure impacts on community and

environmental health throughout the decision-making process. Beyond the traditional environmental health indicators of air and water quality, the emerging practice is to capture impacts to physical health, mental health, quality of life, and community cohesion. Examples of impacts that could be captured include: active transportation opportunities; community connectivity and cohesion; urban heat island effects and associated mental health stressors. These types of assessments can also help evaluate the psychological, mental, and emotional effects on community members in disadvantaged communities that have historically been impacted by infrastructure projects disconnecting their community and the socioeconomic effects of community disruption.

The increased importance of capturing social impacts and health impacts has led practitioners and researchers to recommend incorporating more robust and consistently applied Social Impact Assessments (SIAs) and Health Impact Assessments (HIA). Advocates recommend embedding social and health assessments into transportation long-range planning in an effort to account for community health and well-being. This would require a consistent application with agency guidance with the expectation that the assessment be done in a thorough manner and that findings would inform the final project plans and designs. The US Environmental Protection Agency (US EPA) recently released a report that recommends working with agency partners to strengthen the EPA Cumulative Impact Assessment (CuIA) to incorporate both the legacy impacts of previous actions and proposed actions on the built, natural and social environment. The goal is to assess cumulative impacts on community health, well-being and quality of life (see *Cumulative Impacts Research Recommendations for EPA's Office of Research and Development*, 2022).

Implementation of an HIA process can be structured to be scalable and can vary in approach from NCDOT supporting external partners to NCDOT leading the HIA process. Two potential approaches to implementing consistent and comprehensive health, social, and community impact assessments are presented below as options for consideration.

The first potential option for implementing consistent and comprehensive community health impact assessments would be for NCDOT to develop HIA planning guidance and encourage local planning agencies to consider conducting their own assessments using the NCDOT guidance. While NCDOT could support the effort, this approach would be led locally by planning agencies wanting to establish a voluntary HIA plan for transportation infrastructure. To leverage existing planning efforts, this HIA process could run concurrently with existing Comprehensive Transportation Plans. NCDOT could also consider encouraging HIA development by local and regional transportation planning agencies by offering HIA planning specific funding.

Another approach for NCDOT is to lead the HIA process by conducting comprehensive HIA studies within the current NCDOT long-range transportation planning process. Plans such as CTPs could include an HIA element that looks at the comprehensive impacts of proposed transportation improvements on the physical health, mental health, and quality of life elements. The guidance for these planning elements could draw from the EPA Cumulative Impact Assessment recommendations.

Partnering with Community Stakeholders

Treating community stakeholders like full partners, including compensating key community partners for their time, is another emerging practice that can be particularly valuable for public involvement activities. NCDOT representatives interviewed said the implementation of this practice can be hindered by the lack of clarity in Federal Highway Administration (FHWA) guidance. Specifically, stakeholders noted that a major barrier to community compensation has historically been the lack of clear and consistent guidance from FHWA about using federal funding for this purpose.

Since the time of the stakeholder interviews, the USDOT has released materials that indicate community compensation is eligible for federal funding. The update to the *US Equity Action Plan* (dated September 2023 and released in February 2024) and *Promising Practices for Meaningful Public Involvement in Transportation Decision-Making* (November 2023) both offer guidance. The USDOT's *Promising Practices for Meaningful Public Involvement in Transportation Decision-Making* (Appendix C, 2023) specifically addresses and attempts to clarify federal funding eligibility for public involvement, including:

- Outlining that costs must be "necessary and reasonable" as outlined in 2 CFR §§ 200.403 and 200.405
- Providing illustrative examples of acceptable funding uses for public involvement activities.
- Noting that under the right circumstances practices such as contracting with community-based organizations, providing food at public meetings, providing childcare at public meetings and/or providing financial incentives or reimbursements for participation could be eligible for federal funding.
- Clarifying that the community context is an important factor for public involvement compensation, specifically if the community involved is designated an EJ or disadvantaged community
- Reinforcing that any activity must be appropriately documented and justified (including "necessary and reasonable" expense justifications) and that some expenses may also require prior approval from the funding federal agency.

With USDOT developing guidance to help clarify federal funding eligibility for supporting community participation in the public involvement process, more opportunities may exist to implement this type of community compensation practice. Exhibit 37 summarizes this practice and additional details about it that may be helpful as NCDOT endeavors to practice it.

Exhibit 37: Best Practice - Treat Community Stakeholders Like Full Partners

Emerging Best Practice	Description	Implementation	Anticipated Outcome	Example
Treat Community Stakeholders Like Full Partners	In an effort to treat key community stakeholders as full partners and offset the financial and time burden of participation, stakeholders should be compensated for their time.	Stakeholders from disadvantaged communities who participate in community feedback efforts should be compensated for their time. Key community stakeholders that act as partners and liaisons between the community and transportation and planning agencies for the lifecycle of the project should be compensated for the efforts as a community planning partner. These community partners can be compensated by allocating federal funds from Unified Planning Work Program, special studies and project environmental impact assessment funds.	Ensure quality and consistent community partnership for the life of the project.	The Metropolitan Council of Minneapolis–Saint Paul (Met Council) USDOT Equity Action Plan

In summary, NCDOT has the opportunity to both enhance existing practices and adopt emerging practices to better serve NC communities and align with national best practices.

Conclusion

This research explored the means to identify, mitigate, and limit socioeconomic and environmental justice impacts of transportation decisions on communities. The study identified and presented opportunities for improving transportation inequity and avoiding inequitable transportation investments to develop a more equitable transportation system in North Carolina. This study complements the federal Bipartisan Infrastructure Law (2021), the Inflation Reduction Act (2022), and the Justice40 Initiative (2021). Each of

these includes an emphasis on reducing historical transportation inequalities and enhancing sustainable and resilient transportation infrastructure.

The research team identified leading state transportation agencies nationally that are working to build capacity and gain understanding by developing equity plans and screening tools and researching implementation strategies. The research team found that NCDOT is situated near other leading state transportation agencies that are at the forefront of this change. NCDOT's internal equity plans, research projects, and tool development put them among the leading wave of state transportation agencies that are working to build capacity and explore implementation options.

A comprehensive review of the literature and best practices for equity data, environmental justice (EJ) screening tools, and equity interventions in the transportation decision-making and investment process was also conducted. The insight gained through the literature and the state of the practice review was synthesized into an implementation-focused best practice matrix. As a part of the state of the practice (SOP) review, an extensive and comprehensive examination of national data and screening tools associated with environmental justice and equity was conducted. The review includes data availability, data gaps, and leading tools for identifying communities with a confluence of environmental burdens, vulnerability, and disadvantage.

The result of the SOP was a best practice matrix that highlighted sixteen national best practices that define inequities; identify disadvantaged communities impacted by past and reoccurring inequities; and correct and prevent inequities. The research team then interviewed NCDOT stakeholders within unit-level leadership to capture current practices. The result was an implementation framework that highlight how processes are captured at NCDOT and where future emerging best practices could be incorporated into the NCDOT process. Specifically, recommendations include considering utilizing the forthcoming NCDEQ/NCDIT primary EJScreening tool and implementing health impact assessments (HIA) in the planning process.

Utilizing the data highlighted in the SOP data review, the research team developed case studies to study North Carolina communities with known historic, transportation impacts within EJ and disadvantaged communities. Three in-depth case studies were presented and an additional six case study briefs were developed to look at other communities. The team developed a set of ArcGIS Story Maps for the in-depth case studies and developed case study cut sheets to communicate the results of both in-depth and brief case studies. The research team also compiled a set of national reparative justice case studies and provides an inequity lens with which to examine transportation decision making. The lessons learned from the case studies are presented as an opportunity to apply the results to future transportation decision making.

The results of this research project are several resources for NCDOT to use to identify, mitigate, and correct impacts to EJ and disadvantaged communities. These resources can be categorized as data and policy best practices, community case studies and engagement, and EJ mapping and presentation tools. The research products are laid out in the next section and documented in the appendices.

Key Resources

During the course of the project, the research team developed several resources for NCDOT to use to identify, mitigate, and correct negative impacts on EJ and disadvantaged communities. These resources can be categorized as 1) data and policy best practices, 2) community case studies and engagement, and 3) EJ mapping and presentation tools. The project and developed resources are documented in this final report and the attached appendices.

The project included the development of a State of the Practice (SOP) document that includes a literature review, national best practices review, data review, and data gap analysis (Appendix 1). The SOP included a best practice matrix that captured a set of national best practices in a succinct form that can be used as a guide for NCODT. After the SOP and best practice matrices were completed, the research team interviewed the leadership of several NCDOT units to understand where these practices were being implemented in the current NCDOT transportation investment process and where they could be implemented in the process. The research team used this to build an implementation framework that documents how NCDOT is currently implementing these national best practices and highlights opportunities to implement additional best practices.

The research team also engaged with community stakeholder representing EJ communities across the state, which informed the development of the case studies and best practice matrix (Appendix 1). The research team also developed maps to highlight inequalities in EJ and disadvantaged communities, including the development of three ArcGIS Story Maps to present the stories of Durham (NC-147); Princeville (US-64) and Asheville (I-26 Connector). In addition to these three deep-dive case studies, an additional six case study briefs were created and documented in the case study sheets (Appendix 6).

Needs for Further Research

The research project lays the groundwork for some additional options for future research or study. Two of the clearest opportunities for future research are developing a means to integrate Health Impact Assessments (HIA) into the NCDOT long-range planning process and studying transportation infrastructure-associated heat island effects within EJ communities.

Through the best practice matrix and the implementation framework, the development and implementation of HIAs into the transportation decision making process was identified as a practice that could be implemented into the current NCDOT process. As noted in the implementation frameworks, there is an opportunity for NCDOT to strengthen its understanding of community health needs and hazards in transportation project areas by developing a consistent HIA approach. Doing so can help NCDOT better capture and evaluate transportation infrastructure impacts on community and environmental health throughout the decision-making process. Beyond the traditional environmental health indicators of air and water quality, the emerging practice is to capture impacts to physical health, mental health, quality of life, and community cohesion. Examples of impacts that could be captured include: active transportation opportunities; community connectivity and cohesion; urban heat island effects and associated mental health stressors. The US Environmental Protection Agency (US EPA) recently released a report that recommends working with agency partners to strengthen the EPA

Cumulative Impact Assessment (CuIA) to incorporate both the legacy impacts of previous actions and proposed actions on the built, natural, and social environment. The goal is to assess cumulative impacts on community health, well-being and quality of life that could be used as guidance for an NCDOT specific long-range transportation HIA plan.

Another issue that could warrant future study was the increased urban heat island effect along transportation infrastructure in EJ and disadvantaged communities. The case study work from this project highlighted how EJ communities can experience a reduced number of trees that can negatively impact health. The low number of trees is a product of both urban renewal era redlining practices associated with street beautification and the design decisions of roadway infrastructure in the community. With fewer trees, these areas tend to get hotter in the summer and will become an increasingly pressing issue with the warmer climate trends. Not only does this impact public health, it also makes bicycle and pedestrian travel more complicated and dangerous due to increased heat. Future research could explore the impact of urban heat island effects and approaches to mitigating these effects in EJ and disadvantaged communities.

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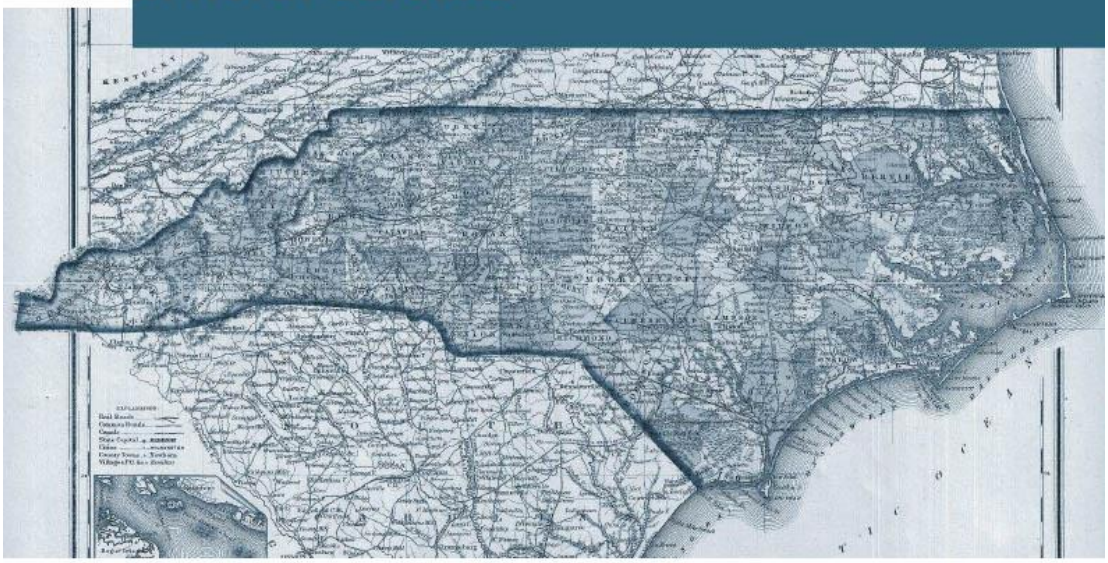
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Appendices

Appendix 1: State of the Practice Document

Assessing Environmental Justice & Historical Transportation Impacts in North Carolina



INTERIM DELIVERABLES:

State of The Practice Report

Best Practice Matrix

Data Review and Inventory

ITRE Institute for Transportation Research and Education

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OVERVIEW OF REPORT

The North Carolina Department of Transportation (NCDOT) has sponsored this research project in an effort to identify, mitigate and limit socioeconomic and environmental justice impacts of transportation decisions on communities. Understanding opportunities for improving transportation inequity and avoiding inequitable transportation investments and impacts in future decision-making processes are critical for realizing a more equitable transportation system in North Carolina. The current research project complements the Bipartisan Infrastructure Law (2021), Inflation Reduction Act (2022) and the Justice40 Initiative (2021) which include an emphasis on improving historical transportation inequalities and enhancing sustainable and resilient transportation infrastructure.

The research team recognizes that this research effort works in concert with recent and ongoing NCDOT sponsored research projects with robust equity elements, including:

- RP 2021-17: Enhancing the Strategic Prioritization Process with Socioeconomic Geospatial Analysis
- RP 2022-17: Including Equity in Benefit-Cost Analysis
- RP 2020-51: NCDOT Community Studies Geospatial Sandbox
- RP 2020-38: Location Aware Approach to Creating Effective Public Outreach
- RP 2023-078: Equity Analysis for Long Range Transportation Planning

This report is divided into three sections: 1) the literature and state of practice review; 2) the best practice matrix, and 3) the data review and inventory (see Figure 1). The literature and state of the practice review serves as the foundation for the best practice matrix. The data review and inventory is the output of an iterative process that both contributes to the state of the practice review and best practice matrix, as well as, being informed by those the benchmark best practices identified in the review process.

Literature and State of the Practice Review	A comprehensive review of literature and best practices was conducted for equity data, environmental justice (EJ) screening tools, and equity interventions in the transportation decision-making and investment process. This document indentifies best practices from the review in call-outs in the doucment and informs the best practice matrix. The literature and the state of the practice review both draws from the data review and inventory and informs the data review in an interative reserach process.
Best Practice Matrix	Knowledge gained through the literature review, state of the practice review, the stakeholder engagement sessions, and the data review and inventory was leveraged to develop a best practice matrix. The best practice matrix captures and builds upon emerging equity practices and highlights best practices from the literature on transportation decision-making and investment. These best practices are also informed by emerging federal initiatives that could serve as the foundation the next generation of federal guidance and policies
Data Review and Inventory	An extensive and comprehensive examination of data and screening tools associated with environmental justice and equity was conducted. The review includes data availability, data gaps and leading tools for identifying communities with a confluence of environmental burdens, vulnerability, and disadvantage. The reserach team highlighted several of the most representative tools at the national and state level for describing how summary metrics, combining perspectives of environmental burden and social vulnerability, can be quantified and how these results have been applied in policy.

Figure 1: Report Road Map

LITERATURE AND STATE OF THE PRACTICE REVIEW

The research team conducted a comprehensive review of literature and best practices for equity data, environmental justice (EJ) screening tools, and equity interventions in the transportation decision-making and investment process. The insight gained through the literature and the state of the practice review was synthesized into an implementation-focused best practice matrix. Peer-reviewed literature, resources created by reputable organizations and state and federal agency guidance were explored to provide NCDOT with insights on identifying and mitigating inequitable impacts associated with transportation systems and the transportation decision-making process. The review also includes an extensive and comprehensive examination of data and screening tools associated with environmental justice and equity. The review includes data availability, data gaps and leading tools for identifying communities with a confluence of environmental burdens, vulnerability, and disadvantage.

While the focus of this review is on highway impacts to communities, the research team also captured relevant literature relating to other modes of transportation. For example, relevant best practices from transit and multimodal decision-making processes can be used to inform recommendations for best practices for identifying and mitigating inequity in the highway transportation decision-making process.

Working definition of Disadvantaged Communities

Disadvantaged communities is a term currently used by the United States Federal Government and refers to communities that typically have one or more of the following socioeconomic and demographic characteristics[1]:

- Low income, high and/or persistent poverty
- High unemployment and underemployment
- Racial and ethnic residential segregation, particularly where the segregation stems from discrimination by government entities
- Linguistic isolation
- High housing cost burden and substandard housing
- Distressed neighborhoods
- High transportation cost burden and/or low transportation access
- Disproportionate environmental stressor burden and high cumulative impacts
- Limited water and sanitation access and affordability
- Disproportionate impacts from climate change
- High energy cost burden and low energy access
- Jobs lost through the energy transition
- Access to healthcare

[1] Young, S.D. et al. (2021) Interim Implementation Guidance for the Justice 40 Initiative, Office of Management and Budget (Report)

For the purposes of this research disadvantaged, vulnerable, and marginalized are all used interchangeably to describe disadvantaged communities.

Community Stakeholder Workshop Overview

As a part of this review, the research team held a stakeholder engagement workshop to capture feedback from communities in North Carolina that have been historically impacted by the traditional highway decision-making processes. Community stakeholders from across the state were invited to participate in the virtual workshop. In a subsequent research task, the research team will conduct one-on-one follow-up interviews with these communities and other communities as part of larger case study efforts.

As a part of the overall study, the research team facilitated an online workshop with representatives of communities from an urban area in western North Carolina, an urban area in central North Carolina and a rural area form eastern North Carolina. The communities that were selected are known to have been negatively impacted by past highway projects. Participants were prompted with the questions related to how transportation decisions have been made in their community, barriers in the decision-making process, opportunity to impact change in the process, access to information, and perceptions of the decision-making process.

Participants began with broad discussion about the impacts of transportation on their communities without specifying state highways and projects. As the discussion continued, comments narrowed to focus on infrastructure decisions. Some of those topics were:

- Pedestrian crashes and fatalities in rural eastern North Carolina counties and the need for crosswalks and pedestrian infrastructure
- Rural vehicle crashes on un-signalized highway intersections and the positive impacts of adding signalization
- A lack of meaningful and impactful community engagement in ongoing freeway development
- Community stakeholders serving as uncompensated community representatives and liaisons between the community and transportation and planning agencies
- Urban redevelopment and proposed freeway development
- Challenges to community input in rural areas including the impact of heirs rights property on notification and awareness of transportation decision making by rural property owners.

Community stakeholder comments lead to three reoccurring themes emerging from the conversation:

- Distrust and the legacy of previous transportation planning engagement approaches
- Capacity building and compensation of community partners
- Mobility beyond automobiles

These themes show the strained relationship between these communities and state and local transportation and planning entities, including frustration over the current public involvement process. The themes also reflect a concerns for community safety and well-being, specifically the health and safety

of community members, the economic viability of the community and the toll it takes to constantly defend and advocate for equitable community well-being.

Best Practices Overview

Knowledge gained through the literature review, state of the practice review, and the community stakeholder workshop were leveraged to develop a series of best practices that were identified in the literature and state of practice review. A best practice matrix was developed to outline implementable approaches for identifying communities impacted by transportation and environmental inequity and offering implementation approaches to develop decision-making processes that are more explicitly focused on equitable outcomes.

The state of the practice research highlights changes to federal policy and guidance on equity in the transportation decision-making process. Additionally, best practices are highlight for state transportation agencies and MPOs that are developing EJ and equity screening tools to identify disadvantaged communities. There is, however, still a disconnect between the data collection and analysis processes and the implementation process. Beyond a few state initiatives that are starting to emerge, the review of the literature and current practices show that implementing processes interventions or developing dedicated funding streams have not yet occurred on a national scale. Federal guidance and internal action plans signal what could be on the horizon for equity-centered regulations in the future.

With potential equity-focused changes to federal policies and guidance, many state transportation agencies are working to build capacity and processes that would address potential future regulations and established their own equity initiatives. The best practice matrix, informed by emerging federal initiatives that could set the next generation of federal guidance and policies, has been developed from current best practices and emerging equity practices in the literature.

BEST PRACTICES

(See Best Practices Matrix Section for full table with implementation considerations)

Data and Screening Tools

Develop Comprehensive Screening Tools
Develop a locally-relevant comprehensive screening tool for environmental justice that highlights the intersection of community vulnerability and environmental burden. A comprehensive screening tool should include environmental exposures, environmental effects, health vulnerabilities, and socioeconomic characteristics of communities.

Public Participation and Field Verification
Develop screening tools through a collaborative process with historically burdened communities and ensure a high level of transparency. Final products should be publically availability and be design to be understandable to the public.

Planning and Project Development Process Improvements

Improve Community Social and Health Impact Assessments
Establish a robust and consistently applied community social and health impact assessment in the transportation decision-making process that focuses on cumulative impacts on community social well-being, mental and physical health and quality of life.

Develop Data for Household Transportation Cost and Travel Time Cost
Capture the household transportation cost and travel time cost that impact disadvantaged communities and pair the results with policy, planning and funding interventions.

Re-Connect Communities
Prioritize increase access to re-connect communities to essential destinations and connect neighboring residential areas for community cohesion.

Funding

Prepare and Apply for Future Federal Funding for Disadvantaged Communities
Establish a process to identify disadvantage communities eligible for federal discretionary funding and a pool of eligible projects at varying stages of project planning and development.

Link Screening Tools Designation with Funding Opportunities
Dedicate specific funding for transportation improvement projects in disadvantaged communities as identified by set criteria and a data-driven EJ screening tool.

Workforce Development

Provide Job and Training Opportunities for Impacted Communities
Provide direct economic impact to local disadvantaged communities by developing a workforce training program and hiring local residents for project related jobs.

Maximize Workforce Development and Disadvantaged Business Enterprise (DBE) Funds
Leverage 100% cost share federal DBE funding for business and workforce development programs in disadvantaged communities impacted by transportation projects and to stimulate economic development in the community.

Public Engagement Processes and Community Partners

Community Engagement Plan with Virtual and In-Person Meetings
Develop a public engagement process that ensures high quality communication and notifications to community members and provides accessible meetings (both in-person and virtually) in an effort to provide opportunities for many diverse community voices.

Treat Community Stakeholders Like Full Partners
In an effort to treat key community stakeholders as full partners and offset the financial and time burden of participation, stakeholders could be compensated for their time.

Environmental Quality and Health Impacts

Mobile Source Air Emissions Reduction
Monitor, mitigate and reduce mobile source air emissions associated with disadvantaged communities proximity to roadways.

Zero Emission Vehicles to Improve Air Quality
Support the transition to zero emission vehicles (ZEV), including electric vehicles (EV), and ensure that disadvantage communities have access to ZEV infrastructure.

Storm Water Infrastructure Improvements
Reduce transportation related flooding impacts on local communities by assessing, mitigating and preparing for more intense and frequent storm events.

Roadway, Bicycle and Pedestrian, and Shared-Mobility Facility Planning and Design

Increase Bicycle and Pedestrian Connectivity
Develop and expand bicycle and pedestrian networks to connect disadvantaged communities to essential services and to re-connect communities that have been divided and cutoff by past highway projects.

Implement Traffic Calming and Roadway Design Measures
Implement traffic calming designs and strategies and improve pedestrian facilities to reduce pedestrian crash and injury risk.

Data Review and Inventory Overview

Data-driven methods used to identify disadvantaged communities and to conduct environmental justice analyses employ a wide variety of data sets that span demographic, socioeconomic, public health, and environmental domains. These tools vary in their design purpose and complexity; however, significant overlap is present in the types of factors analyzed. Environmental justice screening tools are among the most comprehensive approaches to quantifying how the burdens of transportation policies and investments are inequitably distributed, though these tools typically describe environmental conditions beyond the direct impacts of the transportation system. These tools quantify the confluence of vulnerability and environmental burden and map resulting index at a consistent geographic scale (e.g., the census tract, block group, county).

Data-driven tools like environmental justice screens offer an indirect assessment of community conditions that is adequate for making high-level comparisons. A major limitation of these tools is their focus on current conditions. Many tools account for this limitation by incorporating data that reflects historic policies and processes. However, conducting in-depth analysis of historical conditions is challenging due to the lack of robust historical data. Additionally, most tools to not include data describing ongoing changes in community composition that may be relevant when considering durable transportation investments. Finally, all tools include subjective decisions about data and methodology. Tools should be developed, vetted, and continuously verified through engagement with stakeholders and institutions in disadvantaged communities.

The Data Review Section of this report includes a comprehensive landscape analysis of 27 environmental justice screening tools and a detailed inventory of the 64 specific indicators and sources commonly included in these tools (reflected in Figure 2).

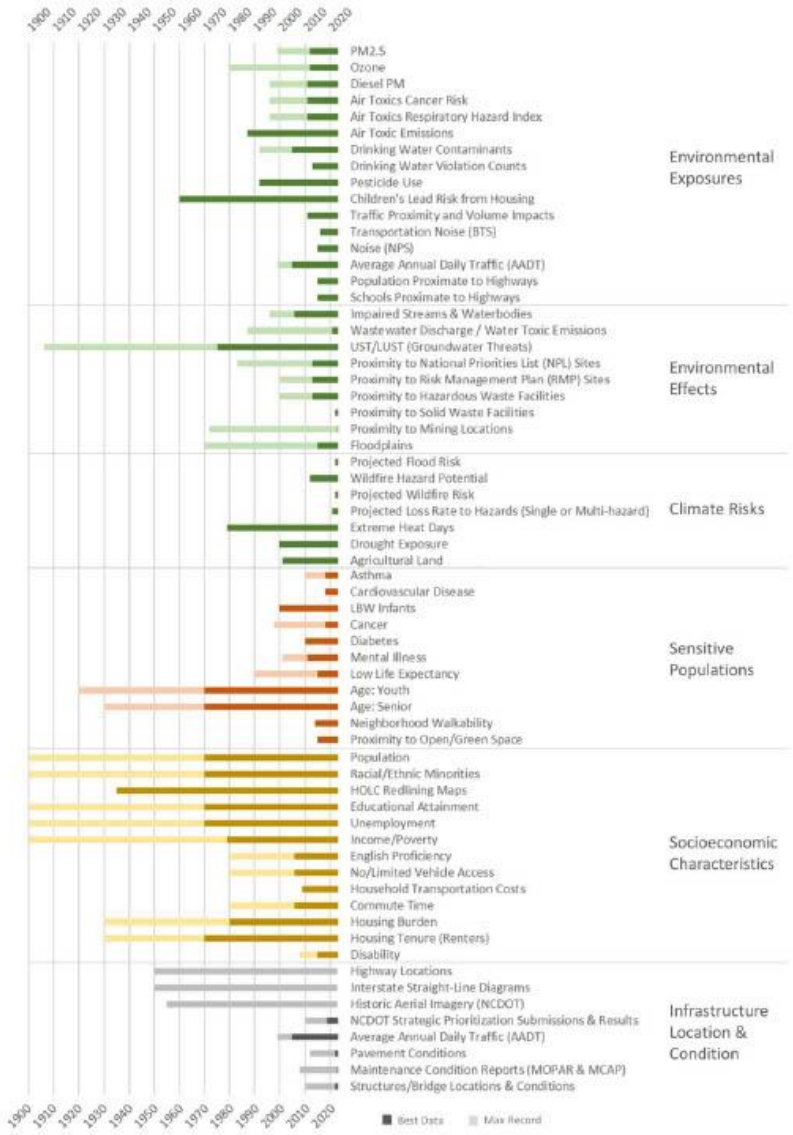

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Air Toxics Respiratory Hazard Index
Air Toxic Emissions
Drinking Water Contaminants
Drinking Water Violation Counts
Pesticide Use
Children's Lead Risk from Housing
Traffic Proximity and Volume Impacts
Transportation Noise (BTS)
Noise (NPS)
Average Annual Daily Traffic (AADT)
Population Proximate to Highways
Schools Proximate to Highways
Environmental Exposures
Impaired Streams & Waterbodies
Wastewater Discharge / Water Toxic Emissions
UST/LUST (Groundwater Threats)
Proximity to National Priorities List (NPL) Sites
Proximity to Risk Management Plan (RMP) Sites
Proximity to Hazardous Waste Facilities
Proximity to Solid Waste Facilities
Proximity to Mining Locations
Floodplains
Environmental Effects
Projected Flood Risk
Wildfire Hazard Potential
Projected Wildfire Risk
Projected Loss Rate to Hazards (Single or Multi-hazard)
Extreme Heat Days
Drought Exposure
Agricultural Land
Climate Risks
Asthma
Cardiovascular Disease
LBW Infants
Cancer
Diabetes
Mental Illness
Low Life Expectancy
Age: Youth
Age: Senior
Neighborhood Walkability
Proximity to Open/Green Space
Sensitive Populations
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Racial/Ethnic Minorities
HOLC Redlining Maps
Educational Attainment
Unemployment
Income/Poverty
English Proficiency
No/Limited Vehicle Access
Household Transportation Costs
Commute Time
Housing Burden
Housing Tenure (Renters)
Disability
Socioeconomic Characteristics
Highway Locations
Interstate Straight-Line Diagrams
Historic Aerial Imagery (NCDOT)
NCDOT Strategic Prioritization Submissions & Results
Average Annual Daily Traffic (AADT)
Pavement Conditions
Maintenance Condition Reports (MOPAR & MCAP)
Structures/Bridge Locations & Conditions
Infrastructure Location & Condition
Best Data
Max Record

Figure 2: Availability of Data for Common Environmental and Social Indicators over Time

COMMUNITY, EVNRONMENTAL AND HEALTH IMPACTS OF TRANSPORTATION INFRASTRUCTURE INVESTMENT

Transportation decisions can either deepen environmental, socioeconomic, and health inequalities or serve to improve quality of life. This is particularly true for communities of color and low-income communities, who are often more vulnerable to adverse effects associated with transportation projects due to geographic location and socioeconomic insecurity.[2] Many disadvantaged communities have experienced deep and long-lasting negative impacts due to transportation policies and projects of the past that limit opportunities for socioeconomic mobility today.[3] This section presents a review of national literature and practices associated with identifying and mitigating these impacts in disadvantaged communities.

Historical Context of Inequity in the Transportation Decision-making Process

During the mid-1900s, transportation and land use policies implemented across the United States furthered structural inequality and deepened spatial inequity in communities of color and socioeconomically disadvantaged communities. The coupling of urban renewal land use policies (such as the Housing Acts of 1949 and 1954) with new federal highway programs (such as the Federal-Aid Highway Act of 1956) led to the clearing of so-called 'slum' housing and 'urban blight' to make way for new highway infrastructure. These policies and infrastructure projects exacerbated inequalities in 'redlined' neighborhoods as highway infrastructure often divided communities of color and displaced neighborhood residents .[4]

The literature situates transportation policy decision-making in the historic context of systematic oppression and racist policies. At the time of the Federal Aid Highway Act, segregated Black communities had already suffered from 20th century segregated housing policies and inequitable development due to racially-restrictive covenants and 'redlining' policies that concentrated restricted black home ownership and housing loans to specific low-income and racialized neighborhoods.[5] The consequences of systematic disinvestment resulted in minority, low-income, and other disadvantaged communities being identified as slums and therefore the targets of slum clearance, urban renewal and urban redevelopment programs. With resources from the Federal Aid Highway Act, these communities were also targeted for highway and freeway construction. Of the many redlined communities across the country, North Carolina's redlined communities included Asheville, Charlotte, Durham, Greensboro, and Winston-Salem.[6] The effects of these policies are still experienced by North Carolina communities today in areas such as Durham, where NC-147 displaced, demolished, and economically disenfranchised the historic Black Hayti community. It is important to note that even outside of systematic redlining of

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[2] Martin, S. A. (2015). A Framework to Understand the Relationship between Social Factors that Reduce Resilience in Cities: Application to the City of Boston. *International Journal of Disaster Risk Reduction*, *12*, 53–80. https://doi.org/10.1016/j.ijdrr.2014.12.001

[3] Archer, D.N. (2021). Transportation Policy and the Underdevelopment of Black Communities. *Iowa Law Review*, vol. 106, no. 5: pp. 2125-2151. *ProQuest*, https://proxying.lib.ncsu.edu/index.php/login?url=https://www.proquest.com/scholarly-journals/transportation-policy-underdevelopment-black/docview/2562275560/se-2.

[4] Woods, L.L. (2012). "The Federal Home Loan Bank Board, Redlining, and the National Proliferation of Racial Lending Discrimination, 1921–1950." *Journal of Urban History* 38, no. 6: 1036–59. https://doi.org/10.1177/0096144211435126.

[5] National Recreation and Park Association. (2021, June 8). Equity in Parks and Recreation: A Historical Perspective. Retrieved April 6, 2023, from https://storymaps.arcgis.com/stories/5727e40084814c559bf0440dc5a21f7f

[6] Nelson, R. K., Winling, L., Marciano, R., & Connolly, N. (2022). Mapping Inequality. In R. K. Nelson & E. L. Ayers (Eds.), American Panorama. Retrieved from https://dsl.richmond.edu/panorama/redlining.

neighborhoods by housing lenders, racially-restrictive covenants, practices, and attitudes embedded segregation into the structure of communities throughout North Carolina.

New highway projects provided connectivity between bedroom communities and job centers, while exclusionary housing policies restricted the types of people who reap this publicly-funded mobility benefit, due to racially-restrictive housing policies preventing Black people from living in newly constructed mid-century suburbs. The same highway infrastructure that harmed communities of color helped increase the wealth and stability of other places, as white homeowners benefited from increased mobility without the environmental burdens.[7] A 2022 study examined housing prices and the impact that a highway development had on home values in Hartford, Connecticut from the late 1930s through the 1960's. [8] The study compared pre-highway and post-highway home values. The research found homes closest to the highways that were subject to noise pollution and a highway view shed had depreciated home values. Homes that were not directly on the highway but within 1.25 miles that

+. had easy access to the highway but had no roadway disturbance increased in value. The study found a disparity between white and black communities in regard to home values, with black residents' home values not accruing the same benefits as white home owners.[9]

Despite federal policies later enacted to enhance protections for disenfranchised communities and mitigate environmental justice impacts (such as the National Environmental Policy Act of 1969), transportation and environmental inequity continues to persist today.[10] Some of the many examples of current inequity in the transportation system include higher bicycle and pedestrian crash rates for people of color, less access to personal vehicles in disadvantaged communities, and increased commute time due to discrepancies between transit and personal vehicle travel time.[11] Additionally, disadvantaged communities are often pushed to marginalized land that is more prone to extreme weather events and more exposed to high concentrations of air and water pollution.[12] For example, in North Carolina the Princeville community, located on a floodplain in Edgecombe County and founded by freed slaves, has repeatedly been devastated by flooding, displacement, and illness.

The historical context of inequity demonstrates that extent to which transportation investments and policies produce inequitable outcomes is inexorably linked to other systems and conditions present in communities affecting how impacts are distributed. That is, the extent to which a community is benefited or burdened by transportation changes is a result of not only the transportation projects and policies themselves, but also how those projects and policies intersect housing systems, environmental systems,

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[7] Karas, David Patrick. "Highway to Inequity: The Disparate Impact of the Interstate Highway System on Poor and Minority Communities in American Cities." (2015).

[8] Cohen, J. P., Lownes, N., & Zhang, B. (2022). 1960s Interstate Highways and Homeowner Wealth Distribution. Federal Reserve Bank of St. Louis Review, 104(4), 317-336. https://doi.org/10.20955/r.104.317-36

[9] Ibid.

[10] National Environmental Policy Act of 1969, 42 U.S.C. § 4321 et seq. (1969).

[11] Harvard T.H. Chan School of Public Health. (2019). Racial Disparities Persist in Traffic Fatalities. Harvard T.H. Chan School of Public Health News. https://www.hsph.harvard.edu/news/press-releases/racial-disparities-traffic-fatalities/;
PolicyLink and USC Equity Research Institute. (2020). National Equity Atlas. Car access: Everyone Needs Reliable Transportation Access and in Most American Communities that Means a Car. Retrieved from https://nationalequityatlas.org/indicators/Car_access#/?geo=02000000000037000;

[12] U.S. Environmental Protection Agency [EPA]. (2021). Climate Change and Social Vulnerability in the United States: A Focus on Six Impacts (EPA 430-R-21-003). Office of Atmospheric Programs, U.S. Environmental Protection Agency. Retrieved from https://www.epa.gov/cira/social-vulnerability-report;
North Carolina Department of Environmental Quality. (2018). NC Climate Risk Assessment and Resilience Plan. https://www.deq.nc.gov/energy-climate/climate-change/nc-climate-change-interagency-council/climate-change-clean-energy-plans-and-progress/nc-climate-risk-assessment-and-resilience-plan

economic systems, cultural forces, and historical conditions, among other factors. Recognizing and attempting to understand these intersections is critical to ensuring more equitable outcome in the future.

History of Efforts to Address Inequity in the Transportation Decision-making Process

During the years of Urban Renewal policies and the Federal Aid Highway Act, resistance movements were initiated by numerous communities challenged highway and freeway construction based on the perception that social costs of development were not sufficiently addressed in project planning. Resistance movements had uneven results.[13] Some were successful due to the wealth and political power of well-resourced activist organizations, and others were not due to lack of resources and power. The legacy of race strongly influenced these outcomes, with many legacy Black and low-income communities unsuccessfully defending their spaces from destruction due to highway and freeway construction. In some cases, communities impacted in that era currently have low levels of social resilience and high levels of social vulnerability,[14] or the potential for negative effects on communities caused by external stresses on human health.[15] During the Urban Renewal period, robust and systematic accounting for environmental and social project impacts was not yet integral to planning processes.

However, the passage of the 1964 Civil Rights Act marked an initial step towards more equitable decision-making. Under Title VI of the Act, recipients of federal funding are prohibited from conducting programs or activities that discriminate on the basis of race, color, or national origin.[16] Title VI provided a legal basis for ending the discriminatory policies of transportation agencies. State transportation departments and metropolitan planning agencies are among the many agencies bound by Title VI to ensure non-discrimination in their activities.

Strides were also made during this period to incorporate environmental effects into decision-making. Baseline information describing historical socioeconomic and environmental impacts of transportation decisions are difficult to systematically recount prior to the National Environmental Protection Act (NEPA) of 1969.[17] Environmental Impact Statement (EIS) and Environmental Assessments (EA), the required documentation of the NEPA environmental review process, provide baseline environmental and socio-economic data for projects and the communities they impact. The literature identifies complex dynamics between transportation, land use and economic development decisions of which affected communities were not aware or in which they did not participate.[18]

The 1970s and 1980s saw the emergence of the concept of environmental justice via activism that raised awareness of the disproportionate burden of environmental pollution borne by people of color. The environmental justice perspective challenges agencies to more equitably distribute benefits and burdens posed by projects with environmental impacts.[19] Executive Order 12898, signed in 1994, amplified the directive of Title VI and marked another step towards reaching this goal. of mitigating and eliminating

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[13] Karas, D. (2015). Karas, D. (2015). Highway to inequity: The disparate impact of the interstate highway system on poor and minority communities in American cities. New Visions for Public Affairs, 7, April 2015.

[14] The Digital Scholarship Lab and the National Community Reinvestment Coalition. (n.d.)., "Not Even Past: Social Vulnerability and the Legacy of Redlining. ," American Panorama, ed. Robert K. Nelson and Edward L. Ayers. Retrieved from, https://dsl.richmond.edu/socialvulnerability.

[15] US Center for Disease Control (2023). CDC/ATSDR Social Vulnerability Index. Retrieved from https://www.atsdr.cdc.gov/placeandhealth/svi/index.html#:~:text=Social%20vulnerability%20refers%20to%20the,human%20suffering%20and%20economic%20loss

[16] Urban Institute. (2020). Defining Communities of Concern in Transportation Planning. Retrieved from https://www.urban.org/sites/default/files/2022-04/defining-communities-of-concern-in-transportation-planning.pdf

[17] National Environmental Policy Act of 1969, 42 U.S.C. §§ 4321-4370e. (2018).

[18] Grabowski, Z., et al. (2022). Is Green Infrastructure a Universal Good? Cary Institute of Ecosystem Studies.

[19] U.S. Federal Highway Administration [FHWA]. (2015). Federal Highway Administration Environmental Justice Reference Guide. Retrieved from https://www.kipda.org/wp-content/uploads/2021/01/FHWA_EJ_Guide_2015.pdf

disproportionate burden on impact communities. The order, titled Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, requires agencies to identify and address disproportionate negative environmental and health impacts to minority and low-income communities.[20]

Though advances have been made in ensuring transportation projects impacts are evaluated and that unjust impacts are avoided, a long history of policies and projects enacted prior to these protections have produced landscapes of inequality. Historically impacted communities still have a disproportionate share of environment and human health. burdens and receive fewer mobility benefits associated with these projects. Current approaches to establish a more equitable transportation decision-making processes and ensure that equitable outcome try to understand, contextualized and mitigate historical inequalities.

Defining Equitable Processes and Results

Developing a project and case specific definition of transportation inequity (or injustice) is identified as a key step in co-creating specific equitable transportation strategies with affected communities. Though definitions vary, transportation inequity definitions generally reference the structural barriers to transportation decision-making faced by disadvantaged communities, as well as the cumulative impacts of environmental burdens and lack of access to environmental benefits from decision-making.

Litman (2022) notes that equity strategies typically employ a lens of either horizontal equity, where the goal is to treat everyone in a specific group similarly, or vertical equity, where disadvantaged groups are provided with recuperative benefits and resources to help them transition from their traditionally disadvantaged position.[21] Nested within horizontal equity are approaches related to fair share and external cost that spread benefits equally among specific groups. Vertical equity approaches are typically focused on inclusivity, affordability and social justice. It is important to note that inclusivity and affordability are programmatic approaches to equity, in which classes of disadvantaged groups are provided additional benefits and resources to ensure more equitable access to mobility options.

The social justice approach is a structural approach through which systemic injustices (such as racism, classism, gender discrimination) are addressed by systemic changes embedded in the transportation decision-making process to ensure equitable processes and outcomes are provided to all. Essential to the social justice approach is that idea that disadvantaged groups are given the resources and benefits needed to recover from previous inequity and to establish a system of sustainable transportation equity within the community.[22] Framing past decision-making in these structural approaches to inequity highlight the need to address reoccurring and cumulative impacts associated with projects that continue to build upon previous inequitable project selection and siting.

To overcome the structural barriers and historical disenfranchisement faced by disadvantaged communities, the literature points to the value of sustainable investments in these same communities. This investment is often in the forms of capacity building, decision-making, and even resource allocation. Two cases, 11th Street Bridge Park and Unity Village/Fruitvale Station, illustrate the long-term impacts of sustained community investment. The 11th Street Bridge Park's Equitable Development Plan uses broad stakeholder collaboration to center and empower disadvantaged communities as leaders in the decision-making process.[23] Their focus on enabling pre-, during, and post-construction benefits to the local

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[20] Urban Institute. (2020).

[21] Litman, T. (2022). Understanding Transport Demands and Elasticities: How Prices and Other Factors Affect Travel Behavior. Victoria Transport Policy Institute. Retrieved from https://www.vtpi.org/elasticities.pdf

[22] Ibid.

[23] Building Bridges Across the River [BBAR]. (2018). 11th Street Bridge Park Equitable Development Plan. Retrieved from https://bbardc.org/wp-content/uploads/2018/10/Equitable-Development-Plan_09.04.18.pdf

community from bridge investment across an array of domains represents one of the most robust equitable development approaches currently underway. Unity Village/Fruitvale Station illustrates the impact of empowered disadvantaged communities working to shape transportation investment into economic development and affordable housing that invested the development of local capacity and community stabilization.[24]

Retrofitting or removing older highways is a strategy that more communities are beginning to pursue revitalizing and reconnecting their community. Revitalizing older road systems as multimodal systems that connect urban and neighboring communities can yield both economic and health benefits for the community. Some of the benefits to multimodal transportation systems that connect neighboring communities include connecting employment, education and healthcare opportunities. Multimodal systems also provide public health benefits and create safer communities.[25] Focusing efforts on highway removal projects in cities with clear unequal distribution of housing wealth accumulation can lead to a more equitable allocation of wealth in the community.[26] The USDOT Every Day Counts (EDC) community connections tools can help to identify new potential projects through informed decision-making and a goal of increasing connectivity and enhancing public health and safety.[27]

Best Practice: Re-Connect Communities
Prioritize increase access to re-connect communities to essential destinations and connect neighboring residential areas for community cohesion.

These emerging strategies for producing more equitable and just processes and outcomes require improved methods of identifying impacts to communities, specifically broad, comprehensive assessments that focus on social, economic and environmental health and wellbeing of community residents. It is important to understand how new approaches and emerging polices for assessing community impacts could be included into the transportation infrastructure decision-making process.

Community Impacts of Transportation Infrastructure Investment

Community Needs Assessments (CNAs) were developed to affect policy, system, and environmental change.[28] Numerous examples abound – most notably in projects designed to improve public health outcomes in disadvantaged communities. For example, Community Impact Assessments (CIAs) are iterative processes that can be used to evaluate the effects of transportation actions on a community and its quality of life. These processes include working in collaboration with community stakeholders to gather baseline data, set goals and objectives, and establish metrics for improved outcomes.[29] These techniques were not formally connected to transportation planning until after NEPA in 1969. NEPA requires an Environmental Impact Statement (EIS) that includes a Social Impact Assessment (SIA) process, which

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[24] U.S. Environmental Protection Agency [EPA]. (2013). Strategies for Advancing Smart Growth, Environmental Justice, and Equitable Development Creating Equitable, Healthy, and Sustainable Communities.

[25] U.S. Federal Highway Administration [FHWA]. (2016). Community Connections: Redesigning Highways to Improve Neighborhood Access and Livability. [Webinar]. Retrieved from https://www.fhwa.dot.gov/planning/css/webinars/community/

[26] Cohen et al. (2022). p.," 326.

[27] FHWA. (2016).

[28] Centers for Disease Control and Prevention [CDC]. (2013). Community Needs Assessment: Atlanta, GA. Retrieved from https://www.cdc.gov/globalhealth/healthprotection/fetp/training_modules/15/community-needs_pw_final_9252013.pdf

[29] U.S. Federal Highway Administration [FHWA]. (2018b. (2018). Community Impact Assessment Quick Reference Guide. Retrieved from https://www.fhwa.dot.gov/livability/cia/quick_reference/ciaguide_053118.pdf

include considerations and accounting for community health and well-being.[30] However, the assessment process is inconsistently applied and enforced in communities, leading researchers and advocates to recommend revised process and policy guidance.

Executive Order 12898 requires federally funded projects, including those related to highways, to demonstrate that they will not increase existing burdens on disadvantaged communities.[31] The EIS also provides a process for participating with community stakeholders, reporting findings, and including them in project reports. However, there is a lack of consistency in this process, especially with regards to the level of transparency of information and decision-making to disadvantaged communities. This lack of consistency impacts transportation investment decisions and outcomes, including mitigating impacts on land use, community design, and community displacement associated with transportation projects[32]

Often policy decisions are conceptualized as having environmental, economic and social impacts. However, Jones and Lucas (2012) noted that these impacts are often treated as parallel and discrete impacts rather than integrated impacts that affect the distributional outcome.[33] Investment decisions and policy interventions create concurrent and integrated environmental, economic and social impacts. Historically, the consideration of the social impacts of transportation policy has been less transparent and it has led to disproportional spatial, temporal and socioeconomic distributional impacts on marginalized communities.[34]

Cumulative Impact Assessment (CuIA) is emerging as a more robust means of including public health impacts in the broader mix of effects faced by communities as a result of a transportation investment. The CuIA process defines and measures toxic exposure risks and can explicitly incorporate air, water, and soil exposure risk data into broader community models.[35] This can create the need for additional capacity by transportation agencies, as well as coordination with other partners to collect, manage, monitor, and disseminate public health impacts of legacy and proposed transportation planning.

In addition to assessment tools, the literature suggests that the data needed for planning and policy decision-making requires establishing trusted relationships with affected communities and disadvantaged stakeholders.[36] Acknowledging that historical decisions have contributed to environmental factors that disproportionately affecting disadvantaged community health is an important step, especially when incorporating processes to improve public health outcomes,. Research shows that empowering affected communities with tools to communicate their own experience with community disparities, as well as communicating the value of community assets, can increase trust.[37] Overcoming systemic barriers, which prevent increased power of affected communities, in the transportation decision process is a recurring theme in the literature reviewed. However, a wide array of strategies are presented, as there is no one-

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[30] U.S. Environmental Protection Agency [EPA]. (2022a) Cumulative Impacts Research: Recommendations for EPA's Office of Research and Development. U.S. Environmental Protection Agency, Washington, D.C., EPA/600/R-22/014a

[31] Chakraborty, J. (2006). Evaluating the Environmental Justice Impacts of Transportation Improvement Projects in the U.SUS. Transportation Research Part D: Transport and Environment, 11(5), 315-323. https://doi.org/10.1016/j.trd.2006.06.003

[32] Ibid.

Li, H., Young, S., Low, S., & Lum, G. (2006). Environmental Justice Assessment in Racially Diverse Areas. Transportation Research Record, 1983(1), 59-66. https://doi.org/10.1177/0361198106198300109.

[33] Jones, P. and Lucas, K. (2012). The social consequences of transport decision-making: clarifying concepts, synthesizing knowledge and assessing implications. Journal of Transport Geography, 24, 1-14. https://doi.org/10.1016/j.jtrangeo.2012.01.012

[34] Ibid.

[35] EPA. (2022a). U.S. Environmental Protection Agency (2022) Cumulative Impacts Research: Recommendations for EPA's Office of Research and Development. U.S. Environmental Protection Agency, Washington, D.C., EPA/600/R-22/014a

[36] Dawodu, A., Cheshmehzangi, A., Sharifi, A., & Oladejo, J. (2022). Neighborhood Sustainability Assessment Tools: Research Trends and Forecast for the Built Environment. Sustainable Futures, 4. https://doi.org/10.1016/j.sftr.2022.100064

[37] Wang, C., & Burris, M. A. (1997). Photovoice: Concept, Methodology, and Use for Participatory Needs assessment. Society for Public Health Education, 24(3), 369-387. https://doi.org/10.1177/109019819702400309

size-fits all solution and approaches should be thoughtfully applied to address the unique needs related to each case.

Best Practice: Improve Community Social and Health Impact Assessments
Establish a robust and consistently applied community social and health impact assessment in the transportation decision-making process that focuses on cumulative impacts on community social well-being, mental and physical health and quality of life.

Water Quality and Air Quality Impacts of Transportation Infrastructure Investment

This section describes the impacts of transportation infrastructure investment on air quality and water quality based on literature review. The section also introduces tools for evaluating such impacts on environmental justice concerns. Details of national- and state-level tools identified in this project are described later in the report.

Transportation emissions are a major source of exposure to air pollution, especially in locations adjacent to transportation facilities.[38] High volume roadways, such as highways, tend to be disproportionately located in close proximity to communities that are already overburdened and historically disenfranchised. For example, communities near a high volume roadway can be the result of historical transportation practices that have intentional located transportation facilities in minority and low-income communities.[39] These historical siting practices can be exacerbated by reoccurring impacts, such as widening a roadway through a impacted community, which further increases environmental pollution exposure and reduces community connectivity.

Quantifying historical and current transportation impacts is a necessary step towards identifying and evaluating mitigations or interventions aimed at reducing disparities. Examples include approaches from ongoing national policies related to vehicle and engine emissions controls as well as those from local or state decisions regarding siting and operations of transportation facilities, among others. Future research and emissions monitoring capacity is need to quantify air pollutant emissions at a community-level spatial resolution that supports the environmental justice assessment process. Many emissions estimates are based on county scale, which is not high enough resolution to adequately monitor air quality impacts in disadvantaged communities.[40]

Carbon dioxide (CO_2) is a greenhouse gas which affects global climate change. For on-road vehicles with internal combustion engines, over 95% of carbon in the fuel is emitted as CO_2 and then released into the atmosphere. Vehicles with internal combustion engines dominate the current and historical on-road transport fleet.[41] Although zero emission vehicles (ZEV) have started to penetrate into the global market, they account for only a small portion of the current fleet.[42] It is important to acknowledge that the

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[38] Rowangould, D., Karner, A., & London, J. (2016). Identifying Environmental Justice Communities for Transportation Analysis. Transportation Research Part A: Policy and Practice, 88, 151-162. https://doi.org/10.1016/j.tra.2016.04.002

[39] The Center for Neighborhood Technology. (n.d.). The H+T® Affordability Index. Retrieved from https://htaindex.cnt.org/

[40] Collins, T. W., Grineski, S. E., & Chakraborty, J. (2015). Household-Level Disparities in Cancer Risks from Vehicular Air Pollution in Miami. Environmental Research Letters, 10(9), 095008. https://doi.org/10.1088/1748-9326/10/9/095008;

Clark, L. P., Millet, D. B., & Marshall, J. D. (2017). Changes in Transportation-Related Air Pollution Exposures by Race-Ethnicity and Socioeconomic Status: Outdoor Nitrogen Dioxide in the United States in 2000 and 2010. Environmental Health Perspectives, 125(9), 097012. https://doi.org/10.1289/EHP959;

Gurram, S., Stuart, A. L., & Pinjari, A. R. (2019). Agent-based modeling to estimate exposures to urban air pollution from transportation: Exposure disparities and impacts of high-resolution data. Computers, Environment and Urban Systems, 75, 22-34. https://doi.org/10.1016/j.compenvurbsys.2019.01.002

[41] Davis, S. C., & Boundy, R. G. (2021). Transportation Energy Data Book Edition 39. Oak Ridge National Laboratory. https://tedb.ornl.gov/wp-content/uploads/2021/02/TEDB_Ed_39.pdf

[42] International Energy Agency. (2021). Global EV Outlook 2021: Accelerating the transition to electric vehicles. Retrieved from https://www.iea.org/reports/global-ev-outlook-2021

transition to EV and other ZEV technologies may be more of a tradeoff that involves reducing and relocating emission impact areas rather than eradicating of emission impacts entirely.

Encouraging the transition to ZEV technologies, such as electric vehicles (EV), can reduce mobile source emissions along high volume corridors and improve air quality along roadways in general. However, it should be noted that the use of ZEV technology will relocate (rather than eliminate) some emissions. The additional electric power generation needed for EVs will require more production from electric power plants and increase the associate air emissions. Power plants also tend to be located in close approximation to disadvantaged communities. Ultimately, while ZEV and EV technology can serve to improve impacts on disadvantaged communities, it should not be thought of a panacea to eliminate all impacts on disadvantaged communities.

Disadvantaged communities are also vulnerable to climate change and extreme weather events such as coastal and inland flooding. These impacts can be exacerbated by transportation infrastructure and create environmental justice concerns .[43] For example, minority communities are more likely to be located in areas with the highest projected increase in traffic delays because of coastal flooding. Low-income populations and populations with lower education levels are more likely live in areas with the highest projected increase in property flood impacts due to coastal flooding. For example, elderly populations are likely live in areas with the highest projected property damage due to inland flooding.

One tool that can help analyze and evaluate climate change impacts in environmental justice communities is the MOtor Vehicle Emission Simulator (MOVES), developed by U.S. Environmental Protection Agency (EPA).[44] This tool is already used to quantify and monitor pollutant emissions inventories in EPA State Implementation Plan and Transportation Conformity processes.[45] MOVES can be used to estimate mobile source air pollutant emissions by user-defined road segments at high spatial resolution and is capable of predicting precise and accurate vehicle emission hotspots based on real-world measurements. For example, Khan and Frey (2016) used MOVES to estimate light-duty gasoline vehicle air pollutant emission rates, including on quarter-mile road segments.[46]

MOVES can also be used to quantify on-road vehicle emissions for selected geographic areas, time periods, and combinations of contributing sources (i.e., the on-road mix of vehicles, such as light-duty vehicles, heavy-duty trucks, buses). The emission estimation can be done at the county, census tract, or possibly census block level, depending on availability of suitable vehicle activity data. Historical vehicle activity data, such as vehicle average speed on specific road segments, can be obtained from traffic simulation models or empirical measurements.[47] Census blocks are formed by streets, roads, railroads, streams and other bodies of water, other visible physical and cultural features, and legal boundaries. The application of high spatially-resolved vehicle emission rates to inform environmental justice analyses using census block information has not yet been demonstrated in the existing literature.

The EPA EJScreen tool quantified the intersection of social vulnerability and exposure to environmental hazards, including hazards stemming from transportation infrastructure. The tool is based on the census

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[43] EPA. (2021).

[44] U.S. Environmental Protection Agency [EPA]. (2022f). Moves3:). Latest Version of the Motor Vehicle Emission Simulator (MOVES). Retrieved from https://www.epa.gov/moves/latest-version-motor-vehicle-emission-simulator-moves

[45] U.S. Environmental Protection Agency [EPA]. (2009a. (2009). Guidance for Developing Transportation Conformity State Implementation Plans (SIPs). Retrieved form https://nepis.epa.gov/Exe/ZyPDF.cgi/P1002W5B.PDF?Dockey=P1002W5B.PDF

[46] Khan, T., & Frey, H. C. (2016). Evaluation of Light-Duty Gasoline Vehicle Rated Fuel Economy Based on In-Use Measurements. Transportation Research Record, 2570(1), 21–29. Retrieved from https://doi.org/10.3141/2570-03.

[47] Zhou, Z., Yang, Z., Zhang, Y., Huang, Y., Chen, H., & Yu, Z. (2022). A Comprehensive Study of Speed Prediction in Transportation System: From Vehicle to Traffic. iScience, 25(3), 103909. Retrieved from https://doi.org/10.1016/j.isci.2022.103909

block level.[48] The census block data from EJScreen include environmental justice indices, socioeconomic indicators, health disparities, pollution sources, and climate change data. Such census block data can be spatially joined with the air emissions data estimated for a study area to identify disparities and to prioritize potential interventions or mitigations aimed at reducing disparities. EJScreen tools can be used to look at historic data as far back as 2015, accounting particularly for historical differences in mobile source air emissions. EJScreen also includes reference layers for climate change data, such as drought, coastal flood hazard, and sea level rise. Such data can be used to analyze and evaluate the climate change impacts on the environmental justice communities.

To avoid disruption of community cohesion, it is important to consider flooding mitigation options that allow communities to stay in place and design infrastructure that will enhance community connectivity. An example is a community-centered, citizens design guide to encourage building more resilient individual residences and communities after a storm event or frequent flooding events.[49] Beyond offering homeowners design guidance on rebuilding their homes in a more resilient manner (higher elevation, resilient design standards), the guide lays out neighborhood-scale, community-driven design approaches to build flood and storm resilient neighborhoods while enhancing community cohesion. These design standards and community driven approach set a series of best practices for mitigating environmental impacts and community disruption. These approaches can be considered for flooding mitigations and community cohesion design standards for communities impacted by transportation infrastructure projects.

Research shows that there are historical inequities related to the marginalization of communities of color to topographically and socially marginalized land, including locations with increased exposure to toxins and environmental hazards such as flooding. Boone (2009) looked at the higher elevations of wealthy settlement compared to low-land and wetland settlements that were populated by communities of color and socioeconomically marginalized populations.[50] For example, the case of I-40 in North Carolina illustrates how the creation of a dam generated floodwater issues for a nearby low-lying communities. City-funded storm water system corrections made after Hurricane Fran were located in wealthy, predominately white neighborhoods, while low-lying neighborhoods of color were required to pay increased water and sewer fees to upgrade the storm water systems in the neighborhood. Local community advocacy ultimately led to the city dropping the additional fees for storm water improvements. The advocacy group utilized the project to establish a recreational opportunity with bicycle and pedestrian connections near community wetlands. This research highlights the need to provide mitigation funding to address inequitable storm water infrastructure in communities of color.[51]

Best Practice: Mobile Source Air Emissions Reduction
Monitor, mitigate and reduce mobile source air emissions associated with disadvantaged communities proximity to roadways.

Best Practice: Zero Emission Vehicles to Improve Air Quality
Support the transition to zero emission vehicles (ZEV), including electric vehicles (EV), and ensure that disadvantage communities have access to ZEV infrastructure.

[48] [EPA]. (2022b). EJ Screen Technical Documentation. Retrieved from https://www.epa.gov/system/files/documents/2023-01/EJScreen%20Technical%20Documentation%20October%202022.pdf

[49] NCSU Coastal Dynamics Design Lab. (2017). Homeplace: A Conversation guide for the Princeville Community, Rebuilding After hurricane Matthew. Retrieved from https://coastalresiliencecenter.unc.edu/wp-content/uploads/sites/845/2018/09/HomePlace-Princeville-1.pdf

[50] Boone, K. (2009). The Resilience of Ruinous Futures: Race, Urbanism, and Ecology in the post-Jim Crow South. Uncommon Ground: Everyday Aesthetics and the Intentionality of the Public Realm, Intensions, Issue 2.0, Spring. Retrieved from http://www.yorku.ca/intent/issue2/articles/pdfs/KofiBooneArticle.pdf

[51] Ibid.

Best Practice: Storm Water Infrastructure Improvements
Reduce transportation related flooding impacts on local communities by assessing, mitigating and preparing for more intense and frequent storm events.

Health Impacts of Transportation Infrastructure Investment

Air pollutant emissions and health impacts from transportation facilities in general tend to be located disproportionately near overburdened communities that have been historically marginalized. Rowangould (2013) studied US Census data and determined that while 20% of the total US population live along high volume roadways, a disproportionate 27% of non-white populations live near these facilities.[52] These communities are also less likely to have air quality monitors. These disparities exist among economically marginalized communities in both urban and rural locations throughout the US. In many cases, the proximity of transportation facilities to overburdened communities is the result of historical planning and transportation investment practices that systematically located high volume through-traffic roadways in minority and low-income communities.

Health impacts associated with air quality along transportation corridors are due in large part to mobile source air emissions such as CO_2, carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (NO_x), and particulate matter (PM).[53] Nitric oxide (NO) and nitrogen dioxide (NO_2) constitute NO_x. The air pollution caused by CO, HC, NO_2, and PM have been associated with adverse health effects.[54] For example, inhalation of $PM_{2.5}$ (particles less than 2.5 µm in aerodynamic diameter) can cause cardiovascular disease and premature mortality because $PM_{2.5}$ can cross from lungs into the bloodstream[55] Additionally, HC and NO_x are precursors for ground-level ozone formation, which is known to cause health problems such as damage to lung tissue and reduction of lung function.[56] NO_2 and PM are also key pollutants of concern to communities overburdened with environmental exposures that contribute to environmental justice concerns.

Research on health related air quality during the COVID-19 pandemic lockdown explored the inequitable spatial distribution of ambient transportation-related NO_2 pollution among socioeconomic groups. The study found that while decreased traffic volume on roadways led to a dramatic reduction in NO_2 levels, the level of NO_2 among non-white populations was still higher than that among white populations.[57] Exposure to NO_2 is a known cause of respiratory disease and can contribute to premature mortality.

Health care access for vulnerable and disadvantaged communities is impacted by transportation cost, access and time burden. Syed et al (2013) conducted a survey and synthesis of existing transportation

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[52] Rowangould, G. M. (2013). A Census of the US Near-roadway population: Public health and environmental justice considerations. Transportation Research Part D: Transport and Environment, 25, 59-67. Retrieved from https://doi.org/10.1016/j.trd.2013.08.003

[53] U.S. Environmental Protection Agency [EPA]. (2014). Near Roadway Air Pollution and Health. Retrieved from https://www.epa.gov/sites/default/files/2015-11/documents/420f14044_0.pdf

[54] Ibid;

U.S. Environmental Protection Agency [EPA]. (2009b. (2009). Exposure Factors Handbook - Update (External Review Draft). Retrieved from https://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=202856;

Kim, K. H., Jahan, S. A., & Kabir, E. (2013). A Review on Human Health Perspective of Air Pollution with Respect to Allergies and Asthma. Environmental international, 59, 41-52

[55] U.S. Environmental Protection Agency [EPA]. (2022g. (2022). Particulate Matter (PM) Basics. Retrieved from https://www.epa.gov/pm-pollution/particulate-matter-pm-basics

[56] Seinfeld, J. H. & Pandis, S. N. (2016). Atmospheric Chemistry and Physics: From Air Pollution to Climate Change. John Wiley & Sons;

U.S. Environmental Protection Agency [EPA]. (2022h. (). Particle Pollution and Respiratory Effects. Retrieved from https://www.epa.gov/pmcourse/particle-pollution-and-respiratory-effects

[57] Kerr, G. H., Goldberg, D. L., & Anenberg, S. C. (2021). COVID-19 pandemic reveals persistent disparities in nitrogen dioxide pollution. Proceedings of the National Academy of Sciences, 118, e2022409118. https://doi.org/10.1073/pnas.2022409118

and public health literature to better understand the relationship between transportation and access to health care.[58] Many of the studies reviewed found that lack of access to a personal vehicle, transit availability, distance to health care and travel time to health care impacted health care visits for members of vulnerable communities. A survey of National Health Interview Survey (NHIS) data, Medical Expenditure Panel Survey (MEPS) data, and Bureau of Transportation Statistics (BTS) data yielded an estimate of 3.6 million people citing transportation barriers as the reason they did not obtain medical care.[59] Those reporting transportation issues tended to be low-income, from minority communities, less educated and female.[60] A study in Texas indicated that over half of black (55%) and Hispanic (60%) cancer patients had trouble accessing cancer care due to transportation issues. The study found 38% of white patients had the same trouble accessing care due to transportation issues.[61] Study results are mixed about differences between rural and urban health care access with some studies showing rural populations more likely to cite transportation access as a barrier to care and some studies indicating there is no significant differences between urban and rural transportation barriers.[62]

One way to address health impacts and access to affordable transportation is providing better multimodal connectivity, specifically bicycle and pedestrian connectivity. Bicycle and pedestrian facility studies evaluate the number of system users or outline the best practices for increasing usage of bicycle and pedestrian networks and their connectivity to transit.[63] The Guidebook for Developing Pedestrian and Bicycle Performance Measures presents seven community goals for analyzing the impacts of bicycle and pedestrian facilities - connectivity, economic, environmental, equity, health, livability, and safety.[64] The Massachusetts DOT and MassTrails studied six categories of bicycle and pedestrian trail-induced impacts on health, accessibility and equity, transportation, economic, environmental, and safety impacts.[65] The study captured a reduction in vehicle miles traveled, and active commute trips enhanced access and connectivity for historically transportation-disadvantaged communities. Research also shows that there

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[58] Syed, S. T., Gerber, B. S., & Sharp, L. K. (2013). Traveling Towards Disease towards disease: Transportation Barriers to Health Care Access. Journal of Community Health, 38(5), 976-993. https://doi.org/10.1007/s10900-013-9681-1

[59] Wallace, R., Hughes-Cromwick, P., Mull, H., & Khasnabis, S. (2005). Access to Health Care and Nonemergency Medical Transportation. *Transportation Research Record: Journal of the Transportation Research Board*, *1924*(1), 76–84. https://doi.org/10.1177/0361198105192400110

[60] Ibid.

[61] Guidry, J. J., Aday, L. A., Zhang, D., & Winn, R. J. (1997). Transportation as a Barrier to Cancer Treatment. *Cancer Practice*, *5*(6), 361–366.

[62] Blazer, D. G., Landerman, L. R., Fillenbaum, G., & Horner, R. (1995). Health Services Access and Use among Older Adults in North Carolina: Urban vs Rural Residents. American Journal of Public Health, 85(10), 1384-1390;

Heckman, T. G., Somlai, A. M., Peters, J., Walker, J., Otto-Salaj, L., Galdabini, C. A., et al. (1998). Barriers to Care Among Persons Living with HIV/AIDS in Urban and Rural Areas. AIDS Care, 10(3), 365-375;

Probst, J. C., Laditka, S. B., Wang, J. Y., & Johnson, A. O. (2007). Effects of Residence and Race on Burden of Travel for Care: Cross Sectional Analysis of the 2001 US National Household Travel Survey. BMC Health Services Research, 7, 40;

Sarnquist, C. C., Soni, S., Hwang, H., Topol, B. B., Mutima, S., & Maldonado, Y. A. (2011). Rural HIV-infected Women's Access to Medical Care: Ongoing Needs in California. AIDS Care, 23(1), 792-796;

Skinner, A. C., & Slifkin, R. T. (2007). Rural/urban Differences in Barriers to and Burden of Care for Children with Special Health Care Needs. The Journal of Rural Health: Official Journal of the American Rural Health Association and the National Rural Health Care Association, 23(2), 150-157;

Syed et al. (2013).

[63] U.S. Federal Highway Administration [FHWA]. (n.d.). PlanWorks: Bicycles and Pedestrians. Retrieved from https://fhwaapps.fhwa.dot.gov/planworks/Applications/Show/bicycles-and-pedestrians;

Ermagun, A., Lindsey, G., & Loh, T. H. (2018). Bicycle, pedestrian, and mixed-mode trail traffic: A performance assessment of demand models. Landscape and Urban Planning, 177, 92-102. https://doi.org/10.1016/j.landurbplan.2018.05.006;

Ryan, S., & Frank, L. F. (2009). Pedestrian Environments and Transit Ridership. Journal of Public Transportation, 12(1), 39-57. doi:10.5038/2375-0901.12.1.3. Available at: https://digitalcommons.usf.edu/jpt/vol12/iss1/3

[64] U.S. Federal Highway Administration [FHWA]. (2013). Guidebook for Developing Pedestrian and Bicycle Performance Measures (Publication No. FHWA-HEP-13-029). Office of Human Environment. Retrieved from https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/performance_measures_guidebook/fhwahep13029.pdf

[65] Massachusetts Department of Conservation and Recreation. (2018). Massachusetts Trails Study: Shared Use Path Impacts Study. Retrieved from https://www.mass.gov/doc/masstrails-shared-use-path-impacts-study/download

are mental health benefits associated with providing better multimodal access for those who are unable to drive.[66] These emerging considerations related to transportation equity, health, and connectivity provide new means for assessing the impacts of projects on disadvantaged communities.

Increasing bicycle and pedestrian facilities in disadvantaged areas requires establishing appropriate accompanying roadway designs to provide safe multimodal mobility. A 2012 observational study in Montreal found that traffic volume and road design differs between wealthy urban neighborhoods and low-income urban neighborhoods, which could help explain the disproportionate road traffic injuries low-income neighborhoods experience.[67] The study found that roadway design in the low-income areas resulted in increased exposure to the higher traffic volumes, higher traffic speeds, more arterial roads and more four way intersections. In contrast, affluent neighborhoods tended to have lower traffic volumes, more traffic calming measures, and more three way intersections. The difference in roadway design features coupled with increased levels of pedestrian activity in the low-income neighborhoods led to six times more pedestrian injuries in the poorest neighborhoods of the city. [68] This research highlights the importance of reducing traffic volume and implementing traffic calming methods as an essential element of roadway design in low-income urban areas to prevent pedestrian injuries.

Additionally, recent research shows that some elements of cycling and walking in disadvantage communities can impact physical safety and mental health. The issue of over-policing of cyclist and pedestrian, where people of color are more likely to be stopped and engaged by law enforcement while cycling or walking, poses a risk and burden in disadvantaged communities.[69]

Best Practice: Increase Bicycle and Pedestrian Connectivity
Develop and expand bicycle and pedestrian networks to connect disadvantaged communities to essential services and to re-connect communities that have been divided and cutoff by past highway projects.

Best Practice: Implement Traffic Calming and Roadway Design Measures
Implement traffic calming designs and strategies and improve pedestrian facilities to reduce pedestrian crash and injury risk.

[66] Marottoli, R. A., Mendes de Leon, C. F., Glass, T. A., Williams, C. S., Cooney Jr, L. M., Berkman, L. F., & Tinetti, M. E. (1997). Driving Cessation and Increased Depressive Symptoms: Prospective Evidence from the New Haven EPESE. Established Populations for Epidemiologic Studies of the Elderly. Journal of the American Geriatrics Society, 45(2), 202-206. doi: 10.1111/j.1532-5415.1997.tb04508.x

[67] Morency, P., Gauvin, L., Plante, C., Fournier, M., & Morency, C. (2012). Neighborhood Social Inequalities in Road Traffic Injuries: The Influence of Traffic Volume and Road Design. American Journal of Public Health, 102(6), 1112-1119.

[68] Ibid.

[69] Brown, C.T., Rose, J. and Kling, S (2023). Barriers to Walking, Biking, and E-Scooter Use in Black Communities In The United States.

TOOLS AND DATA FOR CAPTURING TRANSPORTATION INEQUITY

Assessing how transportation decisions impact communities, especially those that are historically disadvantaged, burdened, or that are physically and/or socially vulnerable is key to improving equity across North Carolina. To better understand the current and emerging practices that can support the identification and measurement of these factors at a community level, the research team reviewed the growing number of resources focused on environmental justice. This perspective provides the benefits of a comprehensive picture of environmental and social stressors faced by communities and a framework for considering multiple environmental and social stressors within a single cumulative measure.

There are national and state resources designed to help transportation practitioners assess impacts related to environmental justice and equity, such as Assessing Indirect Effects and Cumulative Impacts Under NEPA (2016) and EJScreen: Environmental Justice Screening and Mapping Tool.[70] In recent years, new resources, like the FHWA's Community Connections Innovations Handbook (2018) and new tools stemming from the USDOT's Justice40 Initiative (2021) have offered updated guidance on how to mitigate the burdens and enhance the benefits of transportation projects through thoughtful and collaborative processes.[71] However, while these tools provide reputable approaches for examining injustices associated with transportation projects, transportation agencies like NCDOT are still challenged to systematically measure environmental justice impacts and improve approaches for addressing inequities. This is because many of these resources are not designed to capture a deep before-and-after analysis of impacts at the community level and do not include an analysis of historical impacts. Additionally, appropriate approaches for collecting data and community input can vary by geographic area and historical context and the quality and availability of the data required to do such analyses is not always clear.[72] Statewide screening tools like those described in the sections below can augment project-based assessment efforts by contextualizing project locations and impacts within the broader setting of the existing and historical burdens local to impacted communities.

This section describes the existing and emerging tools, methods, and data for describing and quantifying disadvantage and vulnerability within communities and the environmental burdens that communities face. A complete landscape analysis of national and state level environmental justice screening tools, including an inventory of common environmental and social indicators and their sources, is available in the Data Review and Inventory section.

Foundational Socioeconomic Data for Identifying Vulnerable Communities

Environmental justice assessments conducted by local, state, and federal agencies are typically predicated on the definition and identification of communities that have historically lacked equal access to transportation benefit, as well as those communities impacted by the disproportionate burdens from transportation projects. The exact terminology used to define such communities and the specific data and

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[70] American Association of State Highway and Transportation Officials. (2019). Assessing Indirect Effects and Cumulative Impacts Under NEPA: Practitioner's Handbook. Retrieved from https://environment.transportation.org/resources/practitioners-handbooks/assessing-indirect-effects-and-cumulative-impacts-under-nepa/;
EPA (2022b2022).

[71] U.S. Federal Highway Administration [FHWA]. (2018a. (2018). Community Connections Innovations Handbook (Report No. FHWA-HEP-19-002). Retrieved from https://rosap.ntl.bts.gov/view/dot/43556;
White House Office of Management and Budget. (2021). Memorandum on Improving the Federal Government's Consistent Use of Grant Programs to Advance Equity and Support Underserved Communities. Retrieved from communities [PDF]. https://www.whitehouse.gov/wp-content/uploads/2021/07/M-21-28.pdf

[72] FHWA. (2016).

methodologies used to identify them vary across agencies and depend on policy objectives specific to those agencies. However, a review of the state of the practice reveals some common approaches. This is important because how these communities are defined and identified is foundational to emerging environmental justice assessments and indices that more comprehensively understand the burdens experienced by vulnerable populations by incorporating the environmental context.

Many useful models for assessing historically disadvantaged communities within the domain of transportation can be found in definitions for "Communities of Concern" (COCs) applied by metropolitan planning organizations (MPOs). A 2020 analysis by the Urban Institute found that approximately half of all definitions included just two community characteristics: concentration of populations who are low-income and/or in poverty and concentrations of racial and ethnic minority populations.[73] These factors reflect a minimum level of analysis for addressing Executive Order 12898 - Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations.[74] For MPOs that include additional community characteristics in their analysis, common factors include concentrations of limited English proficiency (LEP) populations, senior/elderly populations, populations with disabilities, and households without access to a vehicle.[75]

These definitions rely heavily on public demographic data provided in the U.S. Census, including U.S. American Community Survey (ACS). The ACS is an annual survey on a variety of topics that includes detailed demographic information like race, income, employment, household characteristics that are commonly used for conducting equity analyses.[76] The geographic scale at which this data is analyzed can vary by MPO. The Urban Institute review found that 42 MPOs use at least some data at the census tract level. Seventy-two definitions employ data at a smaller geography, including 36 definitions using census block group data, 24 using traffic analysis zones, and 12 using census blocks.[77] Typically, these analyses employ ACS 5-Year estimates, a running multi-year sample that ensures the greatest statistical reliability for small areas of analysis. There are a variety of strategies used by MPOs to compare community characteristics within regions. For example, one common approach used to define COCs is comparing characteristics at a small-scale census geography to the regional mean or median.

The most basic state-level definitions for historically vulnerable populations within an environmental justice context, where they have been formulated, often use similar indicators and techniques to MPO definitions for COCs. Representative examples include: (1) NCDEQ's definition for "Potentially Underserved Block Groups" employed their 2022 Environmental Justice Report for Biogas Digester General Permit Development, which considers race/ethnicity and poverty, (2) the definition for "Environmental Justice Populations" in Massachusetts, which uses household income, minority, and English language proficiency criteria at the block group level, [78] (3) the definition for "areas of increased concern for environmental justice" in Minnesota, which uses tribal areas and census tracts with poverty and minority criteria,[79] and (4) the definition for communities with environmental justice concerns in

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[73] Urban Institute. (2020).

[74] Executive Order 12898. (1994, February 11). Federal Actions to Address Environmental Justice in Minority Populations and Low-income Populations. Federal Register, 59 FR 7629.

[75] Urban Institute. (2020).

[76] U.S. Census Bureau. (2017). American Community Survey Information Guide. Retrieved from https://www.census.gov/content/dam/Census/programs-surveys/acs/about/ACS_Information_Guide.pdf U.S. Census Bureau. (2022).

[77] Urban Institute. (2020).

[78] Massachusetts Executive Office of Energy and Environmental Affairs. (2020). MA 2020 Environmental Justice Block Groups [Data set]. Retrieved from https://resilientma-mapcenter-mass-eoeea.hub.arcgis.com/datasets/ma-2020-environmental-justice-block-groups-nov2022-update/explore

[79] Minnesota Pollution Control Agency. (2021). Environmental Justice Populations by Census Block Group. [Data file and metadata]. Minnesota Geospatial Commons. Retrieved from https://gisdata.mn.gov/dataset/env-ej-mpca-census

Maryland, which uses poverty, minority, and English language proficiency criteria.[80] The state of Colorado employs a definition for "Disproportionately Impacted Community" in its Environmental Justice Act that employs household income, housing cost-burden, and minority criteria.[81]

Environmental Justice Screening Tools

A number of national- and state-level tools have emerged in recent years to help aid with quantifying and comparing the intersection of vulnerability and environmental burden in communities. The earliest and most commonly replicated of these is CalEnviroScreen, originally developed in 2013 and currently in its fourth version.[82] This tool and others like it are often referred to as "screens", as their primary use is in identifying the presence of environmental justice issues in communities and in facilitating statewide comparisons. The extent to which the information is developed and presented by these tools affects policy varies, as is further discussed herein. Typically, these tools are developed and/or housed within state environmental agencies rather than transportation agencies. However, the indicators employed in environmental justice screening tools often include direct or indirect environmental exposures and effects of transportation systems.

Screening tools provide opportunities to analyze all data relevant to assessing the confluence of vulnerability and burden summarized at a consistent geographic scale (e.g., the census tract, block group, county). In some cases, multiple geographies can be analyzed. Screening tools commonly quantify vulnerability and burden together into an "environmental justice index" by scoring individual criteria within a domain of analysis (e.g., social vulnerability, health, environmental exposure, and environmental effects), weighting each factor and analysis domain, and summing the weighted factors to produce a continuous index of values on 0-100 scale.[83] California's SB 535 Communities is one example of how EJ indices can be used to define a subset of communities with environmental justice issues for the purpose of directing policy.[84] SB 535 Communities are defined as those census tracts scoring in the top 25% in CalEnviroScreen, an index that combines pollution burden and population characteristics. It is important to note that this definition goes beyond demographic and socioeconomic indicators to include all factors related to vulnerability and burden, including public health factors, environmental exposure, and environmental effects. These communities are defined separately from communities with socioeconomic disadvantage factors alone.[85]

The designation of SB 535 communities allows for the formation of specific policy objectives related to these communities. California's SB 535 communities are specifically targeted for investment in mitigation of health, opportunity, and environmental risk disparities using the proceeds of the state's Cap-and-Trade program. New York State's definition for disadvantaged communities within the domain of its 2019 Climate Act ensures that the Act's funding directly benefits historically underserved and vulnerable communities. The Colorado EnviroScreen tool, modeled on CalEnviroScreen, is intended to assist in the

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[80] Maryland Department of the Environment [MDE].. (2020). Environmental Justice Policy. Retrieved from https://mde.maryland.gov/Documents/MDE_EJ_Env%20Justice%20Policy_Final_Dec2020.pdf

[81] Colorado Department of Public Health & Environment [CDPHE]. (2022). Colorado EnviroScreen v 1.0 Basic User Guide. Retrieved from https://drive.google.com/file/d/1aXfZiJtv2-6IfSQeQYfMupIICEXwidiC/view

[82] California Office of Environmental Health Hazard Assessment [COEHHA]. (2022). CalEnviroScreen 4.0. Retrieved from https://oehha.ca.gov/calenviroscreen/report/calenviroscreen-40 COEHHA. (2022).

[83] Ibid.;

MDE. (2020).;

CDPHE. (2022).;

Michigan Department of Environment, Great Lakes, and Energy [MDEGLE]. (2022). MiEJScreen: Environmental Justice Screening Tool (DRAFT). Retrieved from https://www.michigan.gov/egle/maps-data/miejscreenMDEGLE. (2022).

[84] California Senate Bill No. 535. (2012). An act to amend Section 39711 of the Health and Safety Code, Relating to Greenhouse Gases. Retrieved from https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201120120SB535

[85] COEHHA. (2022).

targeting of grants related to environmental justice. Screening tools in other states are tied to initiatives to increase protections and public participation in planning processes.

The White House Council on Environmental Quality's (CEQ) Climate and Economic Justice Screening Tool (CEJST) (currently in beta version) is a new federal tool that presents a tract level analysis of community disadvantage with regards to climate and legacy pollution risks and a variety of socioeconomic factors. The CEJST defines "disadvantaged communities" as any tract meeting a given threshold for any one or more of the tool's categories of burden. In most cases these criteria require communities to be in the 65th percentile for the low-income factor and in the 90th percentile for another factor (e.g., climate risks, health disadvantage, legacy pollution).

Screening tools can primarily aid agencies with the assessment of transportation project impacts by helping to identify projects that may have adverse impacts given their location relative to burdened communities. MPOs may use screening tools to identify communities of concern within project boundaries to ensure project compliance with EJ requirements tied to federal funding.[86] Screening tools may also significantly aid in the development of project assessments through the use of a Transportation Equity Scorecard, such as the one proposed by a University of South Florida guide.[87] Scorecards aid in the synthesis of systematically developed data sources like EJ indices and the particular characteristics of a transportation project. In this way, scorecards account for both project setting and project impact. Screening tools may be developed to assess project locations such that project location information developed from the screening tool can be extracted for use in a scorecard system. The Federal Highway Administration's (FHWA) Screening Tool for Equity Analysis of Projects (STEAP) is one such data extraction tool, which allows users to draw or select project locations and extract socioeconomic information relevant for use in equity analyses.[88]

Best Practice: Link Screening Tools Designation with Funding Opportunities
Dedicate specific funding for transportation improvement projects in disadvantaged communities as identified by set criteria and a data-driven EJ screening tool.

Environmental and Health Factors Employed in Environmental Justice Screening Tools

A previously stated, environmental justice screening tools combine both socioeconomic criteria and environmental, health, and climate factors to identify areas with the greatest confluence of both vulnerability and burden. Environmental and health data considered for environmental justice assessments is often divided into categories of environmental exposure (pollutants in the environment with which people are likely to come into direct contact) and environmental effects (negative environmental conditions resulting from pollutants).[89] Examples of indicators commonly included in these categories are:

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[86] Urban Institute. (2022).

[87] Rojas, M., Lugo, A., & Williams, B. (2021). The Transportation Equity Scorecard User Guide. University of South Florida, Center for Urban Transportation Research.

[88] U.S. Federal Highway Administration [FHWA]. (2020). Screening Tool for Equity Analysis of Projects (STEAP). Retrieved from https://hepgis.fhwa.dot.gov/fhwagis/buffertool FHWA. (2020).

[89] COEHHA. (2022);
CDPHE. (2022);
MDE. (2020);
MDEGLE. (2022).

Environmental Exposure:

- Air Pollutants
- Traffic Proximity
- Toxic Releases to Air
- Lead Risk from Housing
- Drinking Water Contaminants
- Noise Exposure

Environmental Effects:

- Proximity to Sites that Pose Environmental Risks
- Proximity to Solid Waste Facilities
- Proximity to Impaired Waterbodies
- Groundwater Threats

Data for these indicators are available from a variety of federal and state sources. A useful database of national-level sources is maintained by EPA for its EJScreen tool, a mapping and screening tool that combines socioeconomic and environmental indicators in a number of indices to assist in environmental justice analysis. Data for the EJScreen tool is developed and maintained by the EPA and in some cases is partially sourced from other federal agencies, including the Department of Transportation and the U.S. Census Bureau.[90] In many cases, national-level data sources can be supplemented or replaced by more robust local environmental data sources. One key indicator missing from EJScreen that may be available in state-level data for certain states is a measure of local drinking water quality.[91]

Climate-related risk factors are also commonly included with other environmental risks. These risks commonly include vulnerability to extreme heat, flooding, drought, and wildfires.[92] These risks may be estimated using models of future climate conditions. In the case of the EJScreen, this data is sourced from First Street Foundation, a non-profit research group specializing in climate risk modeling. It is important to note that some processing of environmental data is typically required to summarize environmental indicators at the same community level analyzed for socioeconomic criteria. In many cases. The EPA provides data summarized at the block group level for the datasets used in EJScreen.[93]

Health indicators may be included in addition to demographic criteria to capture additional components of community vulnerability to environmental pollutants. Health related indicators describe the presence of

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[90] EPA. (2022b2022).

[91] U.S. Environmental Protection Agency [EPA]. (2022e. (2022). Limitations and Caveats of Using EJSCREEN. Retrieved from https://www.epa.gov/ejscreen/limitations-and-caveats-using-ejscreen

[92] CDPHE. (2022);
New York State Climate Justice Working Group [NYSCJWG]. (2022). Draft Disadvantaged Communities Criteria and List Technical Documentation. Retrieved from https://climate.ny.gov/-/media/Project/Climate/Files/Disadvantaged-Communities-Criteria/Technical-Documentation-on-Disadvantaged-Community-Criteria.pdf

[93] EPA. (2022b2022).

populations physically sensitive to the health risks posed by environmental exposures. Health indicators may include, but are not limited to, life expectancy and the incidence of heart disease, asthma, cancer, diabetes, and mental health conditions.[94] A valuable national source for health data is the Center for Disease Control's PLACES database, which provides community level health indicator estimates for census tracts and other geographies nationwide.[95] State-maintained health data may supplement national data where available.

Best Practice: Develop Comprehensive Screening Tools
Develop a locally-relevant comprehensive screening tool for environmental justice that highlights the intersection of community vulnerability and environmental burden. A comprehensive screening tool should include environmental exposures, environmental effects, health vulnerabilities, and socioeconomic characteristics of communities.

Limitations of Screening Tools

Verifying Data

Screening tools use data and methods to illuminate differences between communities. Although the tools identified in this section reference rigorously reviewed sources, there may be differences between what has been remotely sensed and what is directly observed or experienced "on the ground". Care should be taken to 'ground-truth' indirectly acquired data through a field verification. Additionally, datasets like demographics derived from census tracts and county level analysis can lack the place-specificity required for detailed assessments. Partnering with stakeholders and institutions in disadvantaged communities to engage in field verification and augment indirectly observed data with local knowledge is an opportunity to build trust and empower communities with skills and information.

Data Challenges for Conducting Historical Assessments

In general, the data and tools available for assessing community vulnerability and burdens with respect to environmental justice describe current conditions, which may reflect historic inequities but can provide little context for them. Digital datasets employed in screening tools, including census tables and environmental data, are typically either very limited or not available for years prior to the twenty-first century, with many only available for the last couple of decades of the twentieth century. Additionally, archived records that have not be digitalized are not comprehensive for all relevant datasets. Consequently, data-driven historical analyses of infrastructure project impacts that aim to accurately characterize communities at the time of project construction may need to be informed by other data sources. Nevertheless, current data and the limited historical records are often useful in illuminating the patterns that developed due to historical injustices and inequities.

Datasets that reflect the historical locations of some of the social vulnerability characteristics included in modern EJ analyses include the "redlining" maps produced by the Home Owners' Loan Corporation (HOLC). These maps used color ranking to grade neighborhood quality in many American cities in 1930's

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[94] COEHHA. (2022);
CDPHE. (2022);
MDE. California Environmental Protection Agency, Office of Environmental Health Hazard Assessment. (2022). CalEnviroScreen Indicators. Retrieved from https://oehha.ca.gov/calenviroscreen/indicators;
Colorado Department of Public Health and Environment. (2022). Center for Health and Environmental Data. Retrieved from https://cdphe.colorado.gov/center-for-health-and-environmental-data;
MD Department of the Environment. (2020);
MDEGLE. (2022). Michigan Department of Health and Human Services. (2022). Critical Health Indicators. Retrieved from https://www.michigan.gov/mdhhs/inside-mdhhs/legislationpolicy/critical-health-indicators

[95] Centers for Disease Control and Prevention [CDC]. (2021). Population Level Analysis and Community Estimates (PLACES). Retrieved from https://www.cdc.gov/places/index.html

and which were heavily informed by resident race and ethnicity.[96] Likewise, the long-form decennial U.S. Census provides some socioeconomic data at the tract level (with limited racial categories) for each decade in the twentieth century (and in some cases, earlier decades). Historic aerial imagery may also be available for documenting the physical footprint of many projects; the NCDOT Photogrammetry Unit maintains aerial imagery for the state dating back to 1955.[97]

Community Change

Community Vulnerabilities Beyond the Environment

Environmental justice screening tools are designed to help address inequitable distribution of environmental burdens. It should be noted that communities may be negatively impacted, and have historically been negatively impacted, by transportation policies and projects that disrupt the fabric of communities beyond the limited environmental dimension. These potential social and economic disruptions are not directly accounted for within purely environmental screening tools. The review found that EJ screening tools all lack data needed to quantify historical social and economic disruptionsAs the historical account included in this report demonstrates, communities are characterized by constant change. While many of the screening tools described here attempt to account for historical processes, they generally do not include data or methods that account for future trends. Forces of change already underway like displacement and the suburbanization of poverty are changing the landscape of disadvantage in many communities. While communities change, transportation projects are typically designed to be long-term investments. Failure to account for ongoing changes could result in mismatches between projects and community needs. Additionally, transportation investments can interact with forces of change, in some cases accelerating them. These complicated interactions reinforce the importance of community collaboration for developing more in-depth understanding of community experiences. to communities by transportation projects on a specific, local level.

Best Practice: Public Participation and Field Verification
Develop screening tools through a collaborative process with historically burdened communities and ensure a high level of transparency. Final products should be publically availability and be design to be understandable to the public.

[96] Mapping Inequality. (n.d.).: Redlining in New Deal America. University of Richmond Digital Scholarship Lab. Retrieved from https://dsl.richmond.edu/panorama/redlininghttps://dsl.richmond.edu/panorama/redlining/#loc=[latitude]/[longitude]/[zoom

[97] North Carolina Department of Transportation [NCDOT]. (2018). Photogrammetry Handout. Retrieved from https://connect.ncdot.gov/resources/DMPDT/DMPDT%20Documents/Preconstruction%20Workshop%202018/Informational%20Stations%20-%20Documents%20and%20Handouts/Photogrammetry/Photogrammetry_Handout.pdf

EQUITY IN THE TRANSPORTATION DECISION-MAKING PROCESS

Recently, the federal government established more policies and guidance to address inequity in the transportation planning and investment decision-making process. These polices and guidance range from an executive order that establishes a policy for all federal agencies to a US Department of Transportation (USDOT) action plan designed to address inequality in the federal funded transportation decision-making process. Executive Order 13985 sets the new federal policy across federal agencies by defining inequity among underserved and vulnerable populations as:

> *"the consistent and systematic fair, just, and impartial treatment of all individuals, including individuals who belong to underserved communities that have been denied such treatment, such as Black, Latino, and Indigenous and Native American persons, Asian Americans and Pacific Islanders and other persons of color; members of religious minorities; lesbian, gay, bisexual, transgender, and queer (LGBTQ+) persons; persons with disabilities; persons who live in rural areas; and persons otherwise adversely affected by persistent poverty or inequality"*[98]

Following this executive order, the USDOT developed an Equity Transportation Plan (2022) calling for increased focus on developing scale-able and sustainable interventions to improve access and opportunities to underserved, overburdened and disadvantaged communities. The document lays out equity goals, focus areas and USDOT accountability actions regarding equity in the transportation planning and funding process. Explaining the goal and action items associated with the plan, the document notes that the equity action plan:

> *"...highlights key actions that USDOT will undertake to expand access and opportunity to all communities while focusing on underserved, overburdened, and disadvantaged communities. The actions described here fall under four focus areas – wealth creation, power of community, interventions, and expanding access. Actions include providing technical assistance to small disadvantaged businesses, reinvigorating USDOT's programmatic enforcement of Title VI of the Civil Rights Act, launching a national technical assistance center, and developing a national transportation cost burden measure".*[99]

The action plan outlines a four-stage progression to move from a "foundational stage", where equity is part of the planning discussion but lacks an action plan and defined equity goals, to the culmination of the "institutional stage", where funding in continuous and requisite decision-making is embedded in the overall planning process and organizational structure. USDOT situates this action plan in the two middle stages. The current 'building stage' acknowledges equity as a community benefit, however transportation planning and decision-making processes still lack nationally consistent mechanisms to ensure equitable outcomes. Many of the plan's recommendations are situated in the 'scale up' stage where significant

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[98] Biden, J.R. (2021). Executive Order on Advancing Racial Equity and Support for Underserved Communities Through the Federal Government. The White House. Retrieved from https://www.whitehouse.gov/briefing-room/presidential-actions/2021/01/20/executive-order-advancing-racial-equity-and-support-for-underserved-communities-through-the-federal-government/

[99] U.S. Department of Transportation [USDOT]. (2022). Equity Action Plan. Retrieved from https://www.transportation.gov/sites/dot.gov/files/2022-04/Equity_Action_Plan.pdf

resources need to be provided to ensure equity goals are established consistently throughout the processes.[100]

Understanding the framework developed by the Equity Action Plan and how it addresses comments provided by transportation agencies is vital for understanding the current state of the practice at the state and MPO levels, as well as preparing for any potential federal policy and guidance changes. As a part of the action plan, USDOT released a Request for Information (RFI) and received comments from state transportation agencies, MPOs, public transit and planning agencies, consulting firms and nongovernmental organizations (NGOs). Biskar et al. (2022) studied the comments provided by state DOTs and developed a maturity index to score the 11 state DOTs that responded to the RFI.[101] The researchers examined the response comments for the 11 responding state DOTs regarding their current agency equity processes, data collection and equity metrics. The researcher followed up by reviewing online publicly available data provided by each of the 11 DOTs. The result of research was a ranking of the state DOTs based on a 15-point maturity index. The top scoring state DOTs were California DOT (Caltrans - 15 points), Washington State DOT (WSDOT - 14 points), and Minnesota DOT (MNDOT - 13 points). NCDOT did not provide comments for the RFI and was therefore not scored in the study.

Summarizing the RFI comments, many state agency respondents note that USDOT should provide more guidance and assistance in transportation equity data collection and data sharing. Some called for equity data to be set as a requirement, while others sought to have USDOT simply encourage the development of equity data. Some of the best practices highlighted in the comments include development of an equity index; development of a healthy places index; agency-level equity statements and strategic plans; conducting internal agency equity audits; conducting assessments to compare transit competitiveness with auto-based transportation network performance; conducting equity assessments for agency wide policies; developing environmental justice advisory boards; building transportation equity toolkits; and developing statewide EJ and Health disparity strategic plans.[102] These comments helped inform the final action plan.

Using the four focus areas of the USDOT Equity Transportation Plan (2022) as the framework for exploring national practices for transportation decision-making, best practices will be presented in the thematic categories that parallel the USDOT focus areas: wealth creation, power of community, interventions and expanding access.[103]

Wealth Creation

The goal of this focus area is to use direct contracting dollars to build capital, capacity and networks among historically disadvantaged businesses. The Equity Transportation Plan sets a goal of 20% of federal contracting dollars going to disadvantaged businesses by Fiscal Year 2025.[104] The Transportation Equity Caucus, a large transportation advocacy coalition that advances economic, social and environmental justice policies, notes that equitable workforce development requires providing affordable training opportunity to disadvantaged groups for all aspects of transportation infrastructure

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[100] Ibid.

[101] Biskar, L., McCahill, C., Hughson, L., Nazarali, J., Kimme, A., & Lewis, A. (2022). The USDOT's Request for Information on Transportation Equity Data: An Analysis of State DOT Responses. Policy Lab, SSTI. Retrieved from https://dabiagk9ykpqc.cloudfront.net/wp-content/uploads/sites/1303/2022/08/Policy_Lab_SSTI_RFI_Transportation_Equity_Data.pdf

[102] Biskar et al. (2022);

U.S. Department of Transportation [USDOT]. (2021). Summary of Public Comments: DOT Equity RFI. Retrieved from https://www.transportation.gov/sites/dot.gov/files/2021-11/Summary%20of%20Public%20Comments%20DOT%20Equity%20RFI.pdf

[103] USDOT. (2022b).2022),

[104] Ibid.

development workforce, as well as, strengthen federal contracting goals and accountable for compliance, and ensure that all members of the workforce are paid a fair wage.[105]

One of the mechanisms to advance workforce development and contract equity in disadvantaged communities is federal and state funding for disadvantage business enterprise programs. The Bipartisan Infrastructure Law (BIL) continues the Disadvantaged Business Enterprise Supportive Services (DBE-SS) program. The program is designed to provide training and assistance to minority businesses that conduct federal funding eligible transportation planning, development and delivery activities. The program goal is to create an equitable basis for minority businesses to compete for contracts and subcontracts in the transportation investment process. The law provides $10 million a year in funding to be distributed to state transportation agencies based on formula funding.[106]

Additional funding flexibility allows state DOTs to provide unlimited funding from their National Highway Performance Program, Surface Transportation Block Grant Program, Highway Safety Improvement Program, and Congestion Mitigation and Air Quality Program to engage in workforce development efforts. This funding can be used at a 100% federal cost-share, meaning no state match would be required.[107] Additionally, the BIL authorizes State DOTs to set hiring preferences based on geography or economic disadvantage for construction jobs to create workforce development and employment opportunities for underrepresented and historically disadvantaged groups.[108]

North Carolina has a legislatively mandated NCDOT DBE program that provides minority and women business enterprise certification, small-business enterprise certification, small professional services firm certification, and unified certification programs to qualifying businesses. The North Carolina Department of Administration also offers the Historically Underutilized Business (HUB) certification. A 2020 study from the NC Department of Administration showed that NCDOT awards the highest dollar amount to minority- and women-owned business enterprises in the state, spending $27,385,195 between fiscal year 2014 and fiscal year 2017. The report also praised NCDOT for its user-friendly DBE-certified vendor directory page.[109] The state target for DBE spending is 10% of a state agency's payments. A 2021 NCDOT report examined NCDOT spending from state fiscal years 2013-2018. The study found that 4.38% of spending went to minority-owned businesses and 10.05% went to nonminority women-owned businesses. In total, 14.44% of NCDOT spending went to women- and minority-owned businesses.[110]

The advancement of workforce development and employment-generating opportunities was a topic that local community stakeholders brought up during the community stakeholder workshop held as an element his research project. Some community representatives discussed the need to incorporate workforce development opportunities for NCDOT transportation projects impacting EJ communities. Community stakeholder recommendations included establishing job training programs that would lead directly to employment with firms building roadway infrastructure in EJ communities and allow the local community to directly benefit from the economic impact of roadway construction. Additionally, participants brought up the opportunity for NCDOT to contract with disadvantaged and minority owned businesses from within the area surrounding projects to provide services and materials for transportation projects in EJ communities.

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[105] Ibid.

[106] 23 U.S.C. § 104(a): 23 U.S. Code § 104 - Apportionment (2012). Retrieved from https://www.law.cornell.edu/uscode/text/23/104

[107] 23 U.S.C. § 149 (§ 11115) - Congestion Mitigation and Air Quality Improvement Program. Retrieved from https://www.law.cornell.edu/uscode/text/23/149

[108] Bipartisan Infrastructure Law, Pub. L. No. 117-58, § 13007, 135 Stat. 1236, 1328. (2021).

[109] North Carolina Department of Administration. (2020). Disparity Study Report Volume 1: State Agencies. Retrieved from https://ncadmin.nc.gov/documents/files/disparity-study-volume-1/download

[110] North Carolina NC Department of Transportation [NCDOT]. (2021). 2021 North Carolina Department of Transportation Disparity Study. Retrieved from https://www.ncdot.gov/initiatives-policies/access-for-all/disparity-study/Documents/2021-ncdot-disparity-study.pdf.

Nationally, the 11th Street Bridge Project in the Anacostia neighborhood in Washington, DC is an example of a community-driven infrastructure project that included robust workforce development and small business enterprise elements. The project involved decommissioning an aging bridge across the Anacostia River and transformed the infrastructure into an over-the-river community park and pedestrian path. The community worked with the DC government to develop a First Source agreement to ensure that local community members had access to construction-related job opportunities at a livable wage and required this agreement to be honored by all contractors and subcontractors on the project. The community also worked with the city and local workforce development groups to provide post-construction job opportunities for harder-to-employ residents of the neighborhood.[111]

With a project construction start date of 2023, the actual economic impacts are not yet known. However, a 2014 economic impact study commissioned by Building Bridges Across the River (BBAR) and conducted by HR&A Advisors forecast 175 jobs and $14 million in wages, as well as $31 million in overall economic activity, associated with the construction. They also estimate between $73 and $208 million in annual economic benefits associated with the project.[112]

Best Practice: Provide Job and Training Opportunities for Impacted Communities

Provide direct economic impact to local disadvantaged communities by developing a workforce training program and hiring local residents for project related jobs.

Best Practice: Maximize Workforce Development and Disadvantaged Business Enterprise (DBE) Funds

Leverage 100% cost share federal DBE funding for business and workforce development programs in disadvantaged communities impacted by transportation projects and to stimulate economic development in the community.

Power of Community

The goal of this Transportation Equity Plan focus area is to increase the amount of public participation through the increased quantity, quality, and accessibility of public engagement opportunities provided by State DOTs and MPOs. The plan also focuses on increasing the number of State DOTs and MPOs with explicit EJ screening tools in the State Transportation Improvement Plan (STIP) and Transportation Improvement Plan (TIP) process.[113]

The Public Engagement Process

A lack of universal accessibility to high quality internet connectivity that impacts virtual meetings and online surveys hinders the delivery of equitable outreach , as 10% of Americans lack access to high speed internet.[114] Meetings that are only held virtually can be a barrier for those without access to reliable, high quality internet connectivity and limits the opportunity to obtain feedback from underserved and rural communities. Additionally, communities may vary in their preference for an in-person meeting or a virtual meeting based on community norms, digital literacy, and other factors.[115] The importance of in-person meetings was expressed by some community representatives in the Community Stakeholder Workshop conducted through this study. A local community representative for an eastern North Carolina

[111] BBAR. (2018).

[112] Building Bridges Across the River (BBAR). (2014). Estimated Economic Impacts of the 11th Street Bridge Park.

[113] USDOT. (2022b).

[114] Ibid.

[115] National Academies of Sciences, Engineering, and Medicine. (2020). TCRP research report 214: Equity Analysis in Regional Transportation Planning Processes, Volume 1: Guide. Washington, DC: The National Academies Press. https://doi.org/10.17226/25331

community noted that it was time to move from computer-based engagement and return to in-person meetings. Specifically, they wanted those conducting public engagement to get out in the community and meet with people in the community where they are in everyday life – such a grocery stores and public spaces.

Another critical barrier to public engagement is the time the process requires of both individual stakeholders and community partners. The need for individual stakeholders to spend their time at public meetings advocating for community needs can serve as a barrier for many community voices. Whether due to their lack of awareness of meeting, accessibility constraints, or limited time resources, public engagement efforts. For these reasons and more, planned public engagement activities can often fail to connect younger and low-income community members, as well as those with lower-levels of education. Some of these issues can be mitigated by having meetings in accessible locations that leverage existing community activities (such as grocery store pop-up events or local bike or pedestrian facilities), providing childcare options for a meeting, and advertising beyond traditional print and radio outreach.[116]

Working with partners in the local community is recommended as a way to connect and build trust with local communities. However, known community partners are often asked to participate in many meetings, workshops, and public engagement processes, which can lead to meeting fatigue and long hours of unpaid service. Local stakeholder partners at the Community Stakeholder Workshop noted that they attended many meetings, serving as a community liaison between their own EJ community and transportation, planning and other state and local government agencies. They highlighted that at many of those meeting they are the only ones not being paid to attend. To address these barriers, the Transit Cooperation Research Program highlights the opportunity to allocate public involvement funds to local community partners and organizations to better include them as partners in the public engagement process.[117] The report notes that MPOs can use funds form Unified Planning Work Program funds, special studies funds, regional planning grants and environmental impact assessment allocations. TRCP highlights that this approach was utilized by the Metropolitan Council of Minneapolis–Saint Paul (Met Council) in the early 2000s. The council used a federal sustainable communities planning grant to engage local community partners and organizations supporting with grassroots engagement efforts for the region's corridor plan.

Best Practice: Community Engagement Plan with Virtual and In-Person Meetings
Develop a public engagement process that ensures high quality communication and notifications to community members and provides accessible meetings (both in-person and virtually) in an effort to provide opportunities for many diverse community voices.

Best Practice: Treat Community Stakeholders Like Full Partners
In an effort to treat key community stakeholders as full partners and offset the financial and time burden of participation, stakeholders could be compensated for their time.

EJ Screening in the Planning Process

As noted in the Environmental Justice Screening Tools section, several national- and state-level tools have recently emerged to identify, quantify, and assess vulnerable and overburdened communities. The development of these tools have become more common over the past three years. While utilizing

[116] Ibid;
Boone. (2015).
[117] NASEM. (2020).

screening tools such as CalEnviroScreen, CEQ Climate and Economic Justice Screening Tool, and transportation equity scores are important means of identifying EJ communities, these tools must be linked to the policy and funding decision-making process to have the desired impact. Examples include communities being identified and designated as an EJ community or community of concern impacting the project prioritization processes and funding availability.[118]

Developed in 2013, the CalEnviroScreen is still seen as the benchmark among EJ screening tools and embedded policy actions. Perhaps most relevant to the transportation infrastructure development process is that California's SB 535 Communities. Census tracts scoring in the top 25% in CalEnviroScreen, qualify for specific funding to address inequity in the community. As a funding mechanism for SB 535 communities, a quarter of California's cap-and-trade greenhouse gas reduction program revenues are reinvested to benefit vulnerable and overburdened communities.[119] The state law requires that 25% of the cap-and-trade funding to benefit SB 535 Communities and 10% of cap-and-trade funding must be spent directly in the geographic footprint of these disadvantaged communities. Based on a 2019 update of the SB 535 communities program, $3.39 billion dollars of the $4.47 billion cap-and-trade program funding was spent in disadvantaged communities. Not all projects are transportation-based, but many eligible projects may address historic transportation disparities; eligible SB 535-funded projects include low-carbon transportation investments, workforce development, affordable housing near transit, transit services, clean energy projects, air pollution reduction and many other projects.

New York State offers another example of funding mechanisms tied to an environmental justice screening process. At least 35% of funding form the state's 2019 Climate Leadership and Community Protection Act (Climate Act) must be used to benefit disadvantaged communities. Draft criteria for identifying these communities employs a robust 45-indicator screening process derived from CalEnviroScreen but utilizing locally relevant environmental burdens and demographic factors. The top-scoring 35% of census tracts in this screen will be designated as disadvantaged communities for the purpose of directing Climate Act funding (NYDEC & NYSERDA, 2022).

A new report from PolicyLink offers a contemporary and comprehensive report on infrastructure equity action items that do not require the creation of new laws and can position communities to maximize the benefits of recent legislation including the Bipartisan Infrastructure Law (BIL) and the Inflation Reduction Act.[120] Among its many recommendations, the report suggests creating standards and giving power to the Social Impact Assessment (SIA) process and leveraging the public health improvement potential of the Health Impact Assessment (HIA) process should be components of infrastructure policy and implementation

Interventions

Having available funding is necessary to address, mitigate and prevent undue burden in EJ communities. The third focus area recommends USDOT create new discretionary grants for disadvantaged communities in urban and rural areas that have not been able to obtain funding grants in the past. Additionally, the Equity Transportation Plan (2022) proposes restructuring formula funds in the STIP/TIP to account for equity as a means to increase projects awarded to disadvantaged communities in urban and rural areas. Targeted competitive, discretionary funds for disadvantaged communities can be

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[118] COEHHA. (2022);
Council on Environmental Quality [CEQ]. (2021). Considering Environmental Justice During the National Environmental Policy Act Process: Interim Guidance. Retrieved from https://www.whitehouse.gov/wp-content/uploads/2021/06/20210630-CEQ-NEPA-EJ-Interim-Guidance.pdf

[119] SB 535, Stats. 2012, ch. 807.

[120] PolicyLink. (2023). Building for All: Infrastructure Standards for Transformation of the Built Environment. Retrieved from https://www.policylink.org/resources-tools/building-for-all

important tools to address transportation equity, however, it should be noted that nearly 70% of federal transportation funding is formula-based.[121]

The BIL includes some funding specifically designated for disadvantaged communities. The Rebuilding American Infrastructure with Sustainability and Equity (RAISE) discretionary grant program includes $35 million in funding dedicated to transportation planning, development and construction in historically disadvantaged communities. The funding is a split funding stream with $15 million from BIL funding and $20 million from federal fiscal year 2023 Appropriations Act funding.[122] The BIL authorizes that RAISE funding for historically disadvantaged communities to be funded at 100% federal cost-share.[123] Additional BIL funding for disadvantaged communities include the Reconnecting Communities Pilot program, which awarded $185 million to 45 communities across the country.[124] The Thriving Communities program, which was established by the FY 2022 Appropriations Act, provides $25 million for technical assistance to disadvantaged communities that are adversely or disproportionately impacted by environmental, climate, and human health policy outcomes (USDOT, Thrive 2022).

Prepare and Apply for Future Federal Funding for Disadvantaged Communities
Establish a process to identify disadvantage communities eligible for federal discretionary funding and a pool of eligible projects at varying stages of project planning and development.

Expanding Access

In the fourth focus area, USDOT proposes framing accessibility for disadvantaged communities as a measure of cost-burden – both financial cost and also travel time cost. This approach is supported by previous research that noted the lack of specificity in federal guidance to MPOs on capturing travel patterns of EJ communities.[125] Researchers have also advocated for people-centered planning and proposed a more uniform and well-defined equity analytic be established and incorporated in regional transportation planning processes. Researchers have recommended that a spatial and sociocultural approach combining quantitative and qualitative methods would offer the best framework to analyze mobility inequity.[126]

The USDOT Equity Transportation Plan (2022) recommends that measurements for accessibility improvements in the transportation network for disadvantaged communities could include reduction of transportation cost (as a percentage of household income) and a reduction of travel times.[127] The plan also recommends increasing access to key destinations (employment, education, groceries, health care) and general increased mobility for disadvantaged communities as a key criterion in the transportation decision-making process.

USDOT has laid out accountability action items: (1) Develop criteria for incorporating transportation cost burden measure in project selection decision-making; and (2) Incorporate elements of the transportation cost burden measure into funding programs and policy documents. To capture travel time and

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[121] USDOT. (2022b).

[122] Rebuilding American Infrastructure with Sustainability and Equity, Pub. L. No. 117-58, 135 Stat. 1029 (2021).

[123] U.S. Department of Transportation [USDOT]. (2022a. (2022). Discretionary RAISE Grant, Press Release. Retrieved from https://www.transportation.gov/RAISEgrants

[124] U.S. Department of Transportation [USDOT]. (2023). Reconnecting Communities. Retrieved from https://www.transportation.gov/grants/reconnecting-communities

[125] Karner A., Niemeier D. (2013). Civil Rights Guidance and Equity Analysis Methods for Regional Transportation Plans: A Critical Review of Literature and Practice. *Journal of Transport Geography*, 33, 126-134.

[126] Hidayati, I., Tan, W., & Yamu, C. (2021). Conceptualizing Mobility Inequality: Mobility and Accessibility for the Marginalized. Journal of Planning Literature, 36(4), 492-507. doi: 10.1177/08854122211012898

[127] USDOT. (2022b). (2022).

transportation cost burden, Washington State DOT and New Jersey DOT have included these measures in their state EJ screening tools. However, like the screening tools in general, there is not currently a planning intervention or funding outcome linked to those measurements.

An example of travel time and cost burdens is that that based on 2019 data bus commuters spent 1.7 times longer on their commute than commuters in a personal vehicle, and low-income households spent 37% of their household earnings on transportation cost.[128] However, policymakers often lack the necessary data to include household transportation cost as a metric for EJ assessments. A Mineta Transportation Institute study recommends collecting transportation expenditure data at the census track and block levels to better capture the burden that transportation cost plays in low-income household budgets. Specifically, the study recommends including questions regarding how travel behavior is impacted by transportation cost and tracking both cost and travel time burdens of low-income households.[129]

Beyond direct cost and travel expenditures, health and healthcare access for vulnerable and disadvantaged communities are impacted by transportation cost and time burden. One practice associated with providing better access and health outcomes involves enhancing active transportation connectivity by increasing bicycle and pedestrian connectivity.[130] Some recommendations for providing more equitable transportation access in disadvantaged communities include providing affordable shared-mobility services, such as bike-share, car-share, ride-share, and micromobility alternatives in disadvantaged communities. However, even shared-mobility services can bypass disadvantaged communities. Research on bike share locations showed site selection processes that focuses on maximum coverage area can create inequitable access and suggests that bike share network analysis methods be developed to incorporate equity metrics.[131] Network analysis that focuses on maximum coverage area without incorporating equity metrics could create inequitable access to multimodal mobility for vulnerable and underserved populations. For shared mobility to work as a solution for affordable transportation in disadvantaged communities, there must be bike and pedestrian facilities that connect essential services and provide access to employment centers.

Develop Data for Household Transportation Cost and Travel Time Cost
Capture the household transportation cost and travel time cost that impact disadvantaged communities and pair the results with policy, planning and funding interventions.

[128] U.S. Census Bureau (2021). Estimates Show Average One-Way Travel Time to Work Rises to All-Time High.

[129] Agrawal, A.W., Blumenberg, E., Abel, S., Pierce, G., & Darrah, C. (2011). Getting Around When You're Just Getting By: The Travel Behavior and Transportation Expenditures of Low-Income Adults.

[130] Equity Caucus. (2023). Statement of Principles. Equity Caucus. Retrieved from https://equitycaucus.org/about-equity-caucus/statement-of-principles

[131] Caggiani, L., Colovic, A., & Ottomanelli, M. (2020). An Equality-based Model for Bike-sharing Stations Location in Bicycle-public transport Multimodal Mobility. Transportation Research Part A: Policy and Practice, 140, 251-265. https://doi.org/10.1016/j.tra.2020.08.015

COMMUNITY STAKEHOLDER WORKSHOP SUMMARY

As a part of the overall study, the research team facilitated an online workshop with representatives of communities from across North Carolina that have been negatively impacted by highway projects. Communities represented in the stakeholder meeting include an urban western North Carolina community (Buncombe County), an urban central North Carolina community (Wake County) and a rural eastern North Carolina community (Bertie County). Participants were prompted with the questions related to how transportation decisions have been made in their community, barriers in the decision-making process, opportunity to impact change in the process, access to information, and perceptions of the decision-making process.

Participants were prompted with the following questions:

- Can you share a story about your experience with how a transportation policy decision was made in your community?
- What changes would you like to see in transportation policy decision making in your community?
- Can you share an experience describing how you were prevented from participating in transportation policy decisions in your community?
- What were the barriers?
  - How decisions are made?
  - Who participates in decisions?
  - When decisions are made?
  - What information is shared informing decisions?
  - Where decisions are made?
- What are the opportunities for change?
  - How decisions are made?
  - Who participates in decisions?
  - When decisions are made?
  - What information is shared informing decisions?
  - Where decisions are made?
- Open discussion

Participants began with broad discussion about the impacts of transportation on their communities without specifying state highways and projects. As the discussion continued, comments narrowed to focus on infrastructure decisions including:

- Pedestrian crashes and fatalities in rural eastern North Carolina counties and the need for crosswalks
- Rural vehicle crashes on un-signalized highway intersections and positive impacts of adding signalization
- A lack of meaningful and impactful community engagement in ongoing freeway development

- Community stakeholders serving as uncompensated community representatives and liaisons between the community and transportation and planning agencies
- Urban redevelopment and proposed freeway development
- Challenges to community input in rural areas including the impact of heirs rights property on notification and awareness of transportation decision making by rural property owners.

Distrust and the Legacy of Previous Transportation Planning Engagement Approaches

All of the participants expressed the need for decision-makers to establish trust with communities and to authentically include and engage stakeholders in the decision making process. All participants also shared the need for decision-making to be aware of the legacy of racial discrimination in previous processes, as many of the previous transportation technical experts they've experienced were white and the stakeholders' communities are predominantly Black.

Participants also expressed the need to establish goals that go beyond attempt to share benefits but would also work to redistribute the burdens of transportation infrastructure and not cluster them in disadvantaged communities. Participants shared a perception that burdens historically have disproportionately burdened disadvantaged communities and not other communities

Community Power in the Decision-making Process

All of the participants shared stories about experience with either not being included in the decision making process or not feeling that their participation resulted in the process producing community benefits. Several references were made to the lack of awareness of transportation planning sessions, lack of consideration of community-voiced issues, and a lack of meaningful inclusion of community interests in final planning decisions. There was a sense that if community stakeholders were included and empowered at the start of planning processes, and if there were clearer channels of communication and accountability made by state agencies, some of the distrust of technical experts held by communities might decrease. Additionally, rural participants voiced their concerns about not receiving notification of transportation plans sent to property owners. Heirs property rights can make identifying and contacting all property owners difficult and stakeholders were interested in more due diligence to overcome that communications challenge. Mention was made of the "Digital Divide" and barriers to electronic communication in community engagement. In-person and face-to-face engagement strategies were preferred by most participants.

Capacity Building and Compensation of Community Partners

All participants voiced their frustration with the level of uncompensated effort required of community organizers to mobilize and organize stakeholders throughout the transportation planning process. Participants said they often offer their time and energy due to their commitment to the health of their communities. However, technical consultants from outside of the community are compensated and community residents are typically not. There is a perception by stakeholders that they have been exploited, especially if transportation planning doesn't reflect their interests. Participants discussed the need to invest in community leaders and to support ongoing community development in addition to their relatively short-term commitment to the needs of specific transportation planning projects.

Mobility beyond automobiles

Rural participants discussed how highways designed to move automobiles are also places where people walk and bike. Some rural residents do not have access to automobiles. A series of vehicular and pedestrian crashes resulting in pedestrian fatalities in Bertie County resulted in the implementation of signals and crosswalks on NC-11. Stakeholders praised this decision but lamented that changes weren't made until after lives were lost. Considering rural mobility in addition to automobile use was strongly communicated by stakeholders as a way to address health, safety, and welfare on state highways.

Despite offering a flexible schedule and multiple opportunities, many community representatives were unable or unwilling to attend the stakeholder session. Many invited stakeholders are also asked to serve multiple community advocacy roles, and this speaks to how overburdened community leaders are in disadvantaged communities. Community stakeholders are often asked to participate in planning efforts, often uncompensated, and engaged in many meetings and planning processes that have not produced tangible community benefits

Summary of Equity in Transportation Investment Process

Over the past three years, the USDOT and other federal governments have begun to set new equity-centered guidance, action plans and policy recommendations. New federal discretionary funding exists to focus on disadvantaged communities, some of which are funded a 100% federal cost-share. Many state transportation agencies and MPOs are developing and utilizing EJ and equity screening tools to identify overburdened and disadvantaged communities. However, there is still a disconnect between data collection and analysis and implementation. The review of the literature and state transportation agencies shows that implementing processes interventions or funding streams tied to EJ Screening tools has not yet occurred, with the exception of California's SB535 Communities, which provides cap-and-trade revenue to fund sustainable transportation and clean energy projects, and disadvantaged communities receiving direct funding benefits under New York's 2019 Climate Act. Federal guidance and internal action plans signal what may be on the horizon for equity-centered regulations in the future.

In anticipation of these changes, many state transportation agencies are working to build capacity and processes that would address potential future regulations and established their own equity initiatives. Many of the states that are leading in this endeavor have state mandates for agencies to develop equity strategic plans and equity action plans. The review did not find examples of these novel equity practices being embedded directly in planning, prioritization or project development processes. Beyond California's program, which draws from a very unique pool of funds, there was no direct state funding, changes to funding formulas or changes to project prioritization processes resulting from these screening tools.

Based on the review of equity practices, it appears that California and Washington State are the benchmarks for building equity into their process and are supported by requisite state-wide strategic equity plans. There also appears to be a group of leading state transportation agencies that are working to build capacity and gain understanding by developing equity plans and screening tools and researching implementation strategies. Given these findings, NCDOT is situated on equal footing with other leading state transportation agencies that are the forefront of this change. NCDOT's internal equity plans, research projects, and tool development put them among the leading wave of state transportation agencies that are working to build capacity and explore implementation options.

BEST PRACTICE MATRIX

BEST PRACTICE MATRIX

Summary of Equity in Transportation Investment Process

Over the past three years, the USDOT and other federal agencies have begun to set new equity-centered guidance, action plans, and policy recommendations. New federal discretionary funding has been authorized to address impacts on disadvantaged communities, some of which are funded through 100% federal cost-share. Many state transportation agencies and MPOs are developing and utilizing EJ and equity screening tools to identify overburdened, underserved and disadvantaged communities. However, there is still a disconnect between the data collection and analysis processes and the implementation process. Beyond a few state initiatives that are starting to emerge, the review of the literature and current practices show that implementing process interventions or developing dedicated funding streams have not yet occurred on a national scale. Federal guidance and internal agency action plans are beginning to build the foundation of what are likely to become future equity-centered regulations.

In anticipation of these future equity-centered policies, many state transportation agencies are working to build capacity and processes that would address potential future regulations and established their own equity initiatives. Many of the states that are leading in this endeavor have state mandates for agencies to develop strategic equity plans and implement action plans associated with those strategic goals. This review did not find examples of these novel equity practices being embedded requirements that are uniformly consistent elements of the planning, prioritization or project development processes.

The following best practice matrix captures and build upon emerging equity practices and recommended best practices from the literature regrading transportation decision-making and investment. These best practices are also informed by emerging federal initiatives that could set the next generation of federal guidance and policies.

Purpose, Goals and Scope of Best Practice Matrix

The purpose of the best practice matrix is to highlight practices that can serve to prevent recurrence of past inequities and continuation of current inequities. The goal of these best practices is to eliminate inequities and create a transportation system that provides equitable access and mobility for everyone. The best practices and out-come driven categories reflect the research focus on community inequity. These best practices fall into three outcome-driven categories:

- Define inequities
- Identify disadvantaged communities impacted by past and reoccurring inequities
- Correct, eliminate and prevent inequities

Many best practices incorporate more than one outcome-driven category. Best practices such as data and screening tool development often serve to both define inequity and identify disadvantaged communities. Defining inequity is often established by the data sets selected and screening thresholds established within a screening tool. Some of the outcomes focused on correcting, eliminating and preventing inequities have embedded steps to define inequity and/or identify disadvantaged communities. Below is a table highlighting each outcome-driven category associated with each best practice.

The best practice matrix is presented thematically with the outcome-driven category of each best practice highlighted in the matrix. The six thematic categories presented are:

- Data and Screening Tools
- Funding
- Workforce Development
- Public Engagement Process and Community Partners
- Environmental Quality and Health Impacts
- Roadway, Bicycle and Pedestrian, and Shared-Mobility Facility Planning and Design

The best practices presented here focus on roadway infrastructure with a broad understanding that roadway infrastructure impacts bicycle, pedestrian, public transportation and shared-mobility transportation modes. Highway related inequity among all of these modes are captured in some capacity within the project scope focusing on historic and reoccurring inequity in highway investment and decision making. The research team also recognizes inequalities of highway infrastructure go beyond transportation and impact community cohesion, physical and mental health, social mobility and economic prosperity.

The next phase of this project will draw on the best practices highlighted in the matrix to develop an implementation framework. The framework will provide a menu of potential approaches for addressing inequity in highway infrastructure investment and decision making for NCDOT to consider implementing. While the ensuing implementation framework will not provide formal recommendations or a detailed implementation plan, those elements could be conducted under a future implementation project. However, the framework will highlight some high-level touchstones where these potential approaches could be applied to existing NCDOT process.

Data and Screening Tools

Develop Comprehensive Screening Tools
Develop a locally-relevant comprehensive screening tool for environmental justice that highlights the intersection of community vulnerability and environmental burden. A comprehensive screening tool should include environmental exposures, environmental effects, health vulnerabilities, and socioeconomic characteristics of communities.

Public Participation and Field Verification
Develop screening tools through a collaborative process with historically burdened communities and ensure a high level of transparency. Final products should be publically availability and be design to be understandable to the public.

Planning and Project Development Process Improvements

Improve Community Social and Health Impact Assessments

Establish a robust and consistently applied community social and health impact assessment in the transportation decision-making process that focuses on cumulative impacts on community social well-being, mental and physical health and quality of life.

Develop Data for Household Transportation Cost and Travel Time Cost

Capture the household transportation cost and travel time cost that impact disadvantaged communities and pair the results with policy, planning and funding interventions.

Re-Connect Communities

Prioritize increase access to re-connect communities to essential destinations and connect neighboring residential areas for community cohesion.

Funding

Prepare and Apply for Future Federal Funding for Disadvantaged Communities

Establish a process to identify disadvantage communities eligible for federal discretionary funding and a pool of eligible projects at varying stages of project planning and development.

Link Screening Tools Designation with Funding Opportunities

Dedicate specific funding for transportation improvement projects in disadvantaged communities as identified by set criteria and a data-driven EJ screening tool.

Workforce Development

Provide Job and Training Opportunities for Impacted Communities

Provide direct economic impact to local disadvantaged communities by developing a workforce training program and hiring local residents for project related jobs.

Maximize Workforce Development and Disadvantaged Business Enterprise (DBE) Funds

Leverage 100% cost share federal DBE funding for business and workforce development programs in disadvantaged communities impacted by transportation projects and to stimulate economic development in the community.

Public Engagement Processes and Community Partners

Community Engagement Plan with Virtual and In-Person Meetings

Develop a public engagement process that ensures high quality communication and notifications to community members and provides accessible meetings (both in-person and virtually) in an effort to provide opportunities for many diverse community voices.

Treat Community Stakeholders Like Full Partners
In an effort to treat key community stakeholders as full partners and offset the financial and time burden of participation, stakeholders could be compensated for their time.

Environmental Quality and Health Impacts

Mobile Source Air Emissions Reduction
Monitor, mitigate and reduce mobile source air emissions associated with disadvantaged communities proximity to roadways.

Zero Emission Vehicles to Improve Air Quality
Support the transition to zero emission vehicles (ZEV), including electric vehicles (EV), and ensure that disadvantage communities have access to ZEV infrastructure.

Storm Water Infrastructure Improvements
Reduce transportation related flooding impacts on local communities by assessing, mitigating and preparing for more intense and frequent storm events.

Roadway, Bicycle and Pedestrian, and Shared-Mobility Facility Planning and Design

Increase Bicycle and Pedestrian Connectivity
Develop and expand bicycle and pedestrian networks to connect disadvantaged communities to essential services and to re-connect communities that have been divided and cutoff by past highway projects.

Implement Traffic Calming and Roadway Design Measures
Implement traffic calming designs and strategies and improve pedestrian facilities to reduce pedestrian crash and injury risk.

Data and Screening Tools

Develop Screening Tools that Comprehensively Describe Environmental Burdens and Social Vulnerabilities

Federal, state, and local agencies have developed a variety of methods for identifying and comparing communities that have been disproportionally impacted by transportation policies and investments or that may be particularly vulnerable to the negative effects of future policies and investments. Assessments of current and historical inequities, specifically environmental burden and social vulnerability, are central to understanding how transportation policies and investments may affect communities.

Develop Comprehensive Screening Tools
Develop a locally-relevant comprehensive screening tool for environmental justice that highlights the intersection of community vulnerability and environmental burden. A comprehensive screening tool should include environmental exposures, environmental effects, health vulnerabilities, and socioeconomic characteristics of communities.

Implementation:
Pursue a cumulative picture of burden by accounting for transportation and non-transportation related environmental hazards currently and historically present in communities and populations physiologically and socially vulnerable to environmental hazards.
Augment national datasets with data for locally-relevant data for describing historic inequities, community vulnerabilities and disadvantages and local environmental pollutants and hazards, including climate risks.
Identify and extend inter-agency partnerships to acquire and support data needs. In many cases, state environmental and public health agencies are natural partners for assisting in the development and supporting EJ screening tools.
Seek opportunities to improve upon the limitations of existing screening tools by accounting for community vulnerability to social disruptions, pursuing collaborative verification activities, and considering community change. These factors are reinforced through collaboration with communities.
Utilize screening tools for high-level comparison purposes and use local, project based assessments for more detailed analyses.

Include Public Participation in Screening Tool Development

Screening tools are designed to provide high-level quantitative measures that can be used to contextualize projects and inform project planning and development activities. These quantitative tools should be informed by qualitative experiences of diverse community members to ensure that measures fully reflect risks and vulnerabilities. This requires community engagement prior to starting tool development and continued throughout the process. Screening tool outputs should also be field verified by going back to communities and confirming accurate outputs and capturing community feedback. Screening tools should be designed to be useable and understandable by members of the public.

Public Participation and Field Verification
Develop screening tools through a collaborative process with disadvantaged communities and ensure a high level of transparency. Final products should be publically availability, include community stakeholder input and be design to be understandable to the public.

Implementation:
Prior to tool development, the development team should conduct interviews, focus groups, and public meetings to facilitate community participation in the project. Continue public participation activities should continue through tool refinement and finalization activities.
Field verify or 'ground truth' the tool by going into communities. Partnering with stakeholders and institutions in disadvantaged communities to engage in field verification is an opportunity to build trust and empower communities with skills and information.
Develop user-friendly tool documentation and web-based platforms to ensure public access to methods and results. Consider closed beta testing of any online tools with focus groups.
Continue to provide public engagement and feedback opportunities as tools are updated and refined over time. Ensure updates and change logs are publicly available.

Planning and Project Development Process Improvements

Comprehensive Social and Health Impact Assessments

The increased importance of capturing social impacts and health impacts have practitioners and researchers recommending incorporating more robust and consistently applied Social Impact Assessments (SIAs) and Health Impact Assessments (HIA). Advocates recommend embedding social and health assessments into transportation infrastructure planning and development process in an effort to account for community health and well-being. This would require a consistent application with agency guidance with the expectation that the assessment be done in a thorough manner and that findings would inform the final project plans and designs. The US Environmental Protection Agency (US EPA) recently released a report that recommends working with agency partners to strengthen the EPA Cumulative Impact Assessment (CuIA) to incorporate both the legacy impacts of previous actions and proposed actions on the built, natural and social environment. The goal is to assess cumulative impacts on community health, well-being and quality of life.

Improve Community Social and Health Impact Assessments
Establish a robust and consistently applied community social and health impact assessment in the transportation decision-making process that focuses on cumulative impacts on community social well-being, mental and physical health and quality of life.

Implementation:
Utilize and consistently apply Social Impact Assessments (SIA) and Health Impact Assessments (HIA) as part of NEPA/SEPA environmental review processes and long range multimodal transportation plans.
Use EPA Cumulative Impact Assessment recommendations to support in capturing the breadth of impacts and community well-being outcomes
Encourage Metropolitan Planning Organizations (MPO) and Rural Planning Organizations (RPO) to utilize similar assessment tools in establishing local plans, developing projects and project prioritization processes.

Household Transportation Cost and Travel Time Cost

Measuring transportation costs and travel time burden for disadvantaged communities can help identify disparities in transportation access. For those measurement to have an impact, the results can be tethered to implementation actions such as planning interventions and funding availability. Currently, assessing transportation cost and travel time burdens is recommended by the USDOT internal Transportation Action Plan and has been incorporated into some state transportation agencies EJ screening tools.

Develop Data for Household Transportation Cost and Travel Time Cost
Capture the household transportation cost and travel time cost that impact disadvantaged communities and pair the results with policy, planning and funding interventions.

Implementation:
Collect data on transportation cost as a percentage of household income in local demographic studies and regional transportation surveys.
Analyze travel time cost for disadvantaged communities, including a comparative analysis of transit dependent users and vehicle owners, in regional transportation models and transportation plans.
Use household transportation cost and travel time cost burdens as an element to Environmental Justice screening tools.
Transportation plans that include an analysis and impact assessment on travel cost and travel time for disadvantaged communities and the general traveling public for recommended improvement and preferred alternatives.
Utilize EJ screening tools that include transportation cost and travel time cost burdens as an input in funding and the project prioritization process.

Prioritize Plans Connecting Communities to Essential Destinations

Connecting communities to essential destinations such as employment opportunities, healthy food, healthcare and social activities is important for all communities. In disadvantaged communities this need is even more important.

Historically, community cohesion and access to nearby essential services where bifurcated and disconnected by highway projects. Highway projects have divided and split communities, disconnected full communities from the urban center and surrounding neighborhoods, or displaced have community members from neighborhoods where their families have lived for generations. In addition to the loss of community cohesion and access to vital social networks and essential destinations. being separated by a highway also disconnected the bicycle, pedestrian and road networks with communities, reduced access to the larger transportation network, and created more dangerous pedestrian environments.

Transportation connectivity options to be considered for transportation improvements should include bicycle and pedestrian, transit and micro-transit services, and roadway. Much of the literature defaults on providing bicycle and pedestrian connectivity, however, limiting transportation options to connect disadvantaged communities to essential service only by bicycling and walking is an inequitable approach to restoring and enhancing community connectivity. Engaging with the community to understand their needs and preference is vital to improving re-connecting communities.

Better transportation connectivity can serve as a catalyst to provide greater access to economic opportunities, essential services and social interaction. Often areas are excluded from transportation options, such as bicycle and pedestrian facilities or transit services, because many planning and funding decisions are demand-based leaving communities underserved. To address disadvantaged or underserved communities, developing a planning and funding approach to expand transportation opportunities to serve as a catalyst for providing connectivity.

Re-Connect Communities
Prioritize increase access to re-connect communities to essential destinations and connect neighboring residential areas for community cohesion.

Implementation:
Develop assessment processes to evaluate community connectivity and transportation network gaps in disadvantaged urban and rural communities (include assessment of essential services and internal connectivity for community cohesion).
Engage with the community to understand their connectivity needs and mode preferences. Avoid assuming that areas with zero-vehicle households and transit dependent riders prefer bicycle and pedestrian improvements as the best option for the community.
Dedicated funding for addressing past community connectivity impacts and project prioritization to get community supported improvement projects developed.

Funding

Prepare and Apply for Future Federal Funding

The Bipartisan Infrastructure Law is currently providing additional discretionary funding opportunities for disadvantaged communities and it is likely that federal funding specifically focused on transportation improvements in disadvantage communities will continue. It is worth noting that the USDOT Transportation Action Plan has also recommended a future change to formula funding that would provide more dedicated funds to disadvantaged communities, although it is less clear how this recommendation would move forward to become policy.

To be prepared for current and future funding for disadvantaged communities, state transportation agencies and Metropolitan Planning Organizations (MPOs) can build EJ screening tools to identify disadvantaged communities and develop a pool of eligible projects and programs that could compete for discretionary funds. To be prepared and competitive for both a standard funding cycle and new discretionary funds a project pool, cost-match funding structure and project selection processes could be established. This allows project to be ready to respond to funding opportunities as they may arise quickly and require short turnaround times.

Prepare and Apply for Future Federal Funding for Disadvantaged Communities
Establish a process to identify disadvantage communities eligible for federal discretionary funding and a pool of eligible projects at varying stages of project planning and development.

Implementation:
Develop an EJ screening tool and accompanying process for identifying disadvantaged communities.
Work with MPO/RPOs and local communities to create a pool of federal funding eligible transportation improvement projects in identified communities. Project pool should include projects at varying stages of project development, including planning, design and shovel-ready to be ready to respond to all types of discretionary federal funding opportunities.
Develop a prioritization process or set of criteria to rank eligible projects for submission.
Determine the funding sources and eligibility for non-federal funding cost match. Are all non-federal funds to be locally matched or will types of projects in disadvantaged communities be eligible for state funds to help offset cost share for disadvantaged communities.

Providing Dedicated Funding Opportunities for Communities Identified in EJ Screening Tools

To better address the needs of communities designated as disadvantaged in EJ screening tools, agencies can provide dedicated funding sources and develop specific prioritization criteria to support communities that have been identified as disadvantaged. Some states, such a California and New York, have dedicated funds that allocate specific levels of funding for the explicit purpose of investing in communities identified in their EJ screening tool processes.

Link Screening Tools Designation with Funding Opportunities
Dedicate specific funding for transportation improvement projects in disadvantaged communities as identified by set criteria and a data-driven EJ screening tool.

Implementation:
Develop an EJ screening tool and set of criteria for communities being identified as disadvantaged.
Identify a funding source and allocate funding to transportation improvement projects that directly benefit disadvantaged communities.
Create some eligibility flexibility to fund not only new projects but also to mitigate existing burdens created by previous transportation infrastructure projects (such as impacts to environmental health, flooding, community cohesion and disconnected bicycle and pedestrian networks).

Workforce Development

Jobs and Training Allocations for Impacted Communities

Projects being built in disadvantaged communities can provide direct economic and job benefits back into the community with targeted job training and job allocations programs focus on local residents. These efforts can go beyond existing federal and statewide programs for workforce development and Disadvantaged Business Enterprise (DBE) support to intentionally leverage transportation project activities to help give back to the surrounding community. This allows the community to share the economic benefit of construction to help offset the impacts of project related disruption in the community.

Provide Job and Training Opportunities for Impacted Communities
Provide direct economic impact to local disadvantaged communities by developing a workforce training program and hiring local residents for project related jobs.

Implementation:
Establish a workforce development training program for projects in disadvantaged communities. Programs could include jobs training for local residents in the transportation industry and providing training for third part vendors or suppliers in the community.
Allocate a set number of project related jobs designated for local residents of impacted disadvantaged communities. This can be accomplished by developing a First Source contracting agreement between the transportation agency, (sub)contractors and the local community.
Set an elevated DBE participation goal for projects in disadvantaged communities and, if available, prioritize local DBE services, vendors and suppliers.

Maximize Workforce Development and Disadvantaged Business Enterprise (DBE) Funding

Utilizing the Disadvantaged Business Enterprise Supportive Services (DBE-SS) program, which is supported by federal funding, and capitalizing on converting other federal funding into 504E funds for DBE workforce development, can stimulate economic development opportunities in disadvantaged communities. An advantaged to the DBE-SS and 504E funds is that they are funded at 100% federal cost share with no non-federal match required. This funding can help reach targeted DBE spending goals (a target of 10%DBE spending in North Carolina and USDOT considering a target of 20% of federal funding).

Maximize Workforce Development and Disadvantaged Business Enterprise (DBE) Funds
Leverage 100% cost share federal DBE funding for business and workforce development programs in disadvantaged communities impacted by transportation projects and to stimulate economic development in the community.

Implementation:
Develop a DBE and workforce development program for impacted disadvantage communities
Utilize federal DBE and 504 funding to implement programs. These can serve as funding options for the training and DBE allocations in disadvantaged communities and supporting meeting DBE spending goals.

Public Engagement Processes and Community Partners

Public Meeting Out Reach in Disadvantaged Communities

To help ensure that community members have their voices heard, public engagement meetings need to reach out to all community members and provide an opportunity for participation. Bridging the digital divide is a key element of engagement stakeholders in the transportation decision making process. Some communities do not have internet access or would simply prefer to have an in-person meeting. While other community members do not have the opportunity to attend in person, for reasons such as time constraints or ability to travel to the meeting site, and would prefer an opportunity to meet virtually. As public involvement moves forward form pandemic disruptions, it is important to find a balance of in-person and virtual engagement that meets the needs of diverse community members.

Participants in the community stakeholder workshop highlighted the need for better communication regarding public meetings, designated more meeting locations out in the community and having a mix of in-person and virtual meetings. The literature also notes that multiple modes of advertising are necessary to encourage participation from members who are younger, lower-income and are less knowledgeable about the planning process.

Community Engagement Plan with Virtual and In-Person Meetings
Develop a public engagement process that ensures high quality communication and notifications to community members and provides accessible meetings (both in-person and virtually) in an effort to provide opportunities for many diverse community voices.

Implementation:
Deliver both in-person and virtual public engagement sessions to capture community input.
When holding in-person public meetings, meet people where they are, including holding meetings at or near everyday sites such as grocery stores or community centers.
Advertise public meetings beyond radio and newspaper, utilizing methods such as social media announcements and working through established partnerships in the community.

Ensure language accommodations by distributing meeting notices and providing access to materials in relevant community languages.
Providing onsite child care can help some member of the community be able to attend public meetings.
Understanding a community's unique history and culture is key to meaningful engagement. The history must be defined and contextualized by the community. Those leading public engagement must learn and understand the community by learning from those that live in the community.

Treat Community Stakeholders Like Full Partners

Partnering with local stakeholders in the community is vital to better understanding the needs and issues experienced by members of communities that will or have been impacted by projects. These types of community partners are even more important in disadvantaged communities to help overcome issues of trust and provide clear lines of communication with the local community. However, many community stakeholder partners are volunteers serving as community representatives. These key partners are often not employed by transportation planning or formal community development organizations and have fulltime employment in other sectors. These types of informal community leaders use their own time and resources to serve as a partner and liaison between transportation organizations and the local community. This commitment of time and resources can be especially burdensome for member of a disadvantaged community. Therefore, nationally recommended best practices include utilizing public engagement funding to compensate these key community partners.

Treat Community Stakeholders Like Full Partners
In an effort to treat key community stakeholders as full partners and offset the financial and time burden of participation, stakeholders should be compensated for their time.

Implementation:
Stakeholder from disadvantaged communities who participate in community feedback efforts should be compensated for their time.
Key community stakeholder that act as partners and liaisons between the community and transportation and planning agencies for the lifecycle of the project should be compensated for the efforts as a community planning partner.
These community partners can be compensated by allocating federal funds from Unified Planning Work Program, special studies and project environmental impact assessment funds.

Environmental Quality and Health Impacts

Air Quality Monitoring in Disadvantaged Communities

Disadvantaged communities, including low-income communities and communities of color, are disproportionally higher exposure to air pollutants and are more likely to be located adjacent to high volume roadways. A primary source of poor air quality in disadvantaged communities is mobile source air emissions from high volume roadways, including carbon dioxide (CO_2), carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (NO_x), and particulate matter (PM). Proximity to mobile source

emissions and the associated air pollution exposure is linked to a higher risk of health problems, which further burdens the members of these communities.

Mobile Source Air Emissions Reduction
Monitor, mitigate and reduce mobile source air emissions associated with disadvantaged communities proximity to roadways.

Implementation:
Deploy air quality monitoring in communities that are adjacent to high volume roadways and develop an air quality alert system.
Emerging artificial intelligence (AI) technology is beginning to be used to monitor air quality in real time and has the potential to provide statewide coverage that be captured down to the neighborhood scale. As this technology matures, it would be an opportunity for ubiquitous air quality monitoring for mobile source emissions.
Utilize social and health impact assessments that include long-term health impacts of air quality and adjust project design or location to prevent disproportionate air quality impact in disadvantaged communities.
Encourage adopting of zero emissions vehicle (ZEV) technology along routes in disadvantaged communities.

Zero Emission Vehicles (ZEV) Infrastructure

Encouraging the transition to zero emission vehicle (ZEV) technologies, such as electric vehicles (EV), can reduce can reduce mobile source emissions along high volume corridors and improve air quality along roadways. However, it should be noted that the use of ZEV technology will likely relocate (rather than eliminate) some emissions. The additional electric power generation needs for EVs will result in more production and increased emissions from electric power plants that impact the disadvantaged communities leaving near power plant facilities. However, while acknowledging these emissions trade-offs it is important to ensure that the benefits of reducing roadway-induced emissions are accrued in disadvantaged communities.

Zero Emission Vehicles to Improve Air Quality
Support the transition to zero emission vehicles (ZEV), including electric vehicles (EV), and ensure that disadvantage communities have access to ZEV infrastructure.

Implementation:
Ensure installation of ZEV infrastructure, such as charging stations, along high volume corridors that pass through disadvantaged communities. This can encourage both local and through traffic motorist utilizing ZEV technology to use the corridor and help reduce mobile source emissions.
Install EV charging infrastructure in disadvantaged communities to provide better access to EV technology for local residents. EV charging installation placed near local businesses can also serve to increase economic activity for the community.

Storm Water Infrastructure

The flooding impact of storm events is often disproportionately felt by disadvantaged communities, with some flooding events made worse by runoff from adjacent transportation infrastructure. As storm intensity and frequency increases, so will the flooding of disadvantaged communities located in marginal lands. It is important to assess which community floods are being exacerbated by runoff from highway and interstate infrastructure. Storm water mitigation efforts should be made in communities that are impacted by transportation induced flooding events. Future transportation infrastructure projects should be designed and built with a focus on resiliency in preparation for more intense and frequent storm events. Project should include cumulative, social and health impact assessments of flood impacts on adjacent communities.

Storm Water Infrastructure Improvements
Reduce transportation related flooding impacts on local communities by assessing, mitigating and preparing for more intense and frequent storm events.

Implementation:
Build a storm flooding assessment tool that accounts for changes in storm intensity and frequency and captures project impact on flooding in adjacent communities.
State, regional and local transportation agencies should coordinate to assess the potential to leverage future transportation infrastructure project and develop a partnership to address large regional storm water issues. This could include joint storm water plans, cost-share agreements, coordinated resiliency efforts and best practices for communities to rebuild after a storm events.

Roadway, Bicycle and Pedestrian, and Shared-Mobility Facility Planning and Design

Increase Bicycle and Pedestrian Connectivity

Developing a connected network of neighborhood bicycle and pedestrian facilities can re-connected disadvantaged communities that were bisected and cutoff by past highway projects. Designing these facilities to connect essential services such as access to healthy food, health care and employment opportunities can support zero-vehicle households.

Bicycle, pedestrian, and transit connectivity is important for many zero-car households in urban and rural areas. In addition to connecting essential services, safe bicycle and pedestrian access within and among the neighboring communities is necessary to maintain community cohesion and improve quality of life and well-being. Encouraging active transportation has also been show to improve physical and mental health and enhance quality of life.

Non-motorized access in rural areas require special consideration, as zero-vehicle households need to be connected for longer distances to access essential services. These communities often have less developed bicycle and pedestrian facility networks than urban areas. With limited dedicated land and grade separated options and the limitation of narrow roadway shoulders, rural residents often utilize the road itself to walk or bicycle to destinations, creating unsafe conditions and increasing crash risk for pedestrians and cyclist.

Increase Bicycle and Pedestrian Connectivity
Develop and expand bicycle and pedestrian networks to connect disadvantaged communities to essential services and to re-connect communities that have been divided and cutoff by past highway projects.

Implementation:
Develop metrics and assessment processes to evaluate bicycle and pedestrian connectivity, network gaps in disadvantaged urban and rural communities (include assessment of essential services and internal connectivity for community cohesion). Make dedicated efforts to re-connect safe bicycle and pedestrian routes within communities already impacted by past highway construction projects.
Include bicycle and pedestrian facilities in future roadway improvements projects in disadvantaged communities.
Metric and funding for stand-alone bicycle and pedestrian facilities to be planning and constructed independent of roadway improvements.
Provide dedicated funding with low/no cost-share for bicycle and pedestrian infrastructure as a part of roadway development (both road on new location and widening and intersection improvement projects) in disadvantaged communities.
Assess disadvantaged rural communities for opportunities to improve non-motorized access from residential areas with low rates of car ownership to essential services.

Traffic Calming Designs to Reduce Pedestrian Crashes

Residents of disadvantaged communities are more likely to be exposed to pedestrian crash risk and sustained pedestrian injuries than residents of more affluent communities. The number of high volume, high speed roadways running through low-income communities and the increased number of pedestrians creates an environment more vulnerable to crashes involving pedestrians. Traffic calming measures and improved pedestrian facilities can help reduce the crash and injury risk.

Implement Traffic Calming and Roadway Design Measures
Implement traffic calming designs and strategies and improve pedestrian facilities to reduce pedestrian crash and injury risk.

Implementation:
Reduce posted speed limits in communities with high pedestrian activity and incorporated a reduction in design speeds as roadways are improved and maintained.
Use traffic calming streetscaping to reduce speeds.
Increase pedestrian facilities such as sidewalks, crosswalks and pedestrian refuges.

DATA REVIEW AND INVENTORY

Introduction

Assessments of current and historical inequalities in levels of environmental burden and physical and social vulnerability are central to understanding how transportation policies and investments have affected and may affect communities. This review examines the quantitative tools, methods, and data for conducting environmental justice assessments that not only include the direct impacts of transportation projects and policies, but also the additional factors required to comprehensively describe the environmental conditions and vulnerabilities of communities. This environmental justice perspective calls for the equitable distribution of environmental burdens and benefits across race, national origin, and income. However, federal guidelines do not currently mandate specific metrics for identifying potential injustices. Nevertheless, significant efforts have been made in investigating injustice, including maps and data collection tools to analyze discrepancies in environmental health at a demographic or geographic scale and numerous metrics and schemes for qualitative measures of environmental justice.

Some of these tools and methods have been developed by national, state, and local transportation agencies. Others have been developed by national and state environmental and health agencies with applications that can extend into domain of transportation planning. In all cases, these tools share many common quantitative indicators and data sources. To describe the degree of consensus across mapping tools, the research team has conducted a landscape analysis to identify the socioeconomic, demographic, health, and environmental criteria used to investigate environmental injustices.

Additionally, the research team highlighted several of the most representative tools at the national and state level for describing how summary metrics combining perspectives of environmental burden and social vulnerability can be quantified and how these results have been applied in policy. These representative tools have been used to frame a comprehensive inventory of the specific environmental and social indicators common to these tools, including data sources and the availability of the historical record.

Landscape Analysis

The landscape analysis includes a review of 26 mapping tools. The research team summarized the results into a table detailing six socioeconomic, eight demographic, eleven health, and seven environmental metric categories (Table 1). Socioeconomic and demographic data were included in all 26 mapping tools. However, the metrics employed varied. Measures for income (including poverty) and educational attainment were the most common socioeconomic metrics utilized. Alternatively, vehicle access, housing, and rent burden were the least common. Metrics relating to ethnicity and linguistic isolation were the most commonly used demographic metrics. The least common included gender and population under 18. While there was a broad consensus on the inclusion of socioeconomic and demographic data, only 16 of 26 EJ mapping tools had the addition of at least one health metric. Of these, metrics relating to asthma, respiratory, and cardiovascular health issues were the most common. Most mapping tools (N=22) also included environmental metrics, with traffic proximity, air pollution, and water quality as the most common. The results presented here confirm that in the absence of federal guidelines, entities (i.e., advocacy groups, state and local governments) have identified communities of interest through metrics employed to characterize race, national origin, and income at a minimum, with many tools expanding to include multiple socioeconomic and demographic metrics, along with indicators for community health.[132]

[132] Urban Institute. (2022). Screening for Environmental Justice: A Framework for Comparing National, State, and Local Data Tools. Retrieved from https://www.urban.org/research/publication/screening-environmental-justice-framework-comparing-national-state-and-local

Highlighted Tools For Quantifying the Combination of Environmental and Social Indicators

Ten national and state tools that include quantitative summary measures to aid in comprehensive environmental justice assessments are described in detail in Table 2. These tools represent the most relevant practices for identifying communities with disproportionate environmental burdens and social vulnerabilities that can be used to inform transportation policies and projects. These tools differ in their methodologies and purposes, but each includes a quantitative measurement or classification of risk and/or burden that combines environmental factors with social vulnerability factors. Often, these factors are multiplied to obtain a final cumulative index value.

Though this list is not an exhaustive these kinds of tools (other similar tools are profiled in Table 1), it is representative of the most comprehensive perspective of burden and vulnerability employed by similar tools in the current practice. Additionally, these tools as a whole incorporate the common environmental and social factors that are considered in environmental justice and equity assessments. The significance of individual tools, including the rationale for their selection among the highlighted tools, is described further in the following sections.

National Tools

The US Department of Transportation (USDOT's) Interim Definition for Transportation Disadvantaged Census Tracts uses 22 environmental and social indicators to describe six categories of transportation disadvantage: transportation access, health, environmental, economic, resilience, and equity. This definition includes measured community levels of certain transportation-related environmental exposures and effects. It also incorporates indicators related to average transportation costs, commute times, and walkability, in addition to commonly analyzed social vulnerability factors like poverty, unemployment, and educational attainment. Health vulnerabilities are also included in the definition. Many of these indicators are used in the more broadly-constructed environmental justice screening tools. Disadvantaged tracts are identified at a national level using a percentile-based methodology with multiple eligibility criteria. The definition was developed as part of the federal Justice40 Initiative and will aid in the goal of ensuring 40% of the Initiative's investments benefit disadvantaged communities.[133]

The Environmental Justice Agency's (EPA's) EJScreen tool and the Environmental Justice Index (EJI) developed by the Centers for Disease Control and Prevention (CDC) and the Agency for Toxic Substances and Disease Registry (ATSDR) are more comprehensive screening tools for environmental burden and social vulnerability. These tools capture a larger set of environmental burdens than are included in the USDOT's definition for Transportation Disadvantaged Census Tracts. EJScreen provides a set of indices that blend social vulnerability factors with individual environmental indicators[134], while the CDC/ATSDR EJI definition produces a single cumulative measurement that combines all social and environmental indicators.[135] These tools share many common methodologies and data sets employed by the most recent environmental justice screening tools developed at state agencies.

The Climate and Economic Justice Screening Tool (CEJST) is another national-level tool that incorporates indicators of environmental burden and social vulnerability to define a subset of communities as "disadvantaged". Like the USDOT's Interim Definition for Transportation Disadvantaged Census Tracts, this tool was developed as part of the federal Justice40 Initiative. In addition to commonly used

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[133] U.S. Department of Transportation [USDOT]. (2022c. (2022). Transportation Disadvantaged Census Tracts (Historically Disadvantaged Communities) Interim Definition Methodology. Retrieved from https://www.transportation.gov/priorities/equity/justice40/transportation-disadvantaged-census-tracts-historically-disadvantaged

[134] EPA. (2022b).

[135] Centers for Disease Control and Prevention & Agency for Toxic Substances Disease Registry [CDC and ATSDR]. (2022a). 2022 Environmental Justice Index: Technical Documentation. Retrieved from https://www.atsdr.cdc.gov/placeandhealth/eji/docs/EJI-2022-Documentation.pdf

measurements of environmental burden, the CEJST incorporates indicators related to climate change impacts and energy, among other factors. It also incorporates the USDOT's interim definition for Access Disadvantage, a specific category of disadvantage evaluated by that agency's Interim Transportation Disadvantaged Census Tracts definition.[136]

The Federal Emergency Management Agency's (FEMA's) National Risk Index is included in Table 1 because of the relevance of the data it employs. Like the other cumulative tools, FEMA's NRI combines environmental factors with social vulnerability (borrowed from the Social Vulnerability Index developed by the CDC and ATSDR[137]) to produce an indexed value of risk from natural hazards.[138] Some of these hazards are included in state and national level tools that account for environmental burdens associated with changing climates.

State Tools

CalEnviroScreen are among the earliest-developed and most influential of the state-level tools included in Table 2. Many of the datasets developed by the EPA for use in EJScreen are employed by states in their own environmental justice screening tools. In addition to employing data developed by the EPA for EJScreen, CalEnviroScreen employs many additional datasets from state and federal sources.[139] Other state-level environmental justice screening tools, including those used in New York, Washington, and Colorado, follow this model and combine state and national datasets. State level tools often augment nationally-relevant datasets from federal sources with locally-relevant data from state and local sources. In most cases these tools are developed and housed within state environmental agencies, though the definitions may have implications for transportation planning efforts, including for defining California's SB 535 Disadvantaged Communities and New York's Climate Act Disadvantaged Communities.[140]

The Colorado EnviroScreen tool is included among the highlighted tools because, like the New York Climate Act Tool, the Colorado tool includes indicators related to climate vulnerability. These tools incorporate climate vulnerability tools that are unique to their geographic contexts; for example, the New York tool includes a coastal flooding risk indicator while the Colorado tool includes a drought indicator. In both tools, climate vulnerability is included as a separate category of environmental burden, alongside exposures and effects.[141,142]

New Jersey's Environmental Justice Mapping, Assessment, and Protection Tool, which aids in the identification of Overburdened Communities (OBC's) is included to highlight the unique methodologies of that program's definition, which combines aspects of EJScreen and CalEnviroScreen. The methodology for defining OBC's centers on presence of environmental and social stressors.[143]

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[136] Council on Environmental Quality. (2023). Climate and Economic Justice Screening Tool: Methodology and Data. Retrieved from https://screeningtool.geoplatform.gov/en/methodology

[137] Centers for Disease Control and Prevention & Agency for Toxic Substances Disease Registry [CDC and ATSDR]. (2022b). 2020 CDC/ATSDR Social Vulnerability Index. Retrieved from https://www.atsdr.cdc.gov/placeandhealth/svi/index.html

[138] Zuzak, C., E. Goodenough, C. Stanton, M. Mowrer, A. Sheehan, B. Roberts, P. McGuire, and J. Rozelle. (2023). National Risk Index Technical Documentation. Federal Emergency Management Agency, Washington, DC. Retrieved from https://www.fema.gov/sites/default/files/documents/fema_national-risk-index_technical-documentation.pdf

[139] CAOEHHA. (2021).

[140] CASB 535. (2012)

[141] CDPHE. (2022).

[142] NYSCJWG. (2022).

[143] New Jersey Department of Environmental Protection [NJDEP]. (2022). New Jersey Environmental Justice Mapping, Assessment, and Protection (EJMAP): Technical Guidance. Retrieved from https://www.nj.gov/dep/ej/ejmap-tg.pdf

Common Indicators for Quantifying Environmental Burden and Social Vulnerability

This review attempts to capture the all of the commonly used data and associated metadata for the indicators used in tools listed in Table 2. This list is not exhaustive but it yields a representative set of the data used by agencies in tool development and demonstrates areas of difference and overlap. In addition to basic indicator information, the research team also identified the use cases (for the tools catalogued in Table 2) and the historical availability of the data (Figure 1). The research team divided the historical record for each indicator into two categories: availability of the "best" data (pre-processed, detailed, and/or digital) and the maximum historical record (data that must be processed or digitized, or that is otherwise lacking the level of detail available in the "best" data). These classifications are meant to distinguish between the highest quality, current data, and data that may be available for historical assessments if necessary.

Tables 3-7 borrow their organizing principle from CalEnviroScreen and other state level tools like it that define environmental indicators as either exposures (those environmental factors that cause direct harm, such as air pollution or drinking water contamination) or effects (adverse environmental factors with indirect impacts, such as degraded streams or hazardous facility sites).[144] Vulnerability to climate-related risks may be included as a third category of environmental indicator for some tools, as it is here. Likewise, these tools define social vulnerability indicators as reflective of either sensitive populations (groups with physiological vulnerability to pollutants) or socioeconomic characteristics (social and economic factors that are commonly associated with health disparities, or "social determinants of health").

Data Repositories

Though some of the tools and data sets described in this review are available only from individual state or local sources, much of the data used in these tools is sources from a handful of repositories. These data stores are described in Table 8.

Transportation Project Data

As a component of this review, the research team has also documented the availability of transportation infrastructure data that can support the analysis of how transportation development and planning outcomes may be associated with disproportionate negative impacts in disadvantaged communities. These datasets have been categorized in Table 9 as describing either infrastructure development (describing development locations and timing) or infrastructure conditions (describing a level of service or quality). As was done for the tables created for environmental and social data, the research team divided the historical record for each data set into two categories: the "best" data and the "max record."

Data Gaps

The fundamental difficulty in obtaining data to analyze historic impacts of transportation projects and policies is the lack of detailed and comprehensive historical data to support statewide analyses. Targeted local analyses in settings where data is available are therefore more appropriate for this goal, though local analyses may also be inhibited by the limited historical record. As shown in Figure 1, indicators describing environmental exposures and effects are limited, especially prior to the 1990's. The lack of most environmental records prior to the second half of the twentieth century reflects not only the absence

[144] COEHHA. (2021).

of digital record keeping but also years prior to the EPA (1970) the development of national ambient air quality standards (1970)[145], and the development of national surface water quality standards (1972).[146]

The historical record is likewise limited for the health-related indicators that describe vulnerable populations, with the exception of youth and senior populations that can be described by the Decennial Census. The record for nearly all individual indicators of health conditions is limited to the 2000's and beyond. Analyses of historical conditions with respect to environmental burden and social vulnerability may be therefore best formulated with the available data supporting descriptions of the socioeconomic characteristics of communities supplemented by locally-available data describing the siting and timing of infrastructure projects. A broader perspective of environmental burden and vulnerability can be employed in efforts to analyze more recent projects, and in future decision-making processes.

An additional gap in data availability relates to limitations of data available at the state level. Some of the highlighted tools employ data sets that are collected and/or available in those states but not in North Carolina. One such indicator is contaminants in drinking water. The state-level contaminant data collection programs put in place under New Jersey's Private Well Testing Act[147] allow for a more granular characterization of drinking water quality in that state than in North Carolina, where data is available at the utility system level. In cases such as these, states that lack more detailed data have often found national data that suffices to fill the gap.

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Table 9: Infrastructure Development and Conditions Data Available for Historic Analysis
Figure 1: Availability of Data for Common Environmental and Social Indicators over Time

[145] U.S. Environmental Protection Agency [EPA]. (2022c. (2022c). Evolution of the Clean Air Act. Retrieved from https://www.epa.gov/clean-air-act-overview/evolution-clean-air-act#caa70

[146] U.S. Environmental Protection Agency [EPA]. (2022d. (2022b). History of the Clean Water Act. Retrieved from https://www.epa.gov/laws-regulations/history-clean-water-act

[147] NJDEP. (2022).

Table 1. Landscape Analysis of 26 Environmental Justice Mapping and Screening Tools.

	Environmental Indicator(s)	Traffic Proximity/Volume	Air Quality/Pollution	Water Quality/Pollution	Hazardous Waste Sites	Emissions	Natural Disaster Vulnerability	Climate Change Vulnerability	Socioeconomic Indicators	Poverty/Income	Educational Attainment	Unemployment Rate	Vehicle Ownership/Access	Housing Burden	Renter Burden	Household Size	Household Info	Limited English Proficiency	Linguistic Isolation	Population Age > 64	Population Age < 18	Population Age < 5	Gender	Race/Ethnicity	Health Indicator(s)	Low Life Expectancy	Premature Birth	Mental Health	Diabetes	Birth Weight	Cancer	Asthma	Cardiovascular	Respiratory	Reproductive	Neurological	Link(s)
CA Office of Environmental Health Hazard Assessment (OEHHA); CalEnviroScreen	✓	✓	✓	✓	✓	✓	✗	✗	✓	✓	✓	✓	✗	✓	✗	✗	✗	✗	✓	✗	✗	✗	✗	✗	✓	✗	✗	✗	✗	✓	✗	✓	✓	✓	✗	✗	1
Center for Earth, Energy, & Democracy (CEED) Twin Cities Environmental Justice Mapping Tool	✓	✓	✓	✗	✓	✗	✗	✗	✓	✓	✗	✗	✗	✓	✓	✗	✓	✗	✗	✗	✗	✗	✗	✓	✓	✗	✗	✓	✓	✗	✓	✓	✓	✓	✗	✗	1
Colorado Department of Public Health and Environment (CDPHE) Colorado EnviroScreen	✓	✓	✓	✓	✓	✓	✗	✓	✓	✓	✓	✗	✗	✓	✗	✗	✗	✗	✓	✓	✗	✓	✗	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✗	✗	1
Connecticut Department of Energy & Environmental Protection Connecticut Environmental Justice Communities	✓	✗	✗	✗	✗	✗	✗	✗	✓	✓	✓	✓	✗	✗	✗	✗	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	1
Delaware Valley Regional Planning Commission (DVRPC) Equity Analysis for the Greater Philadelphia Region	✗	✗	✗	✗	✗	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗	✗	✗	✓	✗	✓	✓	✓	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	1, 2
Illinois Environmental Protection Agency Illinois EJStart	✓	✓	✓	✓	✓	✓	✗	✗	✓	✓	✓	✓	✗	✗	✗	✗	✗	✗	✓	✓	✗	✓	✗	✓	✓	✗	✗	✗	✗	✓	✗	✓	✗	✓	✗	✗	• 1, 2, 3
Illinois Solar for all; Environmental Justice Communities	✓	✓	✓	✓	✓	✓	✗	✗	✓	✓	✓	✗	✗	✗	✗	✗	✓	✗	✓	✓	✗	✓	✗	✓	✓	✗	✗	✗	✗	✗	✓	✗	✗	✗	✗	✗	1
Indiana University, Hoosier Resilience Index, Social Vulnerability Mapping	✓	✓	✓	✓	✗	✗	✓	✓	✓	✓	✓	✓	✓	✗	✗	✗	✓	✓	✗	✓	✓	✗	✗	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	1
Mapping for Environmental Justice (MEJ Virginia)	✓	✓	✓	✓	✓	✓	✗	✗	✓	✓	✓	✓	✗	✓	✗	✗	✗	✗	✓	✗	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗	✗	✓	✓	✓	✗	✗	1
Maryland Department of the Environment MDE EJ Screening Tool	✓	✓	✓	✓	✓	✓	✗	✗	✓	✓	✓	✓	✗	✗	✗	✗	✗	✗	✓	✓	✗	✓	✗	✓	✓	✗	✗	✗	✗	✓	✗	✓	✓	✓	✗	✗	1
Massachusetts Executive Office of Energy and Environmental Affairs, EJ Map Viewer	✗	✗	✗	✗	✗	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗	✗	✗	✓	✓	✗	✗	✗	✗	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	• 1, 2, 3, 4
Michigan Department of Environment, Great Lakes, and Energy; MiEJScreen	✓	✓	✓	✓	✓	✓	✗	✗	✓	✓	✓	✓	✗	✓	✗	✗	✗	✗	✓	✓	✗	✓	✗	✓	✓	✓	✗	✗	✗	✓	✗	✓	✓	✗	✗	✗	1
Minnesota Pollution Control Agency (MPCA) Understanding Environmental Justice in Minnesota	✓	✗	✓	✓	✓	✓	✗	✗	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗	✓	✗	✗	✗	✗	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	1
N.C. Department of Environmental Quality (DEQ) NCDEQ Community Mapping System	✓	✗	✗	✗	✓	✗	✗	✗	✓	✓	✓	✗	✗	✗	✗	✗	✓	✓	✗	✓	✗	✓	✗	✓	✓	✓	✓	✗	✓	✗	✓	✓	✓	✓	✓	✗	1
N.C. Department of Environmental Quality (DEQ) NCDEQ Potentially Underserved Block Groups	✗	✗	✗	✗	✗	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	1

	Environmental Indicator(s)	Traffic Proximity/Volume	Air Quality/Pollution	Water Quality/Pollution	Hazardous Waste Sites	Emissions	Natural Disaster Vulnerability	Climate Change Vulnerability	Socioeconomic Indicators	Poverty/Income	Educational Attainment	Unemployment Rate	Vehicle Ownership/Access	Housing Burden	Renter Burden	Household Size	Household Info	Limited English Proficiency	Linguistic Isolation	Population Age > 64	Population Age < 18	Population Age < 5	Gender	Race/Ethnicity	Health Indicator(s)	Low Life Expectancy	Premature Birth	Mental Health	Diabetes	Birth Weight	Cancer	Asthma	Cardiovascular	Respiratory	Reproductive	Neurological	Link(s)
New Jersey Department of Environmental Protection (NJDEP) NJ EJMAP	✓	✓	✓	✓	✓	✓	✓	✗	✓	✓	✓	✓	✗	✗	✗	✗	✗	✓	✗	✗	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗	✓	✓	✓	✓	✗	✗	• 1, 2, 3, 4
New York Climate Justice Working Group Disadvantaged Communities Map	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗	✗	✗	✓	✓	✗	✓	✗	✗	✗	✓	✓	✓	✗	✗	✗	✓	✗	✓	✓	✓	✗	✗	1
NY State Department of Environmental Conservation (NYSDEC) Potential EJ Areas	✗	✗	✗	✗	✗	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	1
Pennsylvania Dept of Environmental Quality Environmental Justice Areas Viewer	✓	✗	✗	✗	✓	✗	✗	✗	✓	✓	✓	✗	✗	✗	✗	✗	✗	✗	✓	✗	✗	✗	✗	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	1
Rhode Island Dept. of Env. Mgmt (RIDEM) Environmental Resource Map	✗	✗	✗	✗	✗	✗	✗	✓	✓	✓	✗	✗	✗	✓	✗	✗	✗	✓	✗	✗	✗	✗	✗	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	1
Seattle Environmental Equity Assessment Pilot	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗	✓	✓	✗	✓	✗	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	1
U.S. Council on Environmental Quality (CEQ) Climate and Economic Justice Screening Tool (CEJST)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗	✗	✓	✗	✓	✗	✗	✗	✗	✓	✓	✗	✗	✓	✗	✗	✓	✓	✓	✗	✗	✗	1
U.S. Environmental Protection Agency (EPA) EJScreen	✓	✓	✓	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✗	✗	✓	✓	✗	✓	✗	✓	✗	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	• 1, 2, 3
University of California, Berkeley, Mapping for EJ Colorado and Virginia	✓	✓	✓	✓	✓	✓	✗	✗	✓	✓	✓	✓	✗	✓	✗	✗	✗	✗	✓	✗	✗	✗	✗	✓	✗	✗	✗	✗	✓	✗	✓	✓	✗	✗	✗	✗	1
University of Maryland, CEEJH Lab; Maryland Environmental Justice Screen Tool (MD EJScreen)	✓	✓	✓	✓	✓	✓	✗	✗	✓	✓	✓	✓	✗	✗	✗	✗	✗	✗	✓	✓	✗	✓	✗	✓	✗	✗	✗	✗	✓	✗	✓	✓	✓	✗	✗	✗	1
Vermont Department of Environmental Conservation (DEC); Vermont Environmental Disparity Index	✓	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	✗	✗	✓	✓	✓	✗	✓	✓	✗	✗	✓	✗	✗	✗	✗	✓	✓	✓	✗	✓	✓	✗	✗	1
Washington State Department of Health Washington Environmental Health Disparities Map	✓	✓	✓	✓	✓	✓	✗	✗	✓	✓	✓	✓	✓	✓	✗	✗	✗	✓	✓	✗	✗	✗	✗	✓	✗	✗	✗	✗	✓	✗	✗	✓	✗	✗	✗	✗	1

Table 2. Highlighted Tools for Quantifying the Combination of Environmental and Social Indicators

Tool Name	Source	Summary	Subjects	Policy Notes
Justice 40 Transportation Disadvantaged Census Tracts	US Department of Transportation (USDOT)	USDOT has drafted an interim definition of transportation disadvantaged Census Tracts (also called "Historically Disadvantaged Communities") using multiple indicators and a transportation focus. The methodology includes 6 categories of disadvantage. A census tract must be at the 50th percentile or above in at least 4 of 6 categories to be defined as a disadvantaged community.	Transportation Access, Health, Environmental Exposure and Burden, Economic Disadvantage, Resilience, Equity	As part of the Justice40 initiative, USDOT is pursuing the goal of ensuring at least 40% of the benefits of its initiatives benefit disadvantaged communities
EJScreen	US Environmental Protection Agency (EPA)	EJScreen is a set of 12 indices that describe the intersection of social vulnerability and exposure to environmental hazards. There is one EJ index for each environmental indicator, created by combining the environmental indicators with a demographic index.	Environmental exposures and effects, Demographic and Socioeconomic Characteristics of Communities	Screening tool to aid in identifying areas of concern, enhancing outreach, or improving enforcement.
Climate and Economic Justice Screening Tool (CEJST)	White House Council on Environmental Quality (CEQ)	Identifies "disadvantaged communities" at the census tract level by using a broad set of categories to define communities as either underserved or overburdened. The criteria for disadvantage varies by category, though a tract must only meet the criteria of a single category to be considered disadvantaged. Each category of burden has an associated socio-economic factor threshold (often low-income) that must also be met.	Climate Change, Energy, Health, Housing, Legacy Pollution, Transportation, Water & Wastewater, Workforce development	This tool is intended to help federal agencies identify disadvantaged communities that will benefit from programs in the Justice40 Initiative, which includes the goal of delivering 40% of the benefits of investments in climate, clean energy, and other areas to disadvantaged communities.
CDC and ATSDR Environmental Justice Index (EJI)	Centers for Disease Control and Prevention and Agency for Toxic Substances Disease Registry	The CDC EJI measures the cumulative impacts of environmental burden and social/health vulnerability. Significant overlap exists between the environmental burdens assed in the EJI and EJScreen. However, unlike EJScreen, the EJI includes health indicators in its measurement of vulnerability.	Environmental Burden, Social Vulnerability, Health Vulnerability	Screening tool to aid in identifying areas of concern, enhancing outreach, and/or improved decision-making.
FEMA National Risk Index (FEMA NRI),	FEMA, with major CDC/ATSDR component	The NRI is an assessment of community risk level with regard to 18 natural hazards, summarized in a composite risk index. The risk equation is a combination of expected losses to hazards, social vulnerability (via the CDC/ATSDR Social Vulnerability Index), and community resilience. Scores are also available for each hazard risk type.	Expected annual loss (buildings, people, agriculture) from natural hazards, Social Vulnerability, Community Resilience	
CalEnviroScreen	California Office of Environmental Health Hazard Assessment	This screening tool is a model upon which many other state tools are being designed. The index incorporates many datasets provided in the EPA's EJScreen, but augments these datasets with other local datasets to create a more detailed picture of environmental factors.	environmental, health, and socioeconomic	Used to define SB 535 Disadvantaged Communities (highest-scoring 25% of census tracts in CalEnviroScreen 4.0 communities) for the purpose of investing cap-and-trade proceeds, including for transportation projects.
New York Climate Act Disadvantaged Communities (NYCADACs)	New York Climate Justice Working Group (CJWG)	This screening tool reflects the CalEnviroScreen model, with additional and substitute indicators used to reflect New York's unique environmental context. The screen includes 45 indicators. The CJWG identified the top-scoring 35% of census tracts in New York as Disadvantaged Communities (DAC's) for the purposes of targeted investment.	Environmental exposures, Environmental effects, Climate vulnerability, Population Characteristics, Health Vulnerabilities	Used to define DACs, which will receive targeted funding from the New York Climate Act, including for transportation projects.
Colorado EnviroScreen	CDPHE	This tool uses a minimal amount of state-level data compared to CalEnviroScreen, while looking at many of the same data sets. The major state level sources are health data from CDPHE (Drinking water regulations, Other air pollutants, Impaired streams and rivers, Proximity to mining locations, Proximity to oil and gas, Asthma hospitalization rate, Heart disease in adults, Life expectancy, Low birth weight)	Environmental exposures, Environmental effects, Climate vulnerability, Sensitive population, and Demographics	Screening tool for the purposes of allocating enforcement and mitigation resources.
Washington Environmental Health Disparities Map (WEHDM)	Washington State Department of Health	Modeled on California's CalEnviroScreen, this tool uses primarily nationally-available data sources to create measures unique to Washington State.	Environmental Exposures, Environmental effects, Social and Health Vulnerability	Recommended for use in state and local decision-making and community engagement activities.
New Jersey Environmental Justice Mapping, Assessment, and Protection (EJMAP)	New Jersey Department of Environmental Protection	Developed with unique method informed by EJScreen and CalEnviroScreen, but tailored for use in New Jersey's unique policy context. Uses a significant amount of data generated in-house and from NJ sources.	Environmental stressors, Socioeconomic characteristics of communities	Screening tool for identifying overburdened communities (OBCs) for the purpose of denying or conditioning new permits where facilities cannot avoid the occurrence of disproportionate impact on OBC's.

Table 3. Common Indicators of Environmental Exposure used in Quantifications of Environmental Burden and Social Vulnerability

Subject	Indicator	Measure	Rationale for Inclusion (see Use Cases for details)	Use Cases	Source	Geography	Earliest: Best Data	Earliest: Max Record
Air	PM2.5	Annual Average PM2.5 in air	PM2.5 refers to small particle pollution that is harmful to heart and lungs. PM2.5 is a common vehicle tailpipe emission.	EJScreen, CalEnviroScreen, Colorado EnviroScreen, CEJST, J40 TDCTs, WEHDM, NYCADACs	EPA[148]	Census tract	2012	1999[149]
	Ozone	Summer seasonal average of daily maximum 8-hour concentration in air	Ozone is a poses a respiratory health risk and is a primary component in smog. Ozone is not directly emitted by tailpipes but forms when emissions react with oxygen and sunlight.	EJScreen, CalEnviroScreen, Colorado EnviroScreen, J40 TDCTs, WEHDM,	EPA[148]EPA[17]	Census tract	2012	1980[b]
	Diesel PM	Diesel PM levels in air	Diesel PM pollutants are emitted by diesel engines. These pollutants are a respiratory and cardiac health risk.	EJScreen, CalEnviroScreen, Colorado EnviroScreen, CEJST, J40 TDCTs, WEHDM, NYCADACs	EPA[148]EPA[17]	Census tract	2011	1996[150]
	Air Toxics Cancer Risk	Lifetime cancer risk from inhalation of air toxics (persons per million lifetime)	A metric that combines exposure estimates and cancer hazard magnitude of cancer-causing pollutants to express a composite value of risk	EJScreen	EPA[148]EPA[17]	Census tract	2011	1996
	Air Toxics Respiratory Hazard Index	Ratio of combined respiratory hazards concentration to health-based reference concentration.	Sum of chronic non-cancer hazard quotients for individual air toxics causing adverse health effects to the respiratory system.	EJScreen	EPA[148]EPA[17]	Census tract	2011	1996
	Air Toxic Emissions	Facility-based emissions of toxics to air	Facilities of a certain size and sector must report annual emissions of known toxic chemicals, including chemical that cause: Cancer or chronic human health effects, acute human health effects, and adverse environmental effects.	CalEnviroScreen (using RSEI Modeling), Colorado EnviroScreen, WEHDM	EPA[151]	Point	1987	1987
Drinking Water	Drinking Water Contaminants	Drinking Water Contaminants by Public Water System (PWS) and Population Served	Detected levels of specific contaminants by public water system, sampling point type, and additional other supporting data	CalEnviroScreen (blended with state data), NJ EJMAP	EPA[152]	PWS, City, County	2005	1992
	Drinking Water Violation Counts	Drinking Water Violations by PWS and Population Served	Number of violations by PWS by year. Violations may include failure to monitor as mandated, failure to meet maximum contaminant levels (MCLs) and/or failure to inform customers.	CalEnviroScreen (blended), Colorado EnviroScreen (violations data provided by CDPHE)	EPA[153]	PWS, City, County	2013	2013

[148] Note: Best Data available via EJScreen.

[149] Historic Data available from EPA Air Data, Annual Summaries Available by CBSA, County, or Monitor and would need to be developed into usable spatial data.

[150] Available from National Air Toxics Assessment (NATA)

[151] Available from EPA Toxic Release Inventory (TRI)

[152] Available from EPA National Contaminant Occurrence Database (NCOD) & Six-Year Reviews; Select Contaminant concentrations also available via CDC

[153] Available from Safe Drinking Water Information System (SDWIS)

Hazardous Sites	Pesticide Use	Pounds of pesticide used per unit of area in a community	Exposure to pesticides can cause acute or long-term health impacts.	CalEnviroScreen	USGS [154]	County	1992	N/A
	Children's Lead Risk from Housing	Occupied Housing units built prior to the nationwide lead paint ban.	Housing unit age is an indicator of the presence of lead-based paint. Lead-based paint was banned in 1978. Houses built in years prior may contain underlying layers of lead-based paint. Some agencies (EJScreen, CEJST, Colorado EnviroScreen) include counts of all homes built before 1960, others (CDC, CalEnviroScreen) use 1980.	EJScreen, CEJST, CDC EJI, CalEnviroScreen, Colorado EnviroScreen, WEHDM, NJ EJMAP	US Census Bureau [155]	Tract / Block Block Group	1960	
Traffic Proximity	Traffic Proximity and Volume Impacts	Count of annual average daily traffic (AADT) at major roads within 500 meters, divided by distance in meters; or similar analysis method	Major roads and highways can bring air pollutants and noise into proximate communities.	EJScreen, CalEnviroScreen (Constructed from proprietary sources), Colorado EnviroScreen, CEJST, J40 TDCTs, WEHDM, NYCADACs	EPA [156] EPA [17]	Block Group	2011	N/A
	Transportation Noise (BTS)	Approximate average noise energy due to transportation noise sources over a 24-hour period. Can be broken down by noise source (i.e., road, rail, aviation)	Common sources of noise pollution include vehicles, trains, aircraft, and industry. Noise pollution has been associated with sleep disturbance, high blood pressure, diabetes, and heart disease.	Colorado EnviroScreen (uses NPS data source)	BTS [157]	Raster	2016	N/A
	Noise (NPS)	Relative loudness (dBA) of noise at a given location measured for calm summer daytime conditions	Common sources of noise pollution include vehicles, trains, aircraft, and industry. Noise pollution has been associated with sleep disturbance, high blood pressure, diabetes, and heart disease.	Colorado EnviroScreen	NPS [158]	Raster	2015	N/A
	Average Annual Daily Traffic (AADT)	Total volume of vehicle traffic on a highway or road for a year divided by 365 days	Traffic volume contributes to pollutants and noise.	Used for calculating traffic proximity in EJScreen and other indices	NCDOT [159]	Traffic Station	2005	1999
	Population Proximate to Highways	Number (or Percent) of People Living within 150 m of a Highway	Roadway proximity increases exposure to pollutants and noise.	Used for calculating traffic proximity in EJScreen and other indices	CDC [160]	Tract	2015	N/A
	Schools Proximate to Highways	Number (or Percent) of Public Schools Located within 150 m of a Highway	Roadway proximity increases exposure to pollutants and noise.	Used for calculating traffic proximity in EJScreen and other indices	CDC [f]	Tract	2015	N/A

[154] Note: Data modeled from Census of Agriculture. CalEnviroScreen employs model based on data available at state level.

[155] Available from U.S. Census ACS; Block group data available for 1990 and later, tract level data available between 1960 and 1990.

[156] Note: Best Data available via EJScreen.

[157] Available from Bureau of Transportation Statistics, Transportation Noise Map.

[158] Available from National Parks Service Sound Map project, see https://www.nps.gov/subjects/sound/soundmap.htm.

[159] Available from Traffic Survey Group.

[160] Available from CDC National Environmental Public Health Tracking Network (NEPHTN).

Table 4. Common Indicators of Environmental Effects used in Quantifications of Environmental Burden and Social Vulnerability

Subject	Indicator	Measure	Rationale for Inclusion (see Use Cases for details)	Use Cases	Source	Geography	Earliest: Best Data	Earliest: Max Record
Water	Impaired Streams & Waterbodies	Impaired waterbody location and impairment type	A set of waters not meeting water quality standards or which have impaired uses. Surface waters impaired by pollution may affect drinking water sources or limit recreation.	CalEnviroScreen (blended), Colorad o EnviroScreen (violations data provided by CDPHE)	NCDEQ [161]	Waterbody	2006	1996
	Wastewater Discharge / Water Toxic Emissions	Modeled toxic chemical release concentrations to stream waterbodies	Facilities of a certain size and sector must report annual emissions of known toxic chemicals, including chemical that cause: Cancer or chronic human health effects, acute human health effects, and adverse environmental effects. The EPA uses the Risk-Screening Environmental Indicators (RSEI) Model substance travel.	EJScreen, Colorad EnviroScreen, CEJST, WEHDM	EPA[162]E PA[17]	Point	2021	1987
	UST/LUST (Groundwater Threats)	Locations of Underground Storage Tanks (USTs) and Leaking Underground Storage Tanks (LUSTs)/UST Incidents	Leaking tanks or tanks that may potentially leak can expose people to contamination in air, soil, and groundwater. Pollution from contaminated groundwater or soil may expose people in their homes and places of work.	EJScreen, CalEnviroScreen, CEJST,	NCDEQ [163]	Point	1975	1906
Hazardous Sites	Proximity to National Priorities List (NPL) Sites	Count of proximate proposed or listed sites on the NPL	The National Priority List identifies sites that have released or could release hazardous substances into the environment, resulting in population exposure.	EJScreen, CEJST, CalEnviroScreen, Colorado EnviroScreen, NJ EJMAP, WEHDM, NYCADACs	EPA[b]	Point	2013	1983[164]
	Proximity to Risk Management Plan (RMP) Sites	Count of RMP proximate (potential chemical accident management plan) facilities	Facilities that use extremely hazardous substances must develop a Risk Management Plan. Communities proximate to these facilities may be at greater risk of exposure to pollutants in the event an incident occurs.	EJScreen, Colorado EnviroScreen, CEJST, WEHDM, NYCADACs	EPA[b]	Point/Polygon	2013	2000[165]

[161] Available from NCDEQ Water Resource Division Integrated Reports.

[162] Note: Best Data available via EJScreen.

[163] Available from NCDEQ Waste Management Division.

[164] Historical date available from EPA Superfund Program, see https://www.epa.gov/superfund/national-priorities-list-npl-sites-listing-date

[165] Historical data available from EPA RMP database.

	Proximity to Hazardous Waste Facilities	Count of all commercial Hazardous Waste Treatment Storage and Disposal Facilities (TSDFs) within 5 km, divided by distance, presented as population-weighted averages of blocks in each block group	The substances at TSDFs may reach humans in a number of ways. Volatile substances may lead to exposure via respiration. Some substances may travel into groundwater. People may be exposed via groundwater consumption or vapor intrusion.	EJScreen, CEJST, CDC EJI, CalEnviroScreen, Colorado EnviroScreen, WEHDM, NJ EJMAP	EPA[b]	Point/Polygon	2013	2000[166]
	Proximity to Solid Waste Facilities	Weighted quantity of solid waste facilities within a community	Locations include landfills, transfer stations, and composting facilities. These facilities may produce odors and other nuisances in communities where they are located. Insufficiently regulation may lead to health risks.	CalEnviroScreen, NJ EJMAP, NYCADACs	NCDEQ[c]	Point	2022	N/A
	Proximity to Mining Locations	Point locations of mining permits	Mining can cause air, water, and soil pollution, exposing nearby populations.	CEJST, CDC, Colorado EnviroScreen	NCDEQ	Point	2023	1972
Flooding	Floodplains	FEMA Flood Insurance Rate Maps and related products	Floods pose a risk to lives and property. Climate change increases the risk and severity of floods.	Colorado EnviroScreen, NYCADACs	FEMA	Panel	2015	1970

[166] Historical data available from EPA RCRA Database

Table 5. Common Climate Risk Indicators used in Quantifications of Environmental Burden and Social Vulnerability

Subject	Indicator	Measure	Rationale for Inclusion (see Use Cases for details)	Use Cases	Source	Geography	Earliest: Best Data	Earliest: Max Record
Climate	Projected Flood Risk	Share of properties at risk from flood in the next 30 years	Floods pose a risk to lives and property. Climate change increases the risk and severity of floods.	CEJST	CEJST[167]	Tract	2022	N/A
	Wildfire Hazard Potential	An index that quantifies the potential for wildfire that may be difficult to control; informs mitigation activities	Wildfires pose a risk to lives and property. Climate change increases the risk and severity of floods.	Colorado EnviroScreen	USDA[168]	Raster	2012	N/A
	Projected Wildfire Risk	Share of properties at risk from fire in next 30 years	Wildfires pose a risk to lives and property. Climate change increases the risk and severity of floods.	CEJST	CEJST[a]	Tract	2022	N/A
	Projected Loss Rate to Hazards (Single or Multi-hazard)	Expected Value of Agriculture/Building/Population lost each year to hazards	Climate hazards pose a risk to agricultural productivity, buildings, and/or human life. Losses are computed as the expected annual total dollar amount of agricultural products, buildings, and human life lost to these hazards.	CEJST, J40 TDCTs, FEMA NRI	CEJST, FEMA NRI	Tract	2021	N/A
	Extreme Heat Days	Average annual days of Extreme Heat	Extreme heat conditions pose a risk to human health and stress buildings and infrastructure. Climate change increases the number and severity of extreme heat days.	Colorado EnviroScreen, NYCADACs	CDC[169]CDC[28]	Tract	1979	N/A
	Drought Exposure	Sum of weekly total percent of an area experiencing a severe, extreme, or exceptional drought	Drought poses a risk to human life and property. Climate change increases the frequency of severity of drought.	Colorado EnviroScreen	US Drought Monitor[170]	County	2000	N/A
	Agricultural Land	Percent of land area in geographic unit that is covered by agricultural land use	Tracts with a higher percentage of agricultural land are at greater risk to lost productivity due to climate change.	NYCADACs	USGS[171]	Raster	2001	N/A

[167] CEJST employs data from First Street Foundation.

[168] Available via Forest Service Research

[169] Available from CDC National Environmental Public Health Tracking Network (NEPHTN).

[170] Note: US Drought Monitor is produced jointly by the National Drought Mitigation Center (NDMC) at the University of Nebraska-Lincoln, the National Oceanic and Atmospheric Administration (NOAA), and the U.S. Department of Agriculture (USDA)

[171] Available from National Land Cover Dataset (NLCD) produced by Multi-Resolution Land Characteristics Consortium.

Table 6. Common Indicators for Sensitive Populations used in Quantifications of Environmental Burden and Social Vulnerability

Subject	Indicator	Measure	Rationale for Inclusion (see Use Cases for details)	Use Cases	Source	Geography	Earliest : Best Data	Earliest: Max Record
Health Conditions	Asthma	Crude prevalence of asthma among adults (tract) or asthma hospitalizations (county)	Environmental factors like impaired air can trigger and exacerbate asthma attacks and make them more severe.	CEJST, CalEnviroScreen, Colorado EnviroScreen, NYCADACs	CDC[172]	Tract	2018	2010
	Cardiovascular Disease	Crude prevalence of heart disease among adults >= 18 years of age, model-based	Environmental conditions like air quality, drinking water quality, and extreme heat can impact cardiovascular health.	CEJST, CalEnviroScreen, Colorado EnviroScreen, WEHDM, NYCADACs	CDC[a]	Tract	2018	N/A
	LBW Infants	Percent low-birthweight infants (<2,500 G) (singletons)	Exposure to toxics in air, among other factors, can affect infant birth weight.	CalEnviroScreen, Colorado EnviroScreen, WEHDM	CDC[a]	County	2000	N/A
	Cancer	Crude Prevalence of Cancer among adults >= 18 years of age, model-based	People with cancer may be immunocompromised and especially susceptible to pollution. Some environmental pollutants are carcinogenic.	J40 TDCTs, Colorado EnviroScreen	CDC[a]	County/Tract	2018	1998
	Diabetes	Prevalence of Diagnosed Diabetes	The environment can affect the development or progression of diabetes, including via neighborhood walkability and air quality.	CEJST, Colorado EnviroScreen	CDC[a]	County	2010	N/A
	Mental Illness	Percent of adults responding as having at least one (or another threshold) poor mental health days in the past 30 days.	The Behavioral Risk Factor Surveillance System (BRFSS) collects data from U.S. residents about their health-related behaviors, conditions, and preventive service use. Environmental factors can cause stress and other mental health problems.	Colorado EnviroScreen	CDC[a], NCDHHS	County	2011	2001[173]
	Low Life Expectancy	Average life expectancy (in years) at birth	The average life expectancy in a community reflects its overall health and wellbeing.	CEJST, Colorado EnviroScreen	CDC[a], NCDHHS	County/Tract	2015	1990[b]

[172] Available from CDC PLACES data repository.

[173] Historical Data available from North Carolina Department of Health and Human Services

Age	Age: Youth	Population above age threshold (e.g., 5, 18 years of age)	Harmful pollutants have a greater impact on children. Some environmental exposures can affect growth and development, much of which occurs under 5 years of age	EJScreen (5), FEMA NRI (Under 18), Colorado EnviroScreen (5)	US Census Bureau	Block group	1970	1920
	Age: Senior	Population below age threshold (e.g., 5, 18 years of age)	People in this age group are more vulnerable to exposures such as pollution and extreme heat. They also are more likely to have other health conditions exacerbated by environmental factors.	EJScreen (65+), J40 TDCTs, FEMA NRI (65+), Colorado EnviroScreen	US Census Bureau	Block group	1970	1930
Built Environment	Neighborhood Walkability	National Walkability Index Value	Characteristics of the built environment may encourage or discourage walking trips. A built environment conducive to walking supports physical health.	J40 TDCT	EPA[174]	Block Group	2014	N/A
	Proximity to Open/Green Space	Proportion of area proximate to open space and/or parks	Green spaces provide access to physical recreation and promote physical activity and health	CDC EJI, NJ EJMAP	CDC[a]	Tract	2015	N/A

[174] Available from EPA Smart Locations Database

Table 7. Common Indicators for Socioeconomic Characteristics used in Quantifications of Environmental Burden and Social Vulnerability

Subject	Indicator	Measure	Rationale for Inclusion (see Use Cases for details)	Use Cases	Source	Geography	Earliest : Best Data	Earliest: Max Record
Population	Population	Total population count at the community level.	Count of population proximate to environmental indicators is used by many cases to scale impacts.	Component of various indicators	US Census Bureau	Block Group/Tract/ County	1970	1900
Race/Ethnicity	Racial/Ethnic Minorities	Population that identifies as racial/ethnic minority	Racism can affect health outcomes, the magnitude of environmental exposures, access to or quality of preventative services, and other determinants of health.	EPA EJScreen, F, Colorado EnviroScreen, WEHDM, NYCADACs	US Census Bureau [175]	Block group	1970	1900
	HOLC Redlining Maps	Historic redlining score for census tracts, developed using digitized HOLC maps.	The Home Owners' Loan Corporation (HOLC) was a U.S. federal agency that graded mortgage investment risk of neighborhoods across the U.S. between 1935 and 1940. These maps included race and ethnicity in their determinations of investment risk, systematically embedding racism in urban investment patterns.	CEJST	CEJST	City & Neighborhood	1935	N/A
Socioeconomic Status	Educational Attainment	Percentage of population over 25 with education less than high school diploma	Low education is associated with lower life expectancy and poorer health outcomes. Additionally, adults with less education are more likely to experience pollution-related health problems.	EJ Screen, CEJST, J40 TDCTs, FEMA NRI, CalEnviroScreen, Colorado EnviroScreen, WEHDM, NYCADACs	US Census Bureau[a]	Census Block	1970	1900
	Unemployment	Percentage of working age population that is unemployed, excluding military personnel and people not looking for work	People who are unemployed may lack health insurance; unemployment stress may adversely affect health; impaired health may impact employment-seeking	EJ Screen, CEJST, J40 TDCTs, FEMA NRI, CalEnviroScreen, Colorado EnviroScreen, WEHDM, NYCADACs	US Census Bureau[a]	County	1970	1900
	Income/Poverty	Percentage of population that is either low-income (using various definitions) or in poverty (using federal poverty level definition).	Low-income and/or poor communities are more likely to be proximate to sources of pollution. Poverty can contribute to weakened immune systems, worsening the effects of pollution exposure.	EJ Screen, CEJST, J40 TDCTs, FEMA NRI, CalEnviroScreen, Colorado EnviroScreen, WEHDM, NYCADACs	US Census Bureau[a]	Census Tract	1979	1900

[175] Available from the Decennial Census and American Community Survey. ACS Data typically provides the greatest detail (block group level values). Geographies available in the historical record vary, and historical geographies may not map consistently to current geographies.

Language	English Proficiency	Percentage of people age 5 and older who speak English "less than well" (among other definitions).	English language proficiency is essential for understanding and responding to hazards.	EJ Screen, CEJST, J40 TDCTs, FEMA NRI, CalEnviroScreen, Colorado EnviroScreen, WEHDM	US Census Bureau[a]	Block Group/Tract	2006	1980
Transportation	No/Limited Vehicle Access	Percentage of population/households with no access to a vehicle.	In locations lacking robust public transportation infrastructure, lacking a vehicle is a major impediment to personal mobility	J40 TDCTs, FEMA NRI	US Census Bureau [176]	Block Group/Tract	2006	1980
	Household Transportation Costs	Modeled transportation costs as a percent of income	Larger household transportation costs are associated with higher transportation burden. The U.S. Department of Housing and Urban Development (HUD) models household transportation costs for the Location Affordability Index.	J40 TDCTs, WEHDM	HUD[177]	Tract	2009	N/A
	Commute Time	Travel time for work for Workers 16 years and over who worked outside the home	Longer commutes are a form of transportation burden.	J40 TDCTs	US Census Bureau[b] Bureau[41]	Tract	2006	1980
Housing	Housing Burden	Percentage of households that are burdened by high housing costs	Housing-burdened households are those that spend a larger than typical percentage of their income on housing. Definitions vary; many examine housing costs as a percentage of income for low-income households (CEJST, CalEnviroScreen, CDC EJI); others look at housing costs as a percentage of income for the population overall or for a regional typical household (J40 TDCTs, Colorado EnviroScreen).	CEJST, J40 TDCTs, FEMA NRI, CalEnviroScreen, Colorado EnviroScreen, WEHDM, NYCADACs	US Census Bureau [178]Bureau[40]	Block Group/Tract/County	1980	1930
	Housing Tenure (Renters)	Percent of housing units that are renter-occupied	Renters often have less social capital to leverage toward environmental decision-making. Research also shows that renters experience worse health outcomes for many conditions compared to owners.	J40 TDCTs, CDC EJI	US Census Bureau[a] Bureau[40]	Block Group/Tract/County	1970	1930

[176] Available from US Census ACS.

[177] Alternative data set available from Center for Neighborhood Technology (H+T Index). See https://htaindex.cnt.org/map/.

[178] Available from the Decennial Census and American Community Survey. ACS Data typically provides the greatest detail (block group level values). Geographies available in the historical record vary, and historical geographies may not map consistently to current geographies.

Disability	Disability	Percent of population over 5 years of age with at least one of six aspects of disability: hearing, vision, cognitive, ambulatory, self-care, and independent living	These conditions can make it more difficult to cope with the effects of environmental or climate hazards and may impact personal mobility.	FEMA NRI, Colorado EnviroScreen	US Census Bureau [179], CDC	Tract/Block Group	2015	2008

[179] Available from US Census ACS.

Table 8. Important Data Repositories and Descriptions

Data Repository	Agency	Description
EPA EJScreen: Environmental Justice Screening and Mapping Tool	EPA	In addition to providing several EJ indices that combine environmental and social factors, EJ Screen is a source for nationally-consistent environmental data at the block group level.
EPA EnviroFacts/EnviroMapper	EPA	A store of nationally-consistent environmental datasets on a variety of topics included in the reviewed tools. EnviroMapper provides an geospatial data browsing utility.
EPA TRI Toxics Tracker	EPA	The EPA's TRI Toxics Tracker is a source for nationwide data on toxic releases included in the Toxics Release Inventory (TRI) Program.
EPA WATERS	EPA	The EPA's Watershed Assessment, Tracking & Environmental Results System is a nationally-consistent data set describing the quality of surface waters.
NCDEQ Community Mapping System	NCDEQ	This tool includes many data layers related to regulated facilities and environmental hazards and includes NCDEQ's definition for Potentially Underserved Block Groups.
CDC PLACES	CDC	The CDC's PLACES repository provides nationally-consistent health data estimates for small areas.
CDC National Environmental Public Health Tracking Network (NEPHTN)	CDC	The NEPHN combines health and environmental data in a single, nationally consistent repository.
North Carolina State Center for Health Statistics (NCSCHS) Health Data Query System	NCDHHS	The Health Data Query System and other NCSCHS products provide information on vital statistics and other NC focused health data.
US American Community Survey	US Census Bureau	The American Community Survey is a regular sample of population and population characteristics used as social indicators in the reviewed tools. Estimates are available from 1-Year, 3-Year, and 5-Year samples.
US Decennial Census	US Census Bureau	The U.S. Decennial Census provides an essential, though limited-detail, historical record of population characteristics that can be used to describe social vulnerabilities.

Table 8. Infrastructure Development and Conditions Data Available for Historic Analysis

Subject	Data Set	Description	Uses	Source	Geography	Earliest: Best Data	Earliest: Max Record
Infrastructure Development	Highway Locations	Locations and dates of highway and state-funded roadway projects	Locations and construction dates are critical to understanding impacts	NCDOT	Network Segment	1950	1950
	Interstate Straight-Line Diagrams	Diagrammatic construction information for N.C. Interstates	Historically used in the planning and development of roadway projects, straight-line diagrams are graphic illustrations of the construction history of North Carolina's Interstates for a particular period.	NCDOT	Network Segment	N/A	1950
	Historic Aerial Imagery (NCDOT)	Digital aerial imagery for select locations and times	Historical aerial imagery may be used to analyze construction projects and assist in identifying and mapping historical conditions.	NCDOT	Small Area	N/A	1955
	NCDOT Strategic Prioritization Submissions & Results	Scores and locations of projects submitted and funded under the Strategic Transportation Improvement Program (STIP)	The Strategic Transportation Improvement Program (STIP) uses a data-driven scoring methodology to rank submitted projects. These projects include highways and other modes.	NCDOT	Project	2019	2010
Infrastructure Conditions	Average Annual Daily Traffic (AADT)	Total volume of vehicle traffic on a highway or road for a year divided by 365 days	Traffic volume contributes to pollutants and noise.	NCDOT	Traffic Station	2005	1999
	Pavement Conditions	Assessment of conditions for state-maintained routes	The NCDOT Pavement Management Unit maintains authoritative pavement conditions data. Pavement Management Systems are the primary source for pavement conditions and maintenance activities history.	NCDOT	Network Segment	2022	2012
	Maintenance Condition Reports (MOPAR & MCAP)	Program to survey and evaluate structure and road conditions statewide and estimate investment needs.	NCDOT reporting summarizes conditions and need within districts. Since 2008, conditions and needs have been surveyed by county. However, they are reported at the division level.	NCDOT	County	N/A	2008
	Structures/Bridge Locations & Conditions	Locations and general conditions of bridges and other NCDOT structures	Structure conditions can be assessed to determine if poor bridge conditions are correlated with other equity concerns.	NCDOT	Structure Location	2023	N/A

Figure 1. Availability of Data for Common Environmental and Social Indicators over Time

PRELIMINARY TIME-SERIES VISUALIZATIONS

Overview

A series of visualizations have been created to demonstrate the range of methods that will be used in future ArcGIS StoryMaps and presentation materials for animating through time. Data from a limited time span (2010 to 2021) have been incorporated to demonstrate the visualization of differences across space and time of communities identified based on three different sets of metrics. Data for earlier periods to facilitate visualization of a longer historical record will be included in later products. Example images of the preliminary visualization products are provided below, including a link to the web-based ArcGIS StoryMaps visualization. Standalone animated GIF files (described in more detail below) will be provided separately.

The research team documented many of the methods for identifying disadvantaged communities. Some of these methods incorporate a broad selection of environmental hazards and health impacts, in addition to a number of demographic characteristics describing community vulnerability. Examples include non-English speakers, age (under 5 and over 65), and educational attainment. This preliminary time-series visualization effort focuses on the North Carolina Department of Environmental Quality's (NCDEQ) definition for potentially underserved communities (PUCs), a definition that includes race, ethnicity, and poverty factors. This definition is situated among the more concise state-level definitions formulated for identifying historically vulnerable populations in transportation and environmental justice contexts. After additional testing and integration of other data sources, the preliminary animations will be enhanced. Along with these visualizations, a written summary describing these efforts to translate GIS models into web-GIS models and ArcGIS StoryMaps will be developed.

This submission includes two formats of visualization: (1) an ArcGIS StoryMaps, a web-based visualization tool that allows users to explore map content with supporting narrative information, and (2) animated GIFs, standalone animated image files that can be incorporated into web-based platforms, including ArcGIS StoryMaps. For this submission, several visualizations have been placed within a StoryMap to allow for viewing. Please note that this is a demonstrational version of the StoryMap deliverable that is built to incorporate data from the limited time span described above. In addition to an extended historical picture, the finalized StoryMap that is designed to support community engagement will be accompanied by extensive dialogue and additional time series animations to introduce the viewer to concepts related to transportation environmental justice.

Methodology

This preliminary set of animations were created using the North Carolina Department of Environmental Quality's (NCDEQ) definition of Potentially Underserved Communities (PUC).[180] These communities are defined as block groups or census tracts that meet or exceed NCDEQ's benchmark criteria for high concentrations of minority and low-income populations. Specifically, a block group or census tract is considered to be potentially underserved if it meets the following criteria for both race/ethnicity and poverty:

[180] North Carolina Department of Environmental Quality. (2022). Community Mapping System: Glossary of Terms and Definitions. Retrieved from https://www.deq.nc.gov/ej/nccms/nccms-glossary-terms-updated-january-2022/download?attachment

Race/Ethnicity
The share of nonwhites and Hispanic or Latinos (of any race) is over 50% **OR**
The share of nonwhites and Hispanic or Latinos (of any race) is at least 10% higher than the county or state share.

AND

Poverty
The share of the population experiencing poverty is over 20%, **AND**
The share of households in poverty is at least 5% higher than the county or state share.

The socioeconomic and demographic data used in these maps were obtained from the respective American Community Survey (ACS) Five-Year Estimate datasets:

- Race: Black or African American Alone + American Indian and Alaska Native Alone + Asian Alone + Native Hawaiian and Other Pacific Islander Alone + Some Other Race Alone + Two or More Races
- Hispanic or Latino Origin by Race
- Poverty Status in the Past 12 Months by Household Type by Age of Householder
- Poverty Status in the Past 12 Months of Families by Family Type

The availability of consistent poverty data (using the exact variables noted above) was the limiting factor in determining the years to be mapped as PUC using the NCDEQ criteria. These poverty data are available by block group for years 2013 through 2021 and by census tract for 2010 through 2021.

Block group data yields a more granular representation compared to census tracts. **Block groups are subdivisions of census tracts and consist of between 600 and 3,000 people each.** The most accurate census data are from decennial years, followed by the 5-year ACS estimates and selected 1-year estimates within 5-year estimates. The series of maps presented here is comprised of 5-year estimates and 1-year estimates by block group or census tract, mapped as an ArcGIS StoryMaps and as animated GIFs.

Demonstrations for Animating through Time

Scrolling Time Series
A StoryMap consisting of a series of scrolling map animations for PUC by year has been created to simulate changes across time. There are four animation series:

- Mecklenburg County Potentially Underserved Block Groups, 2013-2021,
- North Carolina Potentially Underserved Block Groups, 2013-2021,
- Mecklenburg County Potentially Underserved Census Tracts, 2010-2021
- North Carolina Potentially Underserved Census Tracts, 2010-2021

This animation series enables viewing of estimations of annual spatial change in PUC locations across the state and within Mecklenburg County. The changing spatial pattern is of PUCs readily apparent in the annual visualizations, and is most striking at the county level. By scrolling through the years in the StoryMap format, the user can spend as much time on any year as is needed. As previously noted, the

availability of the precise poverty variables (available by block group for 2013-2021 and by census tract for 2010-2021) determined the years employed. Other data and mapping limitations are described below.

Animated GIFs

Animated GIFs (included as an attachment and as example still images in Figures 1 and 2) of four separate animations have been created as additional visualizations. These correspond to the same four scenarios described above for the scrolling maps. The GIFs automatically move from year to year, whereas the scrolling ArcGIS StoryMaps requires manual movement through the years. The appearance is smoother, but the user cannot stop the animation to spend time viewing any one year. Animated GIFs will be inserted into future presentation deliverables and ArcGIS StoryMaps deliverables.

Figure 1. Side-by-Side of Still Images from Animated GIF for Potentially Underserved Communities in Mecklenburg County

Figure 2. Side-by-Side of Still Images from Animated GIF for Potentially Underserved Communities in North Carolina

Data Limitations

As with any mapping process, there are limitations with the data, the mapping techniques, and the technology. In terms of data, there are several issues with census data that make longitudinal analysis challenging. These include:

- The exact poverty variables used for the NCDEQ method of determining potentially underserved communities' dates back to 2013 for block groups and 2010 for census tracts; however, other poverty variables are present in the census dataset for earlier years and may be useful supplements for understanding the spatial distribution of poverty in earlier years.

- PUC mapping for earlier years can be achieved for race/ethnicity at the level of the census tract; however, data for mapping for 2000 and earlier are available via the decennial census only.

- Race/ethnicity data (categories) are less detailed for 1990 and decades earlier; thus, only 2000 and 2005 will allow for PUC mapping of race/ethnicity components that is precisely comparable to 2010 and beyond. Mapping earlier than 2000 can be done for census tracts for 1990 and earlier decennial dates, but with the fewer available race/ethnicity categories.

- One-year estimates are only available for geographic areas with a population of 60,000 or more.

- 5-year estimates begin in 2005-2009 and are available but with limitations. The 5-year estimates reflect a pooled and weighted average of individual years within a 5-year period. The Census Bureau recommends not using estimates from overlapping 5-year periods. We therefore took our estimates from non-overlapping 5-year estimates (see Figure 3). As indicated in the name, however, these are "estimates" and should be viewed as such when comparing the 1-year map animations.

- Census geographies change year to year and when working with ACS data the Census Bureau recommends "…comparisons across time be made with caution, or not compared at all."[181] Block groups are subdivisions of census tracts and consist of between 600 and 3,000 people each, while census tracts bound geographical areas with an average of 4,000 people each. As population numbers change, boundaries are redrawn to reflect the population requirements for block groups and census tracts. Population increase may result in the subdivision of block groups and tracts; likewise, boundaries can be redrawn to reflect population decrease. In viewing animations, therefore, shifting PUC locations reflect changing boundaries as well as population character (race/ethnicity and poverty).

- Note that there are decennial census data for the year 2000 and earlier that are available for mapping within the 2010 census tract geographies. Decennial comparisons for 2010 and earlier for census tracts will therefore be comparable by geography but not necessarily by precise race category.

- The story mapping tool is very useful but has its inherent technological limitations. There are limits to map design and placement of text. The base map tends to shift when moving between dates. The image may appear lighter or darker. Depending on server speed, viewer connection quality, and the

[181] U.S. Census Bureau. (2022). Comparing ACS Data. Retrieved from https://www.census.gov/programs-surveys/acs/guidance/comparing-acs-data.html

viewing platform (phone, tablet, laptop, desktop), the image loading time may be delayed. Please keep these details in mind when viewing the StoryMap.

Figure 3. Non-Overlapping Periods of ACS 5-Year Estimates[182]

GIS analysis is currently ongoing in the following areas: (1) identify PUCs based on two additional definitions, (2) integrate NCDOT infrastructure conditions juxtaposed against PUCs to identify potential areas of opportunities, and (3) explore the utility of dot density mapping in comparison to threshold concentrations by Census geographic areas. A subset of the visualizations created for this deliverable and outcomes of the ongoing work will be integrated into ArcGIS StoryMaps and supported by extensive dialogue and additional time series animations to introduce the viewer to context related to historic transportation environmental justice (EJ) issues and potential opportunities for future transportation investment. Map products will also be integrated into a web application and two canned MS PowerPoint Presentations.

[182] Image Source: U.S. Census Bureau. (2022b). Period Estimates in the American Community Survey. Retrieved from https://www.census.gov/newsroom/blogs/random-samplings/2022/03/period-estimates-american-community-survey.html#:~:text=What%20are%20period%20estimates%3F,to%20create%205%2Dyear%20estimates.

Appendix 2: Geodata Base Development and Mapping Application

The research team created a series of geodatabases for mapping and analysis of transportation EJ issues at the statewide scale. This appendix serves as documentation to capture the development process and data used to create these maps and time series images. The completed refined animation series was delivered at the early stages of this project. Some mapping was further adjusted and refined to include the StoryMaps developed for this project. Appendices 2 through 5 are presented as notations to document the research process.

Exhibit 1: Geodatabases Developed with Statewide Data

Database Name	**Database Description and Application**
ETC-DOT	Geodatabase illustrates selected transportation-related variables within the ETC-DOT mapping tool and relates to the maps we produced to show distribution of Potentially Underserved Communities (PUC's). PUC's were determined by census tract and block group using the NCDEQ formula based upon race and poverty. PUC's were used for this analysis as a spatial boundary that identifies where people live who may have experienced, or are at risk for experiencing environmental injustice based upon race and poverty. These boundaries thus surround populations that satisfy the race and poverty criteria as calculated with the NCDEQ formula: Share of nonwhites and Hispanic or Latino (of any race) is over fifty percent OR Share of nonwhites and Hispanic or Latino (of any race) is at least ten percent higher than County or State share AND Share of population experiencing poverty is over twenty percent AND Share of households in poverty is at least five percent higher than the County or State share.

PavementsGDB	Geodatabase contains numerous data layers that divide the state's pavements by type or category into Primary and Secondary Roads, and Interstates. Within each road category, roads were classified by condition as poor (RTG_NBR< 60), moderate (RTG_NBR>60 and RTG_NBR<80), or good (RTG_NBR>80). Roads by condition were mapped on Potentially Underserved Communities (PUC's) by block group to determine the percent within each category and condition that were located in PUC's. Mapping was done for the state and for Mecklenburg, Durham-Wake, and Forsyth-Guilford Counties.
BridgesGDB	Geodatabase was used to identify those bridges that were designated as Structurally Deficient, Functionally Obsolete, or both. These were mapped with Communities of Concern (also known as Potentially Underserved Communities) to determine the location of deficient bridges within EJ communities across the state.

Below are a few examples from the ETC-DOT, Pavements, and Bridges geodatabases.

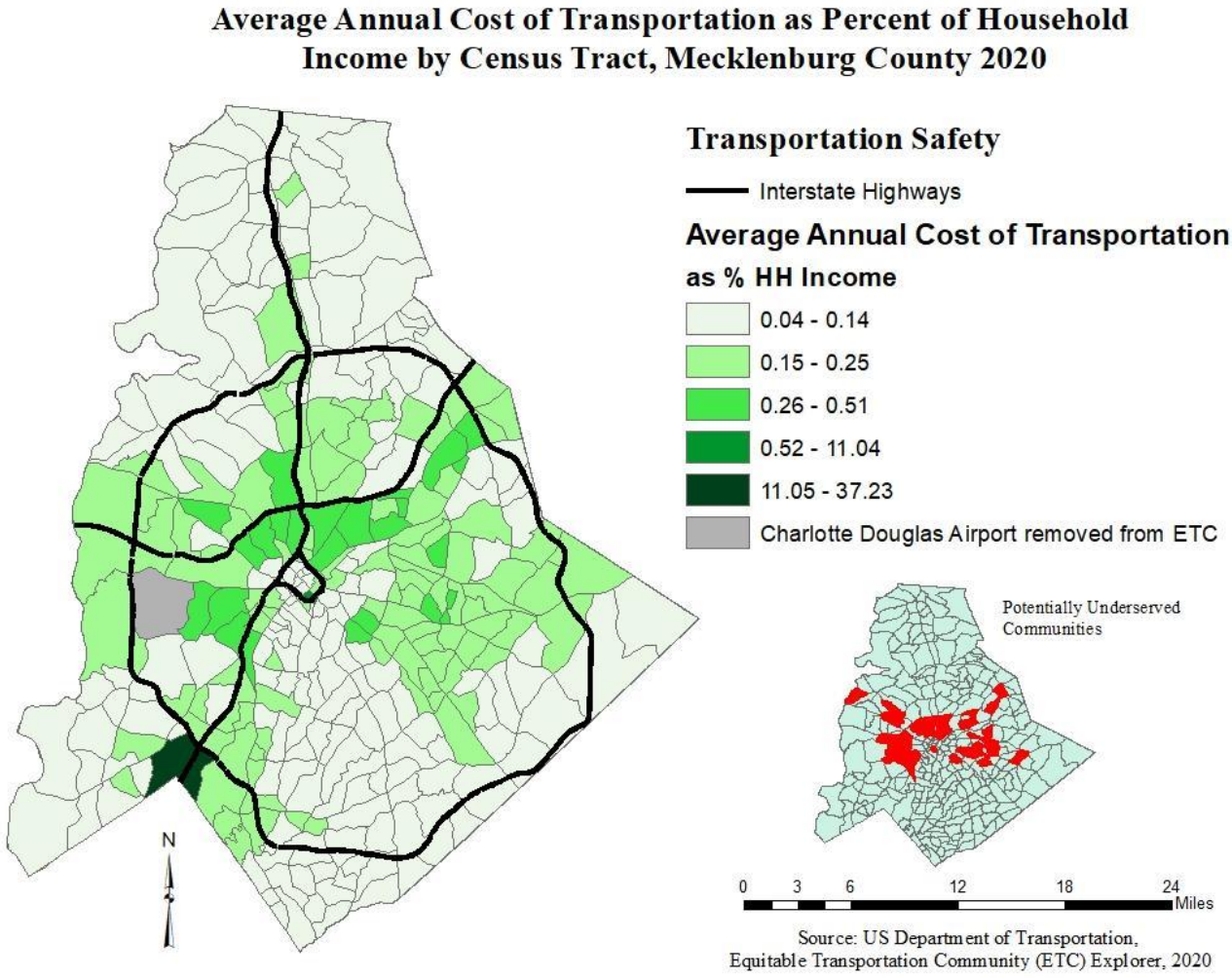


Exhibit 2: Average Annual Cost of Transportation as Percent of Household Income by Census Tract, Mecklenburg County 2020

Data from NCDOT and the Equitable Transportation Community Explorer were used to compile the Average Annual Cost of Transportation as a Percentage of Household Income with Interstate Highways as an overlay, and Potentially Underserved Communities as an inset. For the most part, a larger share of a family's household income is spent on transportation in PUC block groups and along the North-South and East-West extending interstates.

EXAMPLE ANALYSIS WITH PAVEMENTS GEODATABASE

For pavements analysis, pavements were separated by RTG_NBR into Poor (<60), Moderate (60-80) and Good (>80). Each pavement layer (poor, etc) was intersected with the 2020 PUC Block groups to

determine how many segments fell within PUC vs non-PUC block groups. Note that the number of block groups increased in 2020 due to subdivisions to accommodate population growth. The tables below compare 2020 with 2015 for the number and percentage of Interstate, Primary and Secondary roads in poor, moderate and good condition that are located in Non-PUCs vs PUCs. They show, for example, that between 2015 and 2019 there was an over 2 percentage point increase in the percentage of interstate pavements in good condition in PUCs.

North Carolina Interstate Pavement Segments by Condition (Poor or Moderate) that fall within Potentially Underserved Communities by Block Group for 2020 (1390/7111 Block Groups)

		Non PUC #	Non PuC %	PuC #	PuC %
Poor		165	4.81	34	4.12
Moderate		391	11.41	87	10.55
Good		2872	83.78	704	85.33
Totals		3428	100	825	100

North Carolina Interstate Pavement Segments by Condition (Poor or Moderate) that fall within Potentially Underserved Communities by Block Group for 2015 (1937/6155 Block Groups)

		Non PUC #	Non PuC %	PuC #	PuC %
Poor		161	5.38	37	3.35
Moderate		309	10.32	154	13.92
Good		2524	84.30	915	82.73
Totals		2994	100	1106	100

North Carolina Primary Pavement Segments by Condition (Poor or Moderate) that fall within Potentially Underserved Communities by Block Group for 2020 (1390/7111 Block Groups are PUC)

	Segments in PUC by Condition (#)	Segments in Non-PUC by Condition (#)	Total Segments by Condition	% of Segments in PUC by Condition	% of Segments in Non-PUC by Condition
Poor	695	2443	3138	22.15	77.85
Moderate	1176	4173	5349	21.99	78.01
Good	3573	13624	17197	20.78	79.22
Totals	5444	20240	25684	21.20	78.80

North Carolina Primary Pavement Segments by Condition (Poor or Moderate) that fall within Potentially Underserved Communities by Block Group for 2015 (1937/6155 Block Groups are PUC)

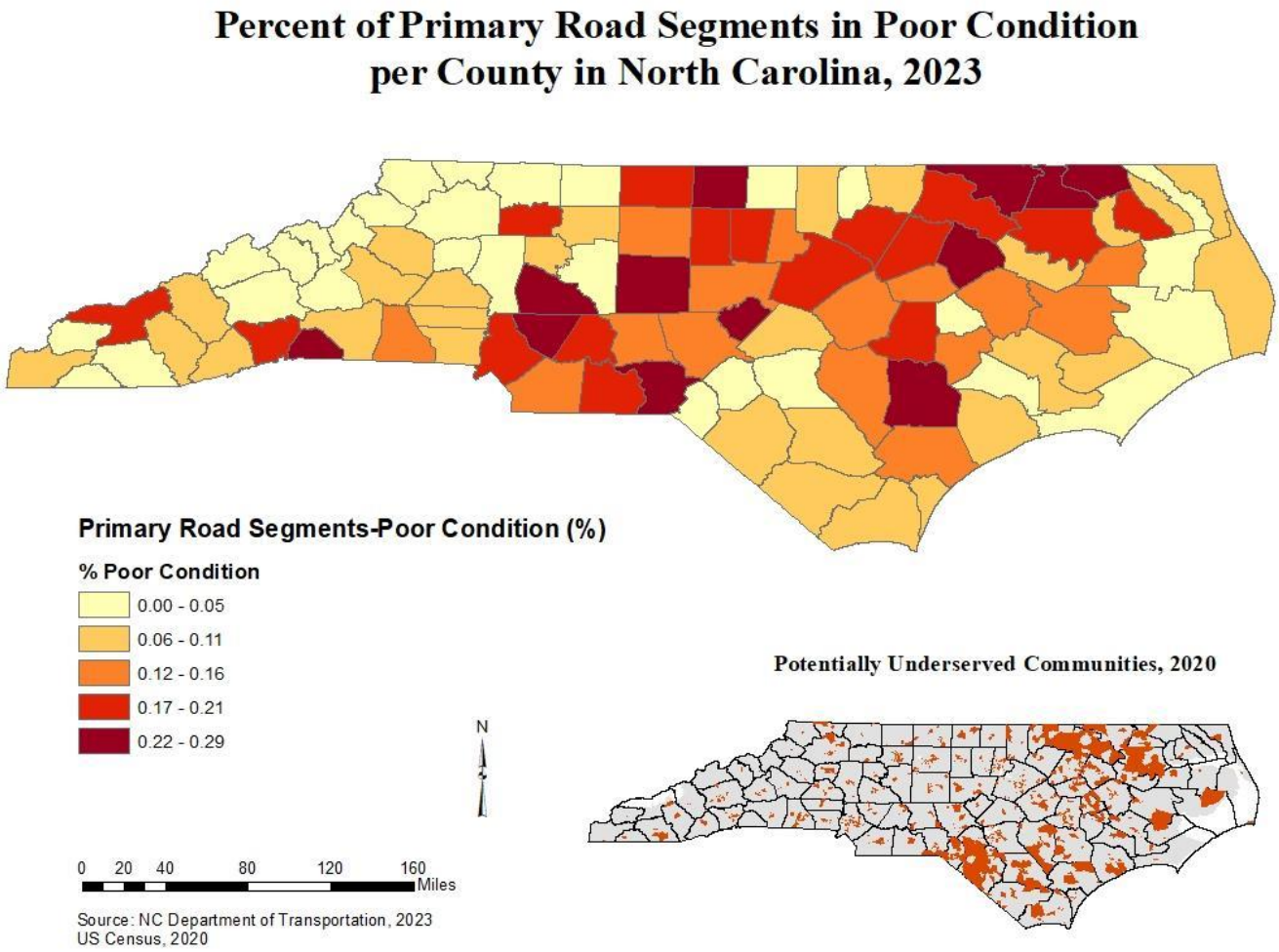
	Segments in PUC by Condition (#)	Segments in Non-PUC by Condition (#)	Total Segments by Condition	% of Segments in PUC by Condition	% of Segments in Non-PUC by Condition
Poor	969	2052	3021	32.08	67.92
Moderate	1855	3348	5203	35.65	64.35
Good	5703	10929	16632	34.29	65.71
Totals	8527	16329	24856	34.31	65.69

North Carolina Secondary Pavement Segments by Condition (Poor or Moderate) that fall within Potentially Underserved Communities by Block Group for 2020 (1390/7111 Block Groups)

		Non PUC #	Non PuC %	PuC #	PuC %
Poor		8505	7.78	1348	8.62
Moderate		26264	24.04	3723	23.81
Good		74494	68.18	10566	67.57
Totals		109263	100	15637	100

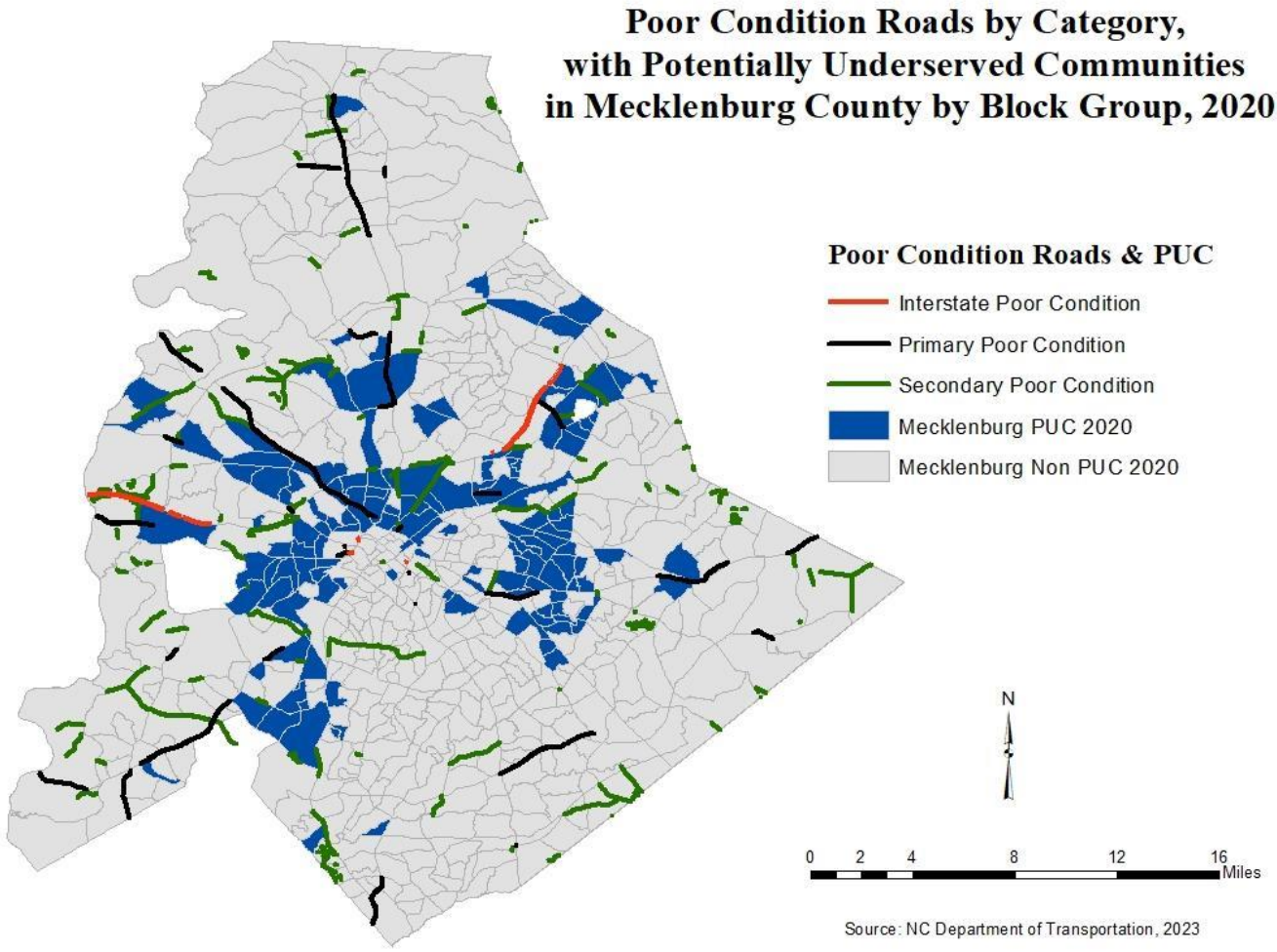
North Carolina Secondary Pavement Segments by Condition (Poor or Moderate) that fall within Potentially Underserved Communities by Block Group for 2015 (1937/6155 Block Groups)

		Non PUC #	Non PuC %	PuC #	PuC %
Poor		7441	7.89	2088	7.64
Moderate		22698	24.07	6481	23.72
Good		64170	68.04	18759	68.64
Totals		94309	100	27328	100



Percent of Primary Road Segments in Poor Condition per County in North Carolina, 2023

The above map illustrates North Carolina counties by percent of primary road segments categorized as being in poor condition. A state-level PUC map by county demonstrates strong visual correlation between PUC's and poor condition primary roads in the Northeast and Eastern counties, and to some extent along South-Southeastern counties.

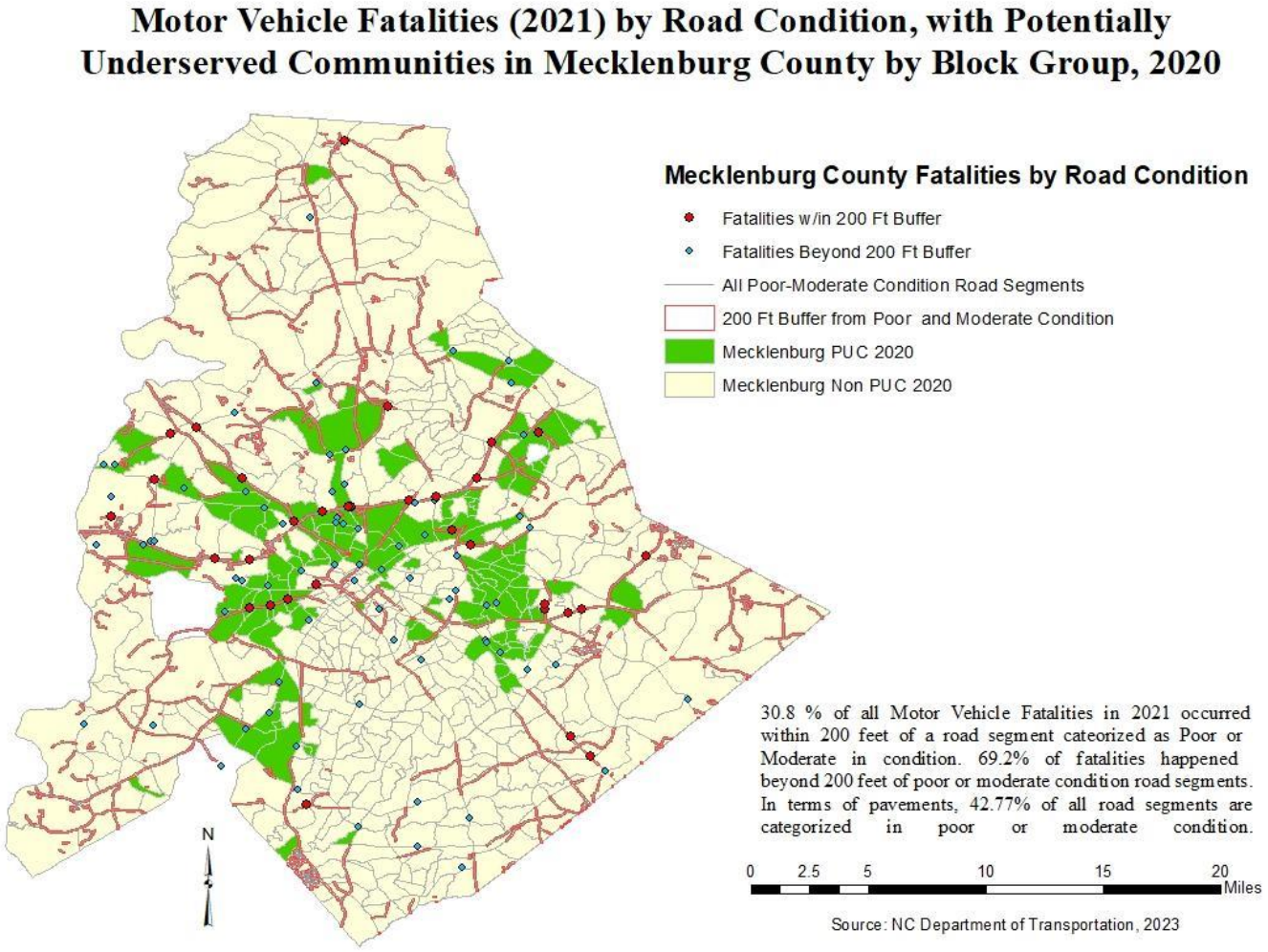


Poor Condition Roads by Category, with Potentially Underserved Communities in Mecklenburg County by Block Group, 2020

Road segments categorized with poor condition are mapped by road type (Interstate, Primary, Secondary) and in reference to PUC's by block group in Mecklenburg County in 2020. A larger number of poor condition primary and interstate segments align with or run through PUC's.

EXAMPLE ANALYSIS WITH SAFETY DATA

In an effort to map PUC locations, highway asset conditions and safety, motor vehicle fatalities were isolated within the buffers to calculate the percent of motor vehicle fatalities that were occurring along poor and moderate condition roads. These were plotted onto the PUCs map by block group to determine the percent that fall within PUCs.



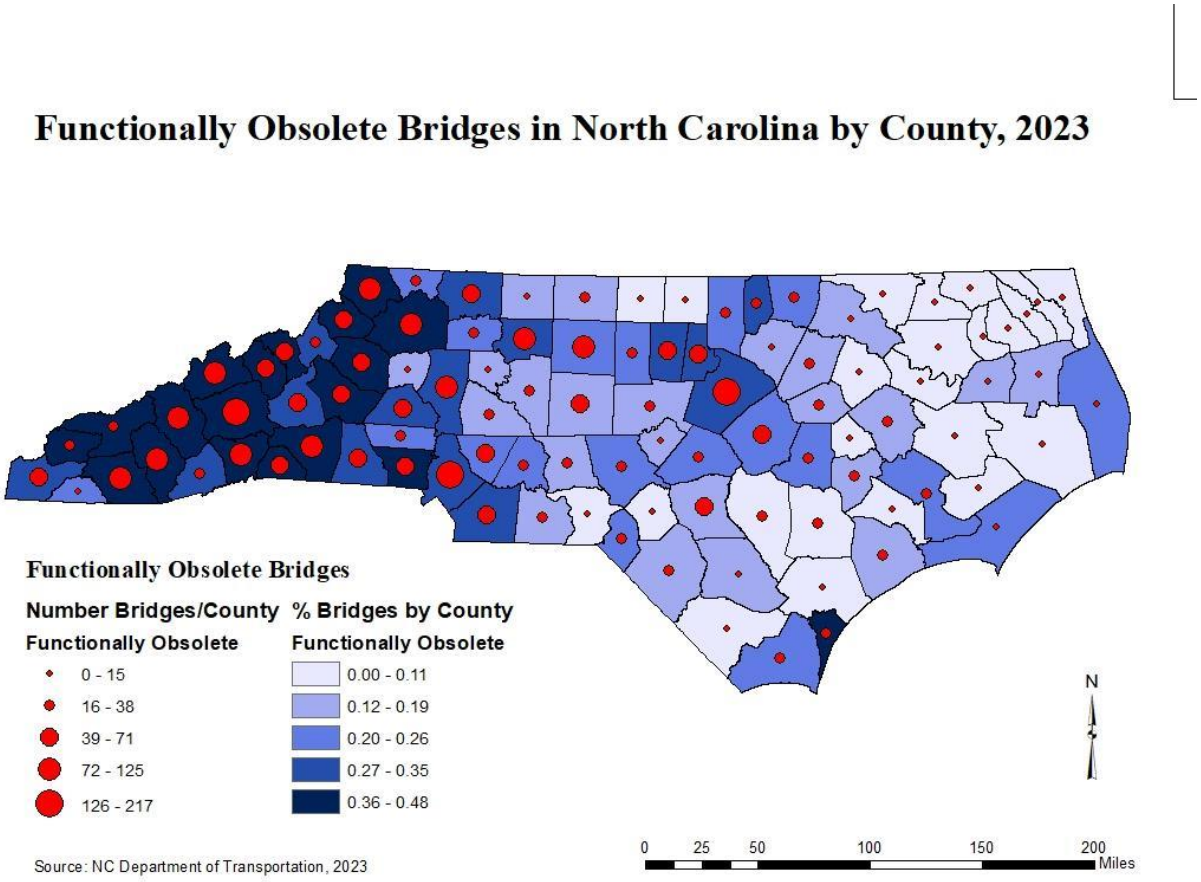
Motor Vehicle Fatalities (2021) by Road Conditions, with Potentially Underserved Communities in Mecklenburg County by Block Group, 2020

In this analysis, Motor Vehicle Fatalities (2021) are mapped within or beyond 200 feet of a road segment categorized as being in poor or moderate condition. The fatalities and poor-moderate road buffers overlay onto PUC's (2020). The map demonstrates that 30.8% of fatalities occurred within 200 ft of a poor or moderate condition road segment. Additionally, 42.7% of all road segments in Mecklenburg County are categorized in poor or moderate condition.

EXAMPLE ANALYSIS WITH BRIDGES GEODATABASE

NCDOT categorizes bridges by condition. Problem bridges are categorized as either Structurally Deficient, or Functionally Obsolete. The above map illustrates the number and percent of bridges by county that are functionally obsolete. Some counties have very few bridges, thus percentages may be

inflated. The number of bridges is included to show counties where the high percent is based upon a large number of bridges.



Functionally Obsolete Bridges in North Carolina by County, 2023

Tabular results compare bridges by condition in relation to PUC's by block group for 2015 and 2020. In 2020, in addition to a different total number of block groups (revised to account for increases in population by block group), fewer poor condition bridges (structurally deficient or functionally obsolete) were found to be located within PUC block groups. This decrease is possibly influenced by the disappearance of PUC's across time using the NCDEQ method of PUC determination. Details on this are found in Appendix 4.

North Carolina Bridges by Condition (Structurally Deficient or Functionally Obsolete, or Both) in Comparison with Potentially Underserved Communities by Block Group for 2015 (1937/6155 Block Groups)

	Total	Non PUC #	Non PuC %	PuC #	PuC %
Structurally Deficient	1175	844	71.83	324	27.57
Functionally Obsolete	3662	2624	71.65	1020	27.85
Both SD and FO	626	464	74.12	161	25.72
All SD and All FO (excl Both)	4837	3468	71.70	1344	27.79
All Bridges	14174	9866	69.61	4166	29.39

North Carolina Bridges by Condition (Structurally Deficient or Functionally Obsolete, or Both) in Comparison with Potentially Underserved Communities by Block Group for 2020 (1390/7111 Block Groups)

	Total	Non PUC #	Non PuC %	PuC #	PuC %
Structurally Deficient	1175	1050	89.36	125	10.64
Functionally Obsolete	3662	3149	85.99	513	14.01
Both SD and FO	626	562	89.78	64	10.22
All SD and All FO (excl Both)	4837	4199	86.81	638	13.19
All Bridges	14174	11983	84.54	2191	15.46

Appendix 3: Geodatabase Tables for Statewide Analysis

A database was used to create maps illustrating selected transportation-related variables within the ETC-DOT mapping tool and relate to the maps we produced to show distribution of Potentially Underserved Communities (PUC's). PUC's were determined by U.S. Census tract and block group using the NCDEQ formula based upon race and poverty.

This appendix serves as documentation to capture the development process and data used to create these maps and time series images. The completed refined animation series were delivered at the early stages of this project. Some mapping was further adjusted and refined to include the StoryMaps developed for this project. Appendices 2 through 5 are presented as notations to document the research process.

ETC-DOT CONTENTS

Layer Name	Description	Geometry	Records
DOT_Index_State_5_3	ETC data at the census tract level for every state in the U.S.	Polygon	85508
DOTIndexNC	ETC data for North Carolina, clipped from DOT_Index_State_5_3.	Polygon	2768
DurhamWake	County boundaries used to form the FatalitiesperTractDurWake layer.	Polygon	2
DurhamWakeNonPUC	Block groups in Durham and Wake Counties mapped as non-PUC (2020).	Polygon	763
DurhamWakePUC2020	Block groups in Durham and Wake Counties mapped as PUC (2020).	Polygon	125
FatalitiesperTractDurWake	ETC data for Durham and Wake Counties, focusing on traffic fatalities per 100,000 people and transportation cost as % of household income.	Polygon	338

Fatalities per TractFG	ETC data for Forsyth and Guilford Counties, focusing on traffic fatalities per 100,000 people and transportation cost as % of household income.	Polygon	256
Fatalities per TractMeck	ETC data for Mecklenburg County, focusing on traffic fatalities per 100,000 people and transportation cost as % of household income.	Polygon	346
ForsythGuilfordNonPUC	Block groups in Forsyth and Guilford Counties mapped as non-PUC (2020).	Polygon	483
ForsythGuilford	County boundaries used to form the FatalitiesperTractFG layer.	Polygon	2
ForsythGuilfordPUC2020	Block groups in Forsyth and Guilford Counties mapped as PUC (2020).	Polygon	160
Interstate HighwayDurWake	Interstate highway segments within Durham and Wake Counties, used as overlay for visualizing potential patterns with ETC tracts.	Line	244
Interstate HighwayFG	Interstate highway segments within Forsyth and Guilford Counties, used as overlay for visualizing potential patterns with ETC tracts.	Line	308
Interstate HighwayMeck	Interstate highway segments within Mecklenburg County, used as overlay for visualizing potential patterns with ETC tracts.	Line	289
MecklenburgCo	County boundary used to form the FatalitiesperTractMeck layer.	Polygon	1
MecklenburgPUC2020	Block groups in Mecklenburg County mapped as PUC (2020).	Polygon	135
MecklenburgNonPUC	Block groups in Mecklenburg County mapped as non-PUC (2020).	Polygon	535

NCDOT_State_Boundary	North Carolina state outline, used to extract DOTIndexNC from DOT_Index_State_5_3.	Polygon	1
PaveCond_CombinedData	All North Carolina pavements combined by type and condition. Used to isolate the interstate highways for mapping purposes.	Line	106286
PaveCond_DurWake	All pavements in Durham and Wake Counties, extracted from PaveCond_CombinedData.	Line	6769
PaveCond_FG	All pavements in Forsyth and Guilford Counties, extracted from PaveCond_CombinedData.	Line	5789
PaveCond_Meck	All pavements in Mecklenburg County, extracted from PaveCond_CombinedData.	Line	2048
Potentially Underserved CommunitiesDurWake	Block groups in Durham and Wake Counties mapped as PUC (2020). Used as overlay onto ETC data.	Polygon	125
Potentially Underserved CommunitiesFG	Block groups in Forsyth and Guilford Counties mapped as PUC (2020). Used as overlay onto ETC data.	Polygon	160
Potentially Underserved CommunitiesMeck	Block groups in Mecklenburg County mapped as PUC (2020). Used as overlay onto ETC data.	Polygon	135

The Pavements geodatabase contains numerous data layers that divide the state's pavements by type or category into Primary and Secondary Roads, and Interstates. Within each road category, roads were classified by condition as poor (RTG_NBR < 60), moderate (RTG_NBR>60 and RTG_NBR<80), or good (RTG_NBR>80). Roads by condition were mapped on Potentially Underserved Communities (PUC's) by block group to determine the percent within each category and condition that were located in PUC's. Mapping was done for the state and for Mecklenburg, Durham-Wake, and Forsyth-Guilford Counties.

PAVEMENTSGDB CONTENTS:

Layer Name	Description	Geometry	Records
BoundaryCountyShoreline:	County boundaries and including Eastern North Carolina shoreline. For mapping total and percent road segments per county.	Polygon	100
DurhamWake	Durham and Wake County boundaries. For clipping data layers within these counties, and for creating maps.	Polygon	2
DurhamWakeInterstatePoor	Interstate highway segments in Durham and Wake Counties classified as poor condition.	Line	11
DurhamWakeNonPUC	Blockgroups in Durham and Wake Counties that are not categorized as PUC using 2020 Census data and NCDEQ Formula.	Polygon	763
DurhamWakePrimaryPoor	Primary Road segments in Durham and Wake Counties classified as poor condition.	Line	111
DurhamWakePUC2020	Blockgroups in Durham and Wake Counties that are categorized as PUC using 2020 Census data and NCDEQ Formula.	Polygon	125
DurhamWakeSecondaryPoor	Secondary Road segments in Durham and Wake Counties classified as poor condition.	Line	653

ForsythGuilfordNonPUC	Blockgroups in Forsyth and Guilford Counties that are not categorized as PUC using 2020 Census data and NCDEQ Formula.	Polygon	483
ForsythGuilford	Forsyth and Guilford County boundaries. For clipping data layers within these counties, and for creating maps.	Polygon	2
ForsythGuilfordInterstatePoor	Interstate highway segments in Forsyth and Guilford Counties classified as poor condition.	Line	33
ForsythGuilfordPrimaryPoor	Primary Road segments in Forsyth and Guilford Counties classified as poor condition.	Line	50
ForsythGuilfordPUC2020	Blockgroups in Forsyth and Guilford Counties that are categorized as PUC using 2020 Census data and NCDEQ Formula.	Polygon	160
ForsythGuilfordSecondaryPoor	Secondary road segments in Forsyth and Guilford Counties classified as poor condition.	Line	841
Interstate	All NC Interstate highways. Using RTG_NBR, interstates were divided into poor, moderate and good condition for the state. Later, each interstate condition was clipped for the three study areas (Mecklenburg, Durham/Wake, and Forsyth/Guilford).	Line	2535
InterstatePoor_Condition_60	Interstate highway segments in the state classified as poor condition (RTG_NBR <60).	Line	160
InterstateGood	Interstate highway segments in the state classified as good condition (RTG_NBR >80).	Line	2114
InterstateGood_Intersect3	The layer intersecting all good interstate segments with counties. This layer was spatially joined to counties to get the total count for good condition interstate segments.	Line	2872

InterstateModerate	Interstate highway segments in the state classified as moderate condition (RTG_NBR >60 and RTG_NBR <80).	Line	291
InterstateModerate_Intersect3	The layer intersecting all moderate interstate segments with counties. This layer was spatially joined to counties to get the total count for moderate condition interstate segments.	Line	391
InterstatePoor_Intersect3	The layer intersecting all poor interstate segments with counties. This layer was spatially joined to counties to get the total count for poor condition interstate segments.	Line	165
InterstateGoodprco	NC Counties spatially joined with the three intersect layers (poor, moderate, good) for interstate highways. The first intersect layer was spatially joined to NC Counties, creating a new layer with the Count field. The second intersect layer was spatially joined to this layer to obtain Count_1, and the third intersect layer was spatially joined with the layer containing the Count and Count_1 fields, to create the Count_2 field.	polygon	45
InterstatePcts	Created from InterstateGoodprco, this layer consists of the counties that contain interstate highway segments, plus the attributes for total poor (count), moderate (count_1) and good (count_2) segments. In this layer, new fields were added for % poor, % moderate and % good interstate segments per county. Field calculator calculated these values for mapping.	Polygon	45
Join_Output_2	NC Counties spatially joined with the three intersect layers (poor, moderate, good) for secondary roads. The first intersect layer was spatially joined to NC Counties, creating a new layer with the Count field. The second intersect layer was spatially joined to this layer to obtain Count_1, and the third intersect layer was spatially joined	Polygon	100

	with the layer containing the Count and Count_1 fields, to create the Count_2 field.		
MecklenburgInterstatePoor:	Interstate highway segments in Mecklenburg County classified as poor condition (RTG_NBR <60).	Line	17
MecklenburgCo	Mecklenburg County boundary. For clipping data layers within these counties, and for creating maps.	Polygon	1
MecklenburgNonPUC	Blockgroups in Mecklenburg County that are not categorized as PUC using 2020 Census data and NCDEQ formula	Polygon	535
MecklenburgPUC2020:	Blockgroups in Mecklenburg County that are categorized as PUC using 2020 Census Blockgroups in Mecklenburg County that are not categorized as PUC using 2020 Census data and NCDEQ formula	Polygon	135
MecklenburgPrimaryPoor	Primary Road segments in Mecklenburg County classified as poor condition.	Line	63
MecklenburgSecondaryPoor	Secondary road segments in Mecklenburg County classified as poor condition.	Line	227
NC_Non_PUC_2020	Blockgroups in the state that are not categorized as PUC using 2020 Census data and NCDEQ Formula.	Polygon	5658
NC_Potentially_Underserved_Communities_2020	Blockgroups in the state that are categorized as PUC using 2020 Census data and NCDEQ formula.	Polygon	1390
NoData	Block groups for North Carolina in which there was no data (either poverty or race) for calculating PUC. These were removed to a separate layer, separate from PUC and Non PUC block groups.	Polygon	63

PaveCond_CombinedData	All pavements (road segments) for North Carolina.	Line	106286
PriGoodnPcts	NC Counties spatially joined with the three intersect layers (poor, moderate, good) for primary roads. The first intersect layer was spatially joined to NC Counties, creating a new layer with the Count field. The second intersect layer was spatially joined to this layer to obtain Count_1, and the third intersect layer was spatially joined with the layer containing the Count and Count_1 fields, to create the Count_2 field.	Polygon	100
Primary	All primary road segments in North Carolina, queried from PaveCond_CombinedData	Line	13500
Primary_Poor_Condition_60	Primary Road segments in the state classified as poor condition. Queried from Primary using RTG_NBR <60	Line	1649
PrimaryGood	Primary Road segments in the state classified as good condition. Queried from Primary using RTG_NBR >80	Line	9206
PrimaryGood_Intersect3	The layer intersecting all good primary road segments with counties. This layer was spatially joined to counties to get the total count for good condition primary road segments.	Line	10929
PrimaryModerate	Primary Road segments in the state classified as good condition. Queried from Primary using RTG_NBR >60 and RTG_NBR <80	Line	2645
PrimaryModerate_Intersect3	The layer intersecting all moderate condition primary road segments with counties. This layer was spatially joined to counties to get the total count for moderate condition primary road segments.	Line	3348

PrimaryPoor_Intersect3	The layer intersecting all poor condition primary road segments with counties. This layer was spatially joined to counties to get the total count for moderate condition primary road segments.	Line	8505
Secondary	All secondary road segments in North Carolina, queried from PaveCond_CombinedData	Line	90251
Secondary_Poor_Condition_60	Secondary Road segments in the state classified as poor condition. Queried from Secondary using RTG_NBR <60	Line	6530
SecondaryGood	Secondary Road segments in the state classified as good condition. Queried from Secondary using RTG_NBR >80	Line	62704
SecondaryGood_Intersect3	The layer intersecting all good secondary road segments with counties. This layer was spatially joined to counties to get the total count for good condition secondary road segments.	Line	74494
SecondaryModerate	Secondary Road segments in the state classified as good condition. Queried from Secondary using RTG_NBR >60 and RTG_NBR <80	Line	21017
SecondaryModerate_Intersect3	The layer intersecting all moderate condition secondary road segments with counties. This layer was spatially joined to counties to get the total count for moderate condition secondary road segments.	Line	26264
SecondaryPoor_Intersect3	The layer intersecting all poor condition secondary road segments with counties. This layer was spatially joined to counties to get the total count for moderate condition secondary road segments.	Line	8505
Counties_No_Interstates	NC counties that do not have an interstate. Created with Switch Selection (from Select by Location of Counties that contain an interstate segment). In order to calculate percent per road condition	Polygon	55

	per county for interstates, it was necessary to isolate counties with and without interstates. Otherwise the field calculator would reject the calculations at the first instance of dividing by zero (no interstate segments within a given county).		
Counties_with_Interstate_Highways	NC Counties that contain at least one interstate segment. Created with Select by Location of Counties that contain an interstate segment. Then used with a series of spatial joins of poor, moderate and good condition interstate segments, each join field (count) attached to the new layer of the previous spatial join.	Polygon	45
Interstates	All Interstate Highway segments in North Carolina, queried from PaveCond_CombinedData	Line	2535
Interstate_Poor_Condition_60	Query of all interstates for interstate segments labeled as in poor condition (<60). Used for mapping and for spatial join with NC counties for totals per county and for determining percent per county.	Line	130
InterstateGood	Query of all interstates for interstate segments labeled as in good condition (>80). Used for mapping and for spatial join with NC counties for totals per county and for determining percent per county.	Line	2114
InterstateModerate	Query of all interstates for interstate segments labeled as in moderate condition (60-80). Used for mapping and for spatial join with NC counties for totals per county and for determining percent per county.	Polygon	291

NC_Non_PUC_2020	North Carolina block groups that do not qualify as Potentially Underserved Communities using 2020 census data and the NCDEQ formula.	Polygon	5658
NC_Potentially_Underserved_Communities_2020	North Carolina block groups that do qualify as Potentially Underserved Communities using 2020 census data and the NCDEQ formula.	Polygon	1390
NC_County_Boundaries	Polygon boundaries for 100 North Carolina Counties. Used for calculating and mapping percentages of poor, moderate and good condition interstates and primary and secondary roads per county.	Polygon	100
NoData	The few block groups for which there was not data for calculating PUC	Polygon	63
PaveCond_CombinedData	All North Carolina pavement segments (interstates, primary and secondary roads of all condition categories)	Line	106286
Primary	All primary road segments, queried from PaveCond_CombinedData	Line	13500
Primary_Poor_Condition_60	Query of all primary roads for segments labeled as in poor condition (<60). Used for mapping and for spatial join with NC counties for totals per county and for determining percent per county.	Line	1649
Primary_Moderate	Query of all primary roads for segments labeled as in moderate condition (60-80). Used for mapping and for spatial join with NC counties for totals per county and for determining percent per county.	Line	2645
Primary_Good	Query of all primary roads for segments labeled as in good condition (>80). Used for mapping and for spatial join with NC counties for totals per county and for determining percent per county.	Line	9206

Secondary_Poor_Condition_60	Query of all secondary roads for segments labeled as in poor condition (<60). Used for mapping and for spatial join with NC counties for totals per county and for determining percent per county.	Line	6530
SecondaryRdSegments_Good_n_Pct	NC Counties spatially joined with the three intersect layers (poor, moderate, good) for secondary roads. The first intersect layer was spatially joined to NC Counties, creating a new layer with the Count field. The second intersect layer was spatially joined to this layer to obtain Count_1, and the third intersect layer was spatially joined with the layer containing the Count and Count_1 fields, to create the Count_2 field.	Polygon	100
Secondary_Moderate	Query of all secondary roads for segments labeled as in moderate condition (60-80). Used for mapping and for spatial join with NC counties for totals per county and for determining percent per county.	Line	21017
Secondary_Good	Query of all secondary roads for segments labeled as in good condition (>80). Used for mapping and for spatial join with NC counties for totals per county and for determining percent per county.	Line	62704

The Bridges geodatabase was used to identify those bridges that were designated as Structurally Deficient, Functionally Obsolete, or both. These were mapped with Communities of Concern (also known as Potentially Underserved Communities) to determine the location of deficient bridges within EJ communities across the state.

BRIDGESGDB CONTENTS:

Layer Name	Description	Geometry	Records
AllBridgesNonCoC	All Bridges in Non-Communities of Concern	Point	11983
AllBridgeswinCoC	All Bridges in Communities of Concern	Point	2191
AllSDFONonCoC	All Bridges that are both Structurally Deficient and Functionally Obsolete, and are in Non-Communities of Concern	Point	4199
AllSDFOwinCoC	All Bridges that are both Structurally Deficient and Functionally Obsolete, and are in Communities of Concern	Point	638
FONonCoC	All Bridges that are Functionally Obsolete and are in Non-Communities of Concern	Point	3149
FOwinCoC	All Bridges that are Functionally Obsolete and are in Communities of Concern	Point	513
NCBridges_Both_SD_and_FO	All Bridges that are both Structurally Deficient and Functionally Obsolete	Point	626
NC_Functionally_Obsolete_FO_Bridges	All Bridges that are Functionally Obsolete	Point	3662

NC_Structurally_Deficient_SD_Bridges	All Bridges that are Structurally Deficient	Point	1175
SDFONonCoC	Bridges that are both Structurally Deficient and Functionally Obsolete, and are in Non-Communities of Concern	Point	562
SDFOwinCoC	Bridges that are both Structurally Deficient and Functionally Obsolete, and are in Communities of Concern	Point	64
SDNonCoC	Bridges that are Structurally Deficient and are in Non-Communities of Concern	Point	1050
SDwinCoC	Bridges that are Structurally Deficient and are in Communities of Concern	Point	125

Appendix 4: Geodatabase Tables for Local Analysis

The following tables present data geospatially captured for pavement quality, which was connected to data for Potentially Underserved Communities (PUC's) as a demonstrative exercise through this project.

This appendix serves as documentation to capture the development process and data used to create these maps and time series images. The completed refined animation series were delivered at the early stages of this project. Some mapping was further adjusted and refined to include the StoryMaps developed for this project. Appendices 2 through 5 are presented as notations to document the research process.

PAVEFACILITIES-MECKLENBURG

Layer Name	Description	Geometry	Records
All Poor-Moderate Condition Road Segments	Combined layer with all poor and moderate condition road segments (Interstate, Primary, Secondary) in Mecklenburg County. For buffering to determine fatalities within 200 feet of these road segments.	Line	1129
c2021_Fatal_Motor_Vehicle_Meck	All motor vehicle fatalities, 2021, clipped to Mecklenburg County. For mapping in relation to poor and moderate condition road segments.	Point	107
Fatalities Beyond 200 Ft Buffer	Motor vehicle fatalities, 2021, that mapped outside of the 200 ft buffer of poor-moderate condition road segments	Point	74
Fatalities w/in 200 Ft Buffer	Motor vehicle fatalities, 2021, that mapped within the 200 ft buffer of poor-moderate condition road segments	Point	33
Mecklenburg Non PUC 2020	Block groups in the county that are not categorized as PUC using 2020 Census data and NCDEQ Formula	Polygon	535
Mecklenburg PUC 2020	Block groups in the county that are categorized as PUC using 2020 Block groups in Mecklenburg County that are not categorized as PUC using 2020 Census data and NCDEQ formula.	Polygon	135

MecklenburgCo	Mecklenburg County boundary for clipping other layers to the county.	Polygon	1
T200 Ft Buffer from Poor and Moderate Condition	Buffer (200 ft) of all poor-moderate condition road segments. For determining motor vehicle fatalities occurring within or beyond the buffer zone. 200 ft was determined (after experimenting) as a suitable distance given the positional inaccuracies of both roads (lines) and fatality points.	Polygon	1

PAVEFACILITIESDURHAM-WAKE

Layer Name	Description	Geometry	Records
All Poor-Moderate Condition Road Segments	Combined layer with all poor and moderate condition road segments (Interstate, Primary, Secondary) in Mecklenburg County. For buffering to determine fatalities within 200 feet of these road segments.	Line	2282
c2021_Fatal_Motor_Vehicle_DurWake	All motor vehicle fatalities, 2021, clipped to Durham-Wake County. For mapping in relation to poor and moderate condition road segments.	Point	96
Fatalities Beyond 200 Ft Buffer	Motor vehicle fatalities, 2021, that mapped outside of the 200 ft buffer of poor-moderate condition road segments	Point	60
Fatalities w/in 200 Ft Buffer	Motor vehicle fatalities, 2021, that mapped within the 200 ft buffer of poor-moderate condition road segments	Point	36

Durham-Wake Non PUC 2020	Block groups in the county that are not categorized as PUC using 2020 Census data and NCDEQ Formula	Polygon	763
Durham-Wake PUC 2020	Block groups in the county that are categorized as PUC using 2020 Block groups that are not categorized as PUC using 2020 Census data and NCDEQ formula.	Polygon	125
DurhamWake	Durham and Wake County boundaries for clipping other layers to the counties.	Polygon	2
T200 Ft Buffer from Poor and Moderate Condition	Buffer (200 ft) of all poor-moderate condition road segments. For determining motor vehicle fatalities occurring within or beyond the buffer zone. 200 ft was determined (after experimenting) as a suitable distance given the positional inaccuracies of both roads (lines) and fatality points.	Polygon	1

PAVEFACILITIES-FORSYTH-GUILFORD

Layer Name	Description	Geometry	Records
All Poor-Moderate Condition Road Segments	Combined layer with all poor and moderate condition road segments (Interstate, Primary, Secondary) in Mecklenburg County. For buffering to determine fatalities within 200 feet of these road segments.	Line	2507
c2021_Fatal_Motor_Vehicle_ForGuil	All motor vehicle fatalities, 2021, clipped to Forsyth and Guilford County. For mapping in relation to poor and moderate condition road segments.	Point	129
Fatalities Beyond 200 Ft Buffer	Motor vehicle fatalities, 2021, that mapped outside of the 200 ft buffer of poor-moderate condition road segments	Point	67
Fatalities w/in 200 Ft Buffer	Motor vehicle fatalities, 2021, that mapped within the 200 ft buffer of poor-moderate condition road segments	Point	62
Forsyth-Guilford Non PUC 2020	Block groups in the county that are not categorized as PUC using 2020 Census data and NCDEQ Formula	Polygon	483
Forsyth-Guilford PUC 2020	Block groups in the county that are categorized as PUC using 2020 Block groups that are not categorized as PUC using 2020 Census data and NCDEQ formula.	Polygon	160
ForsythGuilford	Mecklenburg County boundary for clipping other layers to the county.	Polygon	2
T200 Ft Buffer from Poor and Moderate Condition	Buffer (200 ft) of all poor-moderate condition road segments. For determining motor vehicle fatalities occurring within or beyond the buffer zone. 200 ft was determined (after experimenting) as a suitable distance given the positional inaccuracies of both roads (lines) and fatality points.	Polygon	1

Appendix 5: Geospatial Exploration Over Space and Time

A geospatial exploration over space and time was conducted to further understand variations in the communities identified as potential EJ communities based on varying criteria. In the absence of federal guidance specific criteria for identifying EJ communities, municipalities and public agencies have proposed varying methodologies. We take a three-pronged approach to explore these differences that consist of: (1) geospatially comparing three different methods in the absence of temporal variation, (2) evaluating one method under temporal variation to understand complexities of changing communities, and (3) compare one methodology applied at varying scales through bright-lining and dot-density mapping. Outcomes of this work shed light onto the high variability for which communities are identified and can be used to determine a methodology for identifying vulnerable communities that would best serve the needs of NCDOT's Environmental Justice emphasis on Advancing Equitable Transportation.

This appendix serves as documentation to capture the development process and data used to create these maps and time series images. The completed refined animation series were delivered at the early stages of this project. Some mapping was further adjusted and refined to include the StoryMaps developed for this project. Appendices 2 through 5 are presented as notations to document the research process.

Aim 1: Comparison of Three Methodologies for Identifying Potentially Underserved Communities (PUCs)

Numerous methodologies have been developed throughout the U.S. These vary in types of variables selected and complexity of calculation. For this comparison, we explore a common North Carolina method proposed by North Carolina Department of Environmental Quality (NCDEQ)and compare with two others that are selected to assess variations in using 'and' vs. 'or' statements, and incorporating health indicators. The three methodologies utilized and compared were:

- **North Carolina Department of Environmental Quality (NCDEQ)** - The North Carolina method identifies communities based upon a threshold of race/ethnicity and poverty.
- **Massachusetts Environmental Justice Criteria** - This method determines race/ethnicity and poverty with a different formula than NCDEQ, thus providing a comparison between the two methods for identifying PUC's. In addition to race/ethnicity and poverty, this method includes English language isolation, or lack of English proficiency, as an additional social measure of vulnerability not considered by the NCDEQ method.
- **Michigan Environmental Justice Database** - In comparison with the previous methods, this is an all-encompassing method that considers a larger variety of population/socio-economic characteristics and includes environmental and health effects. Variables are modeled through weighting and proximity analysis.

The data sources and methodologies used in each of these methods are outlined in detail within this appendix, along with map examples. Each of the methods identified potentially underserved communities (PUCs) but with some variations and limitations. These differences are described as well.

North Carolina Department of Environmental Quality (NCDEQ)

INTRODUCTION

The identification of communities most affected by Environmental Justice (EJ) concerns requires the use of a consistent identification term. The North Carolina Department of Environmental Quality's (NCDEQ) definition of Potentially Underserved Communities (PUC) was adopted to refer to EJ communities[1] across all three methods. For the NCDEQ method, these communities are defined as block groups or census tracts that meet or exceed NCDEQ's benchmark criteria for high concentrations of minority and low-income populations.

NCDEQ CRITERIA

A block group is selected as a potentially underserved community if it meets the following criteria for Race/Ethnicity and Poverty:

- Race/Ethnicity:
  - Share of non-whites and Hispanic or Latino (of any race) is over fifty percent, OR
  - Share of non-whites and Hispanic or Latino (of any race) is at least ten percent higher than the County OR State Share.
- Poverty:
  - Share of the population experiencing poverty is over twenty percent, AND
  - Share of households in poverty is at least five percent higher than the County or State share.

DATA SOURCES

For map series starting with the year 2010 or 2013, the poverty component of the criteria comes from a selection of the 2020, 2015, and 2010 ACS data from the tables B03002—Hispanic or Latino Origin by Race—and B17017—Poverty Status in the Past 12 Months by Household Type by Age of Householder. Additionally, for the state level census tract map series starting with 1960, only race/ethnicity was used to create the maps because the poverty variable only started in the 2010 ACS.

MAPS CREATED

The following sets of maps utilize NCDEQ's preliminary screening methodology for identifying Potential Underserved Communities. On the U.S. Census Block Group level, the data for Poverty and Race and Ethnicity were overlaid on the map of North Carolina block groups. If the NCDEQ definition of Potentially Underserved Communities was met (meaning the above NCDEQ criteria were present in the block group), the block group was selected. The same was done for census tracts. The criteria for the block group were compared for selected Counties and for the State. The criteria for census tracts were compared only for the state.

Massachusetts Environmental Justice Criteria

INTRODUCTION

Massachusetts identifies Environmental Justice (EJ) populations using Census 2020 block groups that meet any of the following criteria:

MASSACHUSETTS EJ CRITERIA

Income: The annual median household income is not more than 65% of the statewide annual median household income.

English Language Isolation: 25% or more of households lack English language proficiency.

Minority Population: Minorities comprise 40% or more of the population.

Minority Population + Income: Minorities comprise 25% or more of the population and the annual median household income of the municipality in which the block group is located does not exceed 150% of the statewide annual median household income.

DATA SOURCE

B03002—Hispanic or Latino Origin by Race, B17017—Poverty Status in the Past 12 Months by Household Type by Age of Householder, American Community Survey 2021 5-Year Estimates S1602

MAPS CREATED

State Level for both block groups and census tracts for the year 2021. The block group and census tracts have five maps: one for each indicator and one for if it identifies as a potentially underserved community.

State level Massachusetts method maps for block groups are shown below in Figures 1a to 1e. Figure 1c is most comparable to the NCDEQ method in terms of variables selected but not in spatial distribution of PUC's (See Figure 1g).

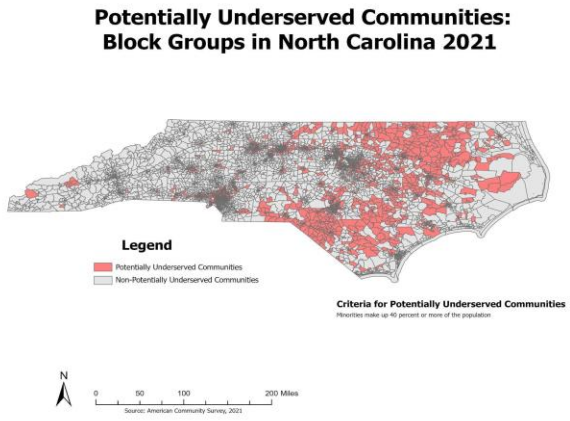


Figure 1a: Minority Population by Block Group

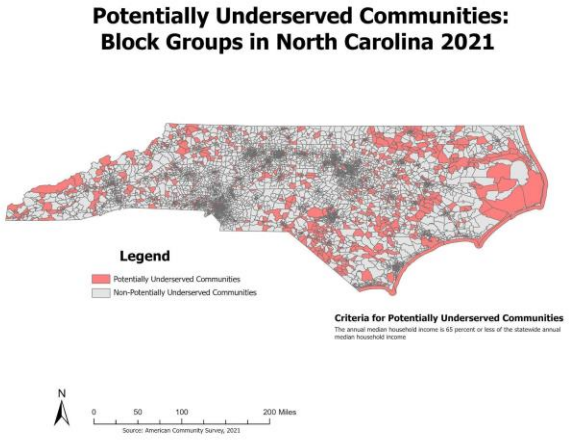


Figure 1b: Median Household Income (MHI)

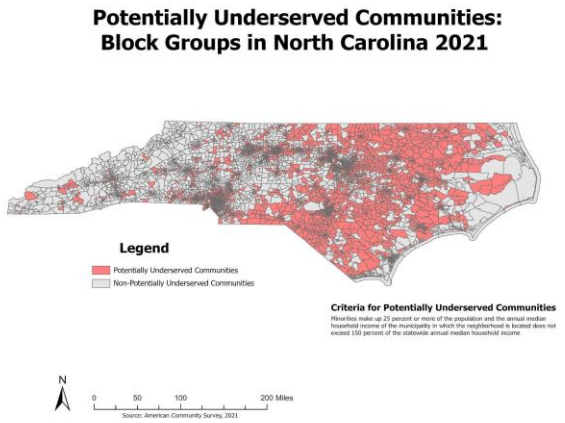


Figure 1c: Minority and MHI

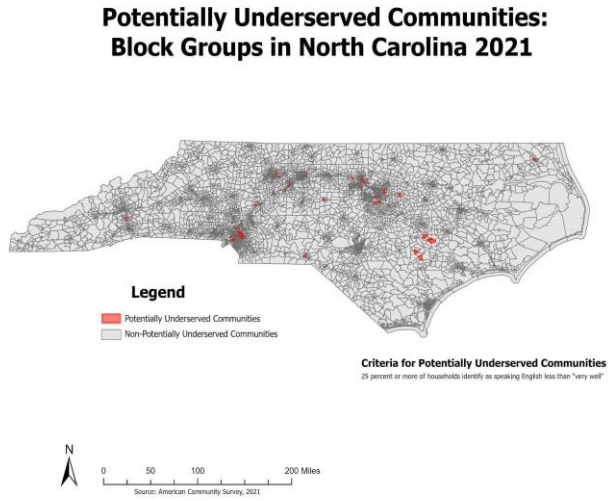


Figure 1d: Limited English

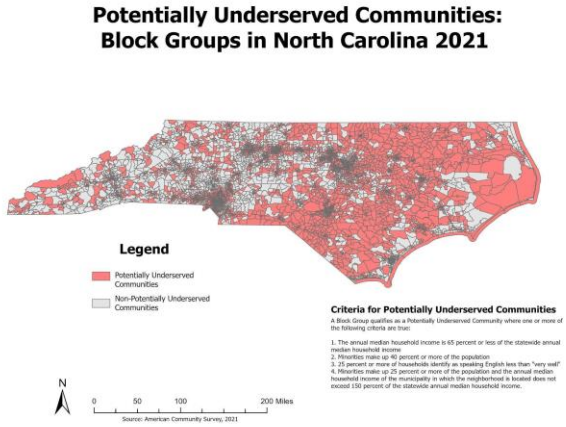


Figure 1e: All standards combined by block group.

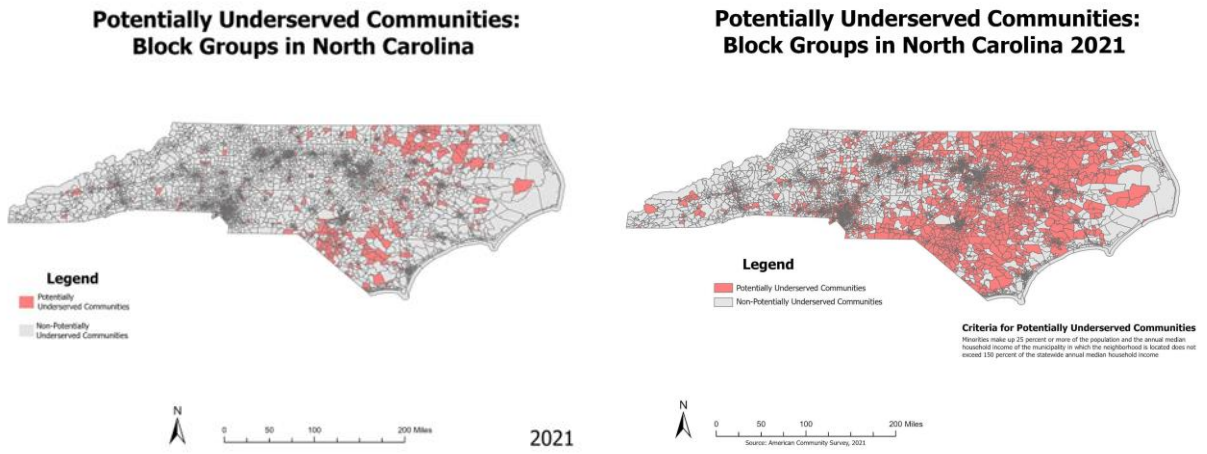


Figure 1g: Comparison of NCDEQ with Massachusetts: NCDEQ Method by Block Group (left) vs Massachusetts Method by Block Group (right) for 2021. The Massachusetts method identifies far more block groups as PUC's than for state level block groups using the NCDEQ formula.

State level Massachusetts method maps for census tracts are shown below in Figures 1a to 1e. As with block groups, Figure 1c is most comparable to the NCDEQ method for census tracts in terms of variables selected but not spatial distribution (see Figure 1g).

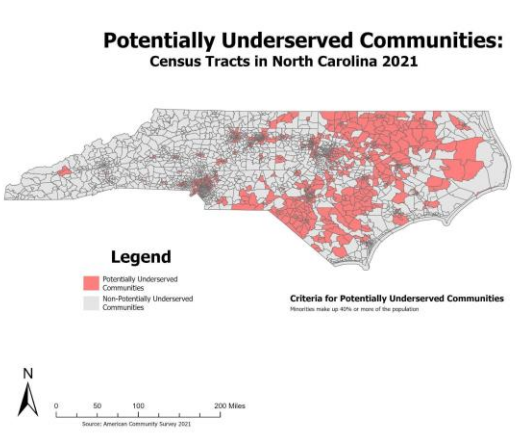


Figure 2a: Minority Population by Census Tract

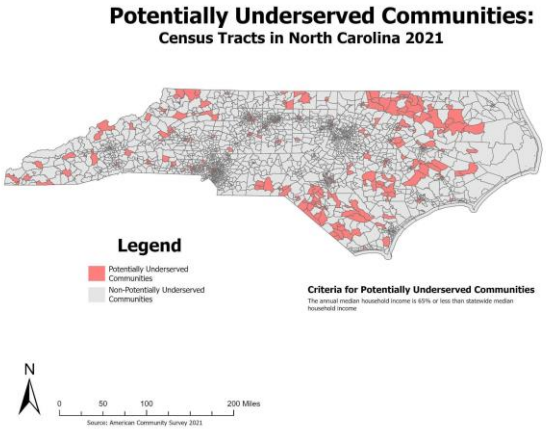
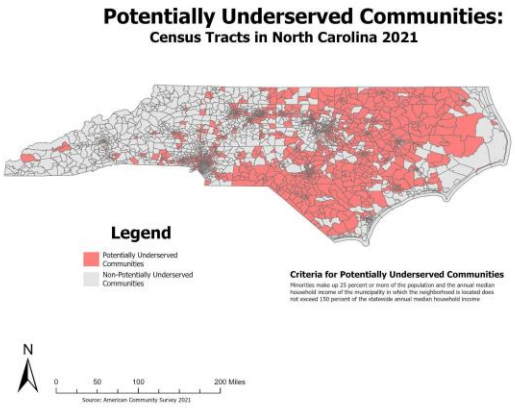


Figure 2b: Median Household Income (MHI)



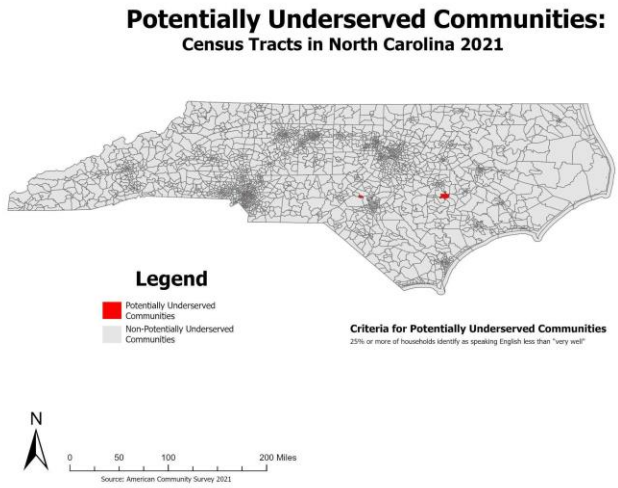


Figure 2c: Minority Population and MHI

Figure 2d: Limited English

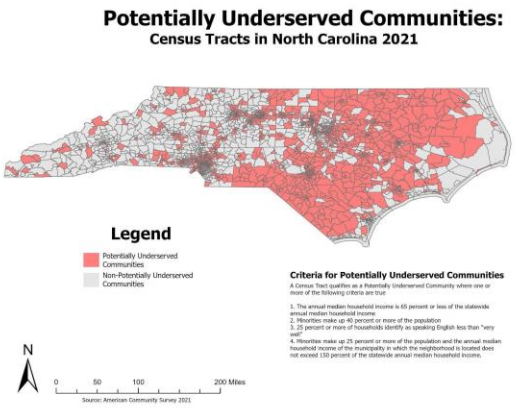


Figure 2e: All standards combined, by Census Tract

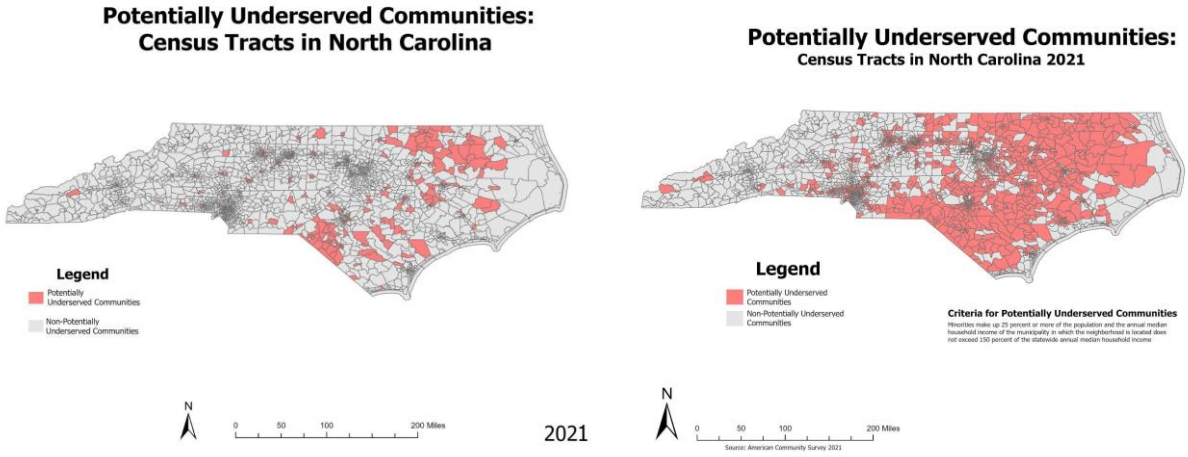


Figure 2g: Comparison of NCDEQ with Massachusetts: NCDEQ Method by Census Tract (left) vs Massachusetts Method by Census Tract (right) for 2021. The Massachusetts method identifies far more census tracts as PUC's than for state level census tracts using the NCDEQ formula.

Michigan Environmental Justice Database

WEIGHTED-MULTI-RINGED-BUFFER PROXIMITY METHOD

The Michigan Environmental Justice database incorporates a multifaceted approach that considers a variety of socioeconomic, environmental and health characteristics that contribute to population vulnerability. Given the "environmental" focus of Environmental Justice, this method does well to employ detrimental environmental impacts in the identification of Potentially Underserved Communities.

In addition to including multiple vulnerability variables, the method calculates PUC's with a weighted, multi-ring buffer proximity method that takes into account hierarchy of impact as well as spatial distribution. For most of the Environmental Effects indicators and sub layers (Cleanup Sites Proximity, Solid Waste Sites Proximity, and Hazardous Waste Generators and Facilities), the CalEnviroScreen Site Weight-Multi-Ringed Buffer Proximity method was applied to selection of weights and for determining proximity. Selected sites were scored based on a site weight and a proximity to census blocks that met threshold population criteria.

SCORING PROCEDURE

For each indicator, raw values or percentages for each census tract were ranked from highest to lowest. Each census tract was then assigned a percentile score based on its rank among the other tracts' indicator values.

For each subcategory, an average of the percentile rankings is obtained and then a percentile ranking is performed.

Environmental Conditions: Environmental Effects Indicators Average Percentile Score is weighted at one and a half of its original value, then averaged with the environmental exposure indicators average score.

Population Characteristics: Uses the average of the sensitive populations and socioeconomic factor categories.

The Environmental Conditions Scale and Populations Characteristics scores are combined and assigned a value between 0 and 10 (represented in the dashboard as a decimal percent between 0 and 1).

These two categories are multiplied by each other. Since they have been scaled to 0-10, the maximum score is 100, theoretically.

ENVIRONMENT AND HEALTH INDICATORS USED

Environmental Exposure variables are obtained from the Environmental Protection Agency (EPA) EJ Screen tool:

- NATA Air Toxics Cancer Risk
- NATA Respiratory Hazard Index
- NATA Diesel Particulate Matter
- Particulate Matter (PM2.5)
- Ozone
- Traffic Density
- Environmental Effects:
- Proximity to Cleanup Sites (including Part 213, Superfund, Brownfields)
- Proximity to Hazardous Waste Facilities
- Proximity to Solid Waste Sites and Facilities
- Lead Paint Indicator
- Proximity to RMP Sites

- Wastewater Discharge Indicator

Sensitive Populations (Health) (CDC data from the PLACES maps):

- Asthma
- Cardiovascular Disease
- Life Expectancy

Note: Michigan incorporated different health categories that were collected by their state and not nationally. We matched their variables as closely as possible using national CDC data.

SOCIO-ECONOMIC INDICATORS AND DATA SOURCES, OBTAINED FROM THE AMERICAN COMMUNITY SURVEY (ACS):

- Low Income Population: Source: American Community Survey 2021 5-Year Estimate: B17010
- Black, Indigenous, People of Color Population: Source: American Community Survey 2021 5-Year Estimate: B03002
- Educational Attainment: Source: American Community Survey 2021 5-Year Estimate B15003
- Linguistic Isolation: Source: American Community Survey 2021 5-Year Estimates S1602
- Population Under 5: Source: American Community Survey 2021 5-Year Estimates S0101
- Population Over Age 64: Source: American Community Survey 2021 5-Year Estimates S0101
- Unemployment: Source: American Community Survey 2021 5-Year Estimates S2301
- Housing Burden: Source: American Community Survey 2021 5-Year Estimates DP04

MAPS CREATED

An interactive mapping dashboard was created to show the Michigan EJ Criteria Potentially Underserved Communities in North Carolina, found at:
https://www.arcgis.com/apps/dashboards/a6ca04aafc4b4b1dac5efc5f5ecb5ba5

It includes Percentile Ranking Choropleth Maps on the following layers:

1. Overall Environmental Justice Score
2. Environmental Exposure
3. Environmental Effects
4. Socioeconomic
5. Sensitive Populations

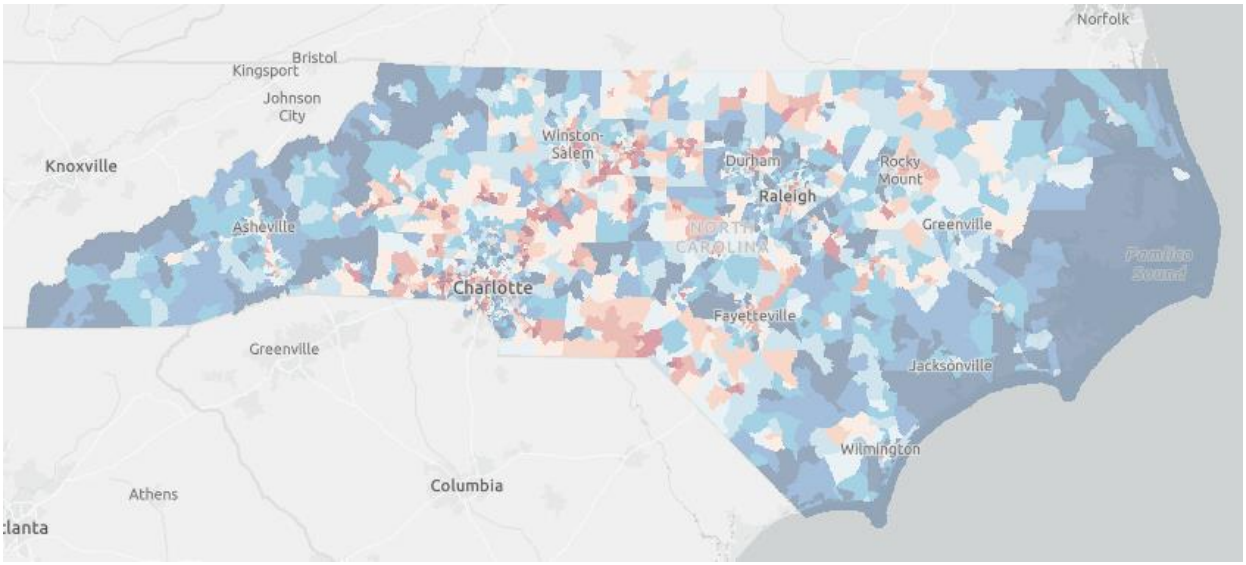


Figure 3 above is an image of the overall Environmental Justice Areas from the Michigan method covering the entire state at the census tract level. Shown are shadings from dark red (percentile ranking of .9 - 1.0) to light pink and light to dark blue (percentile ranking of 0.0-0.1) to represent percentile rankings of variables utilized to compile the map. It captures urban, and fast growing rural areas well with the red and pink shades. Census tracts identified with the first two methods (NCDEQ and Massachusetts) are categorized as either PUC or non-PUC. By Michigan's version, tracts may be more, or less strongly identified as PUC depending on the combinations of socioeconomic, environmental, and health variables.

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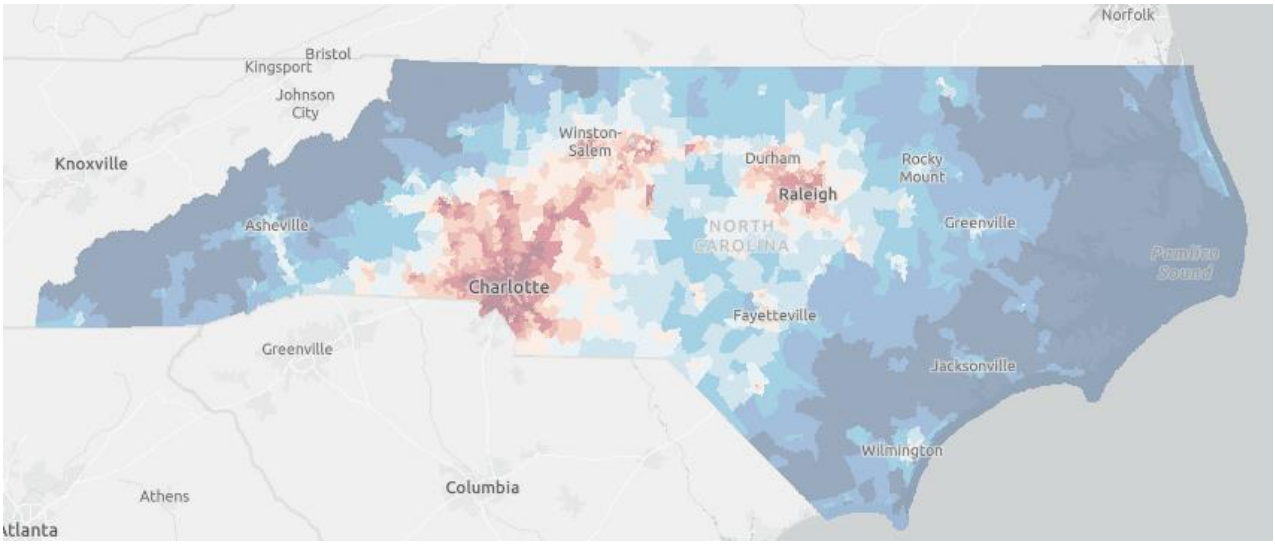


Figure 4 above: Michigan Percentile Ranking of Environmental Exposure. Metropolitan areas in and around Mecklenburg County, Forsyth-Guilford, and Wake-Durham Counties are strongly differentiated with the dark red shades indicating highest levels of environmental exposures.

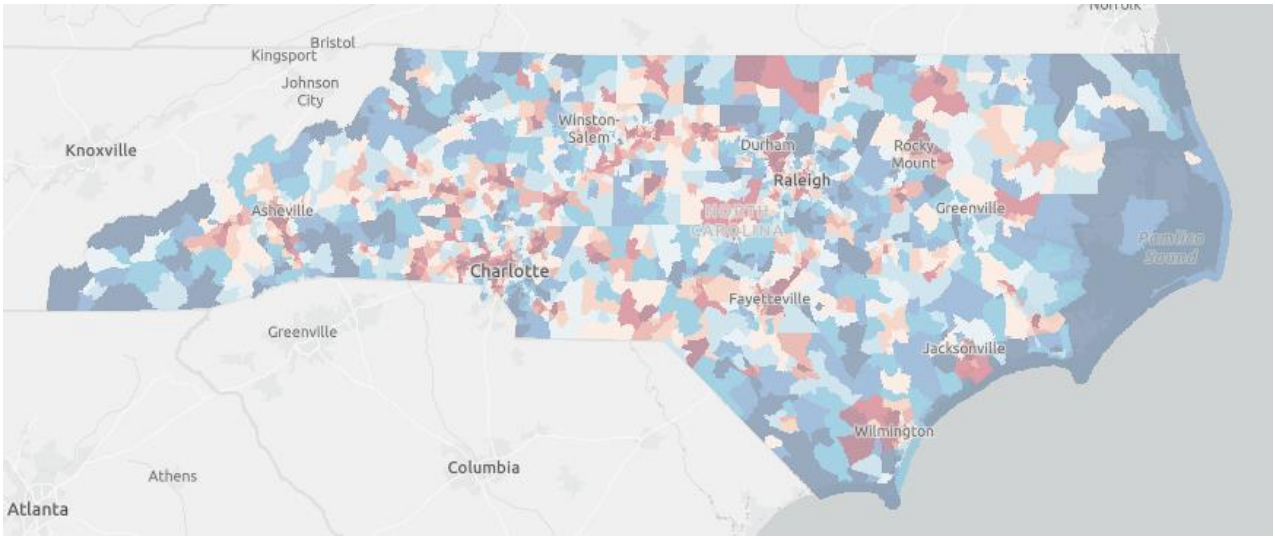


Figure 5 above: Michigan Percentile Ranking of Environmental Effects. A greater number of populated areas, including some rural towns, show in red shades for environmental effects.

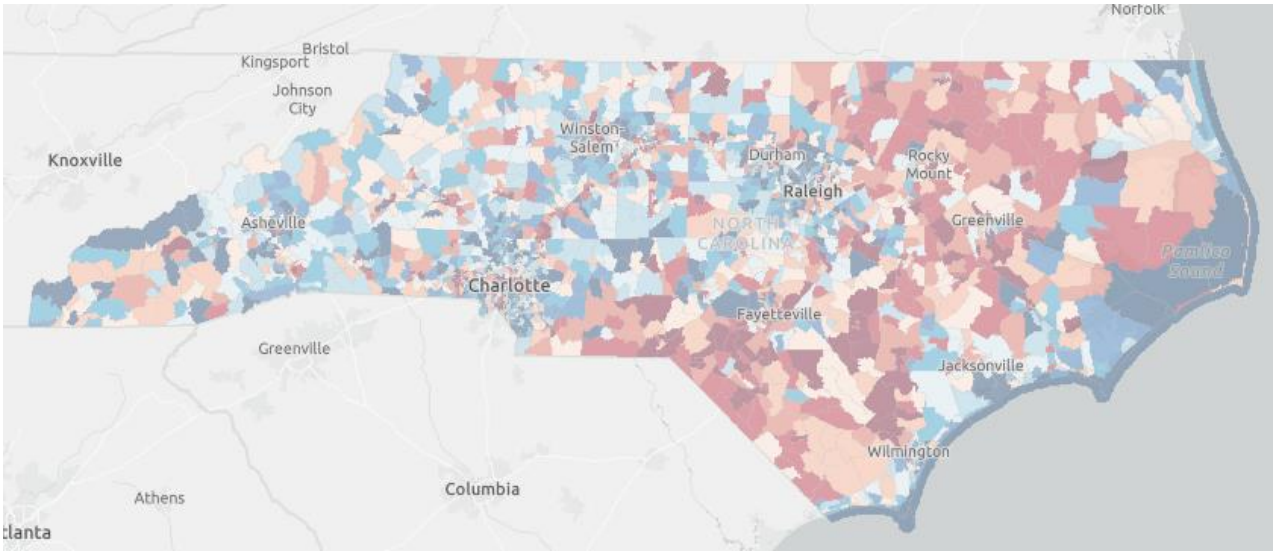


Figure 6 above: Michigan Percentile Ranking of Socioeconomic Factors. Red shades illuminate both urban and rural areas of vulnerability based upon such characteristics as race/ethnicity, age, linguistic isolation, income/poverty, unemployment, and housing burden.

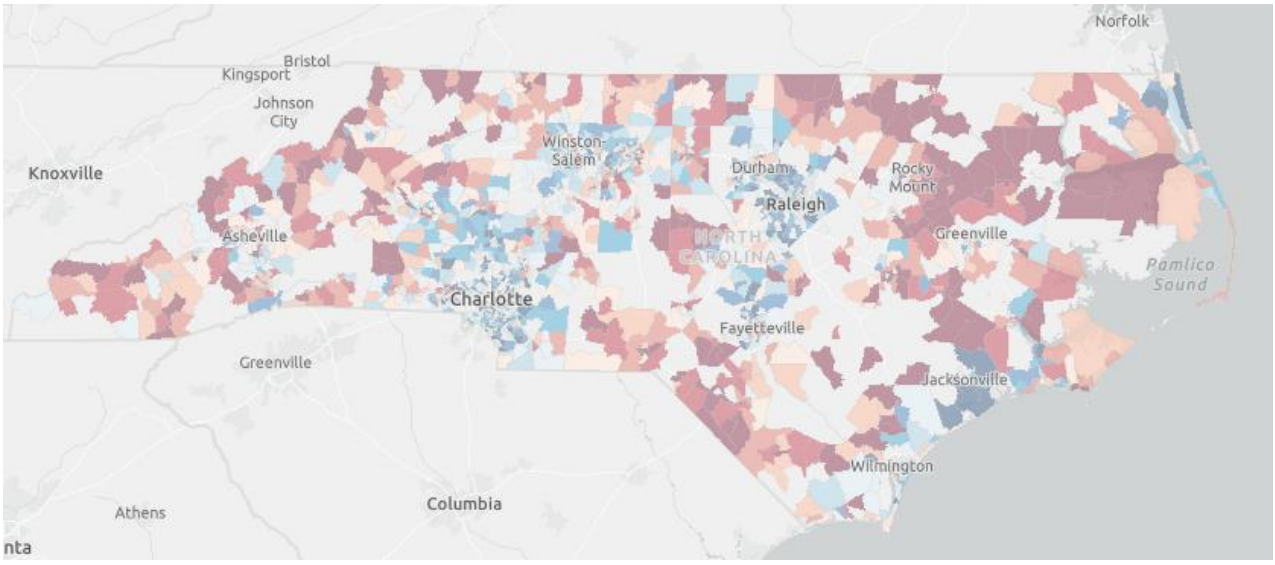


Figure 7 above: Michigan Percentile Ranking of Sensitive Populations. Red shades represent areas with populations experiencing the highest levels of health conditions (asthma and cardiovascular disease used in this map) and resultant lower life expectancy. There are many health burdens that can increase risk for lower life expectancy. Measures used here appear prevalent throughout much of the state.

Next, the overall environmental justice areas by the Michigan method are visually compared with PUC's by the NCDEQ method for Mecklenburg County.

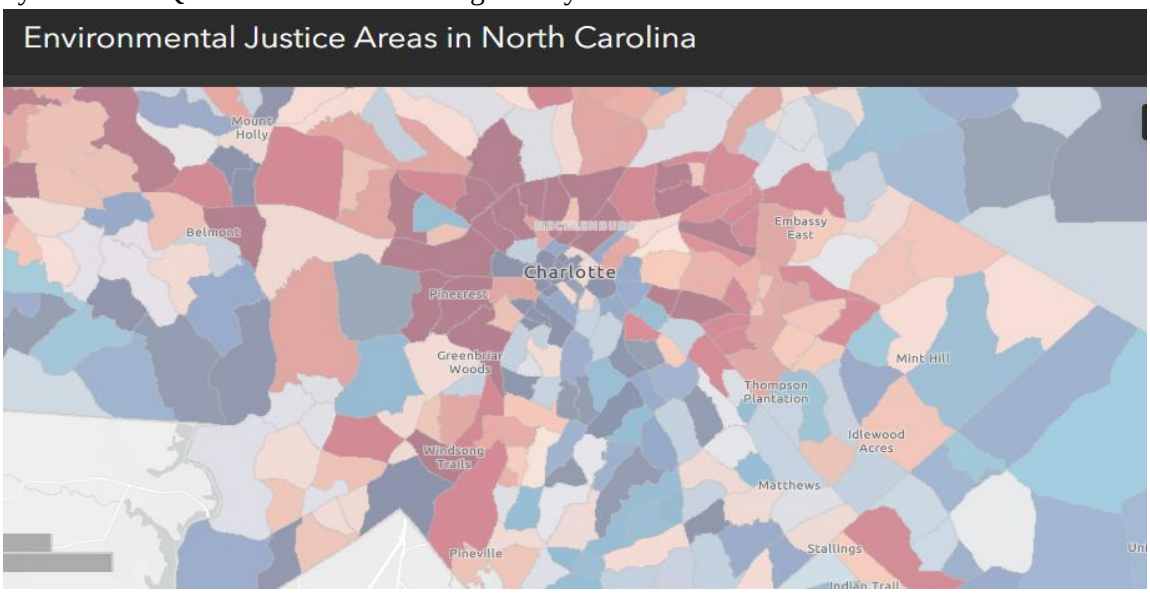


Figure 8: PUC's identified by the Michigan Overall EJ Criteria for Mecklenburg County in 2021 (zoomed in from State level). The spatial pattern is that of a crescent and resembles the NCDEQ map of PUC's by Block Group for 2015 (see Figure 11 below for comparison).

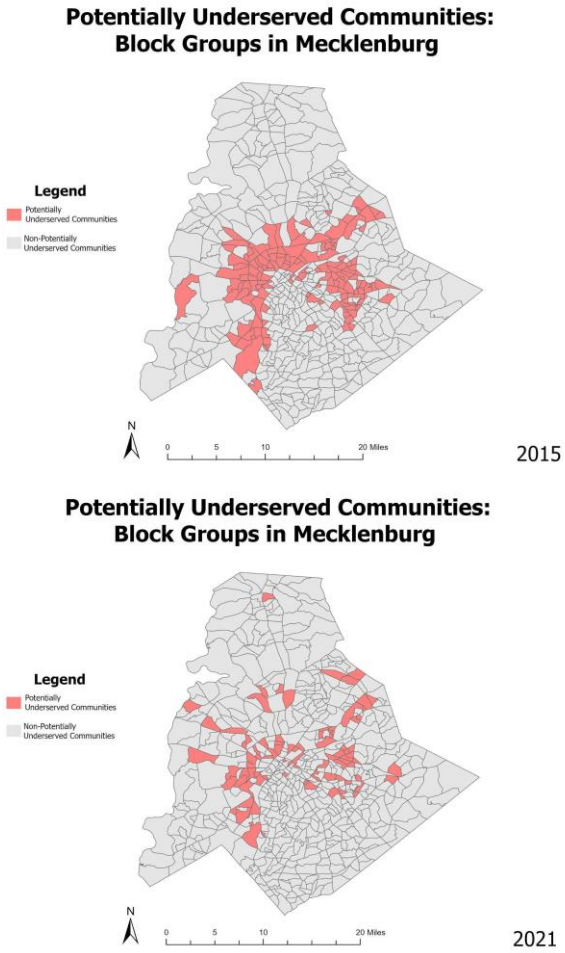


Figure 9 PUC's by Block Group in Mecklenburg County using the NCDEQ method: 2015 (left) and 2021 (right). Although Michigan's method is applied to Census Tracts, the overall spatial pattern of the two methods is similar when comparing Michigan, 2021 with NCDEQ, 2015. Michigan, 2021 identifies far more PUC's than does NCDEQ in 2021.

Below are segments from each of the five sections of the Michigan dashboard, for Mecklenburg County, along with a selection from the list of variables to represent each of the data layers within one identified census tract. Keep in mind the closer the percentile ranking is to 1.0, the higher the degree of exposure or vulnerability within the specific criteria category (unemployment rate, environmental exposure, sensitive population, etc.).

The method is complex both in variables selected, and in calculation and identification of areas to show varying degrees of vulnerability. The remaining figures provide a few examples of variables and corresponding weighted and proximity analysis indices within each of the five percentile ranking categories.

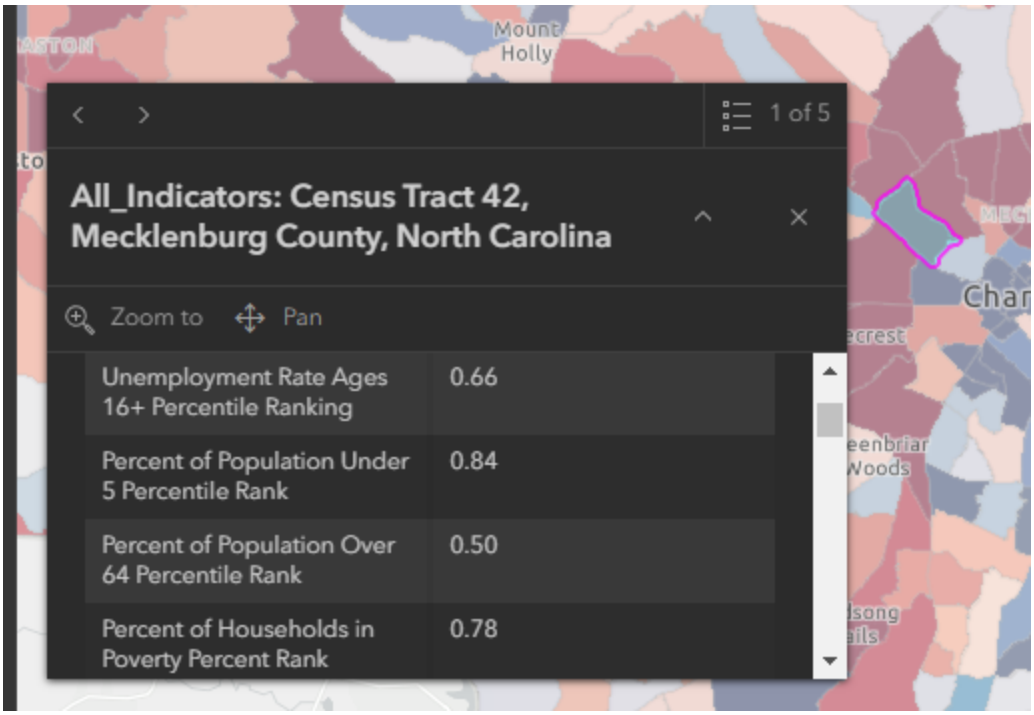


Figure 10a: All Indicators are represented in the final ranking of each census tract. Shown here are a few socio-economic variables within Census Tract 42. This method includes numerous demographic and socioeconomic variables not found in most other methods.

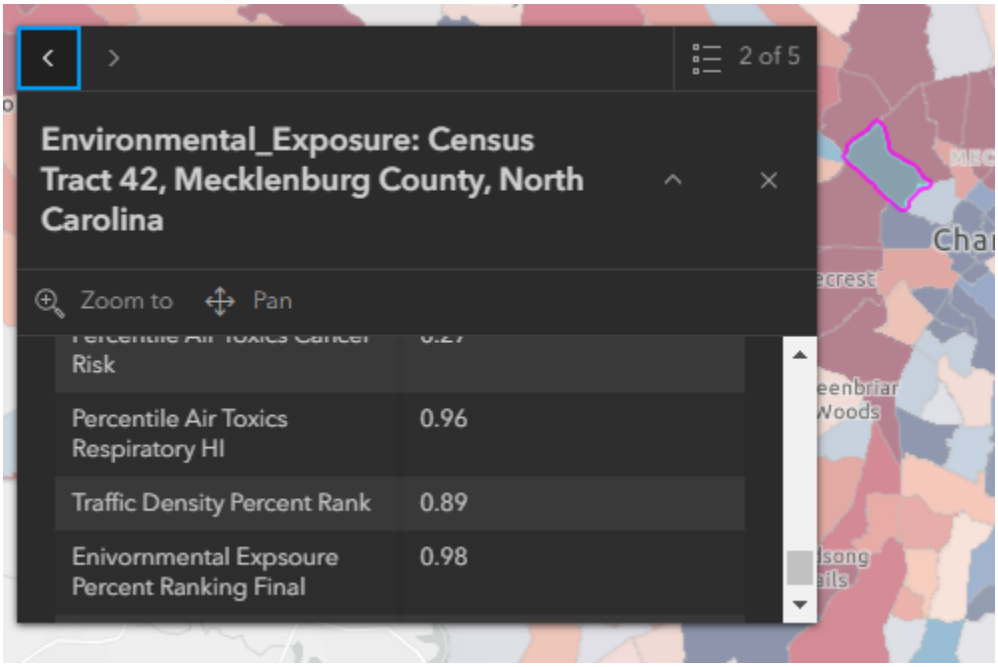


Figure 10b: Percentile rankings for Environmental Exposure indices within this selected census tract.

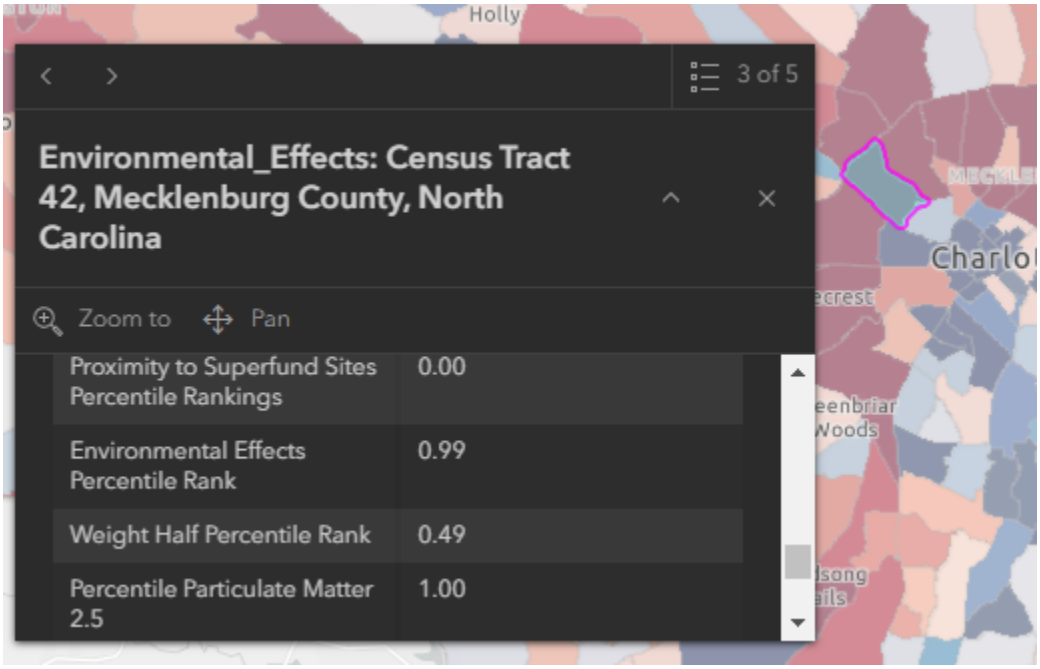


Figure 10c: Percentile rankings for Environmental Effects within this selected census tract.

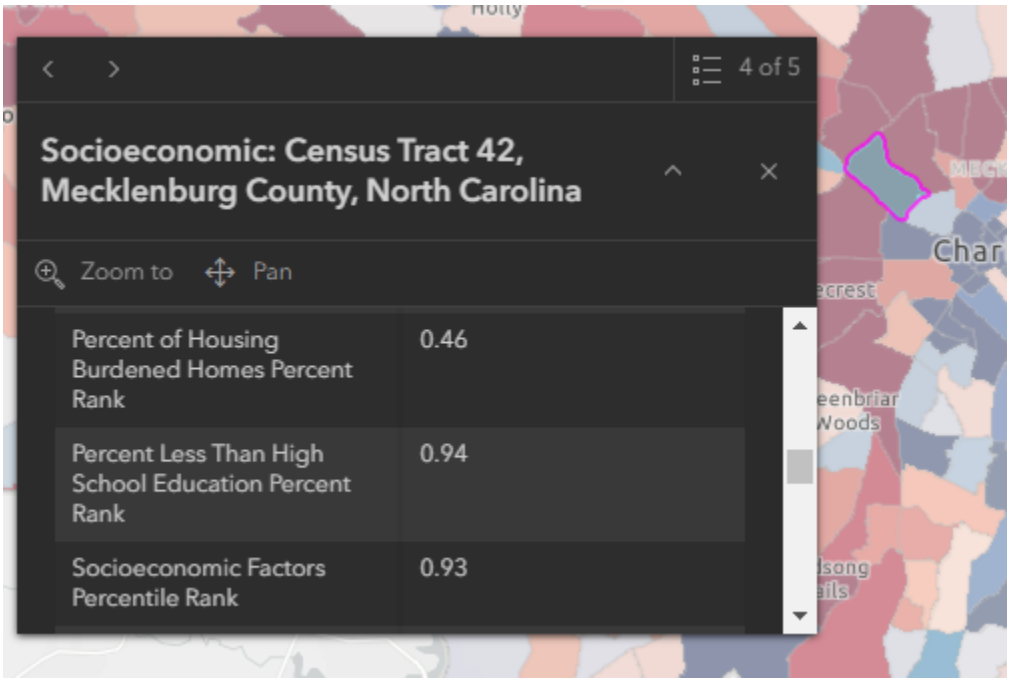


Figure 10d: Percentile rankings for Socioeconomic indices within this selected census tract.

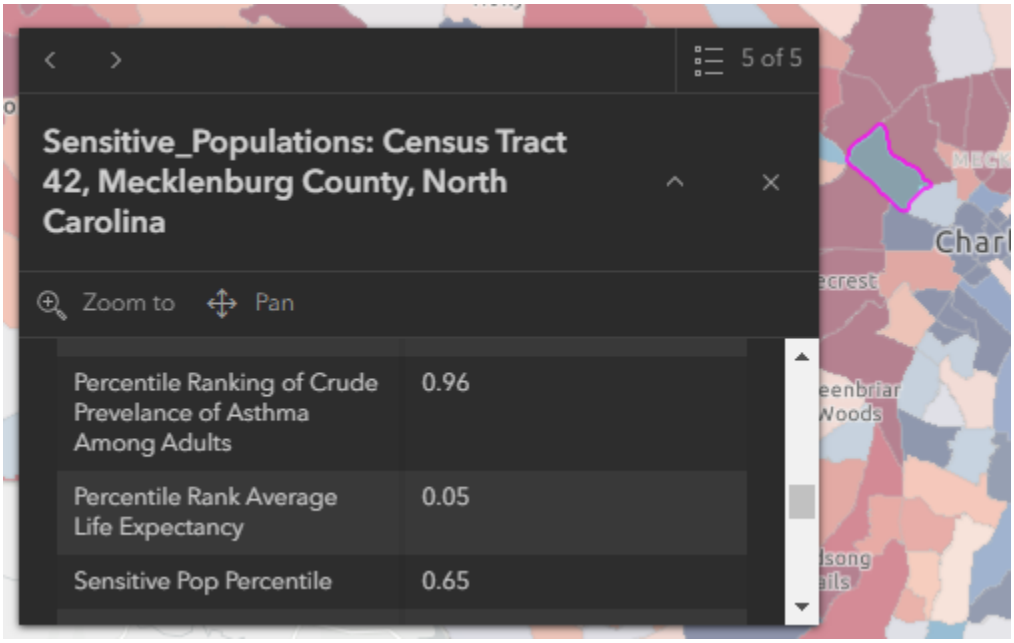


Figure 10e: Percentile rankings for Health indices within this selected census tract. Residents in poor health are considered to be sensitive populations in that they are more vulnerable to additional health effects from poverty and from environmental exposures.

Aim 2: Assess NCDEQ PUC Criteria Over Time

Scrolling Time Series Animations

A StoryMap consisting of a series of slider maps and map animations (animated GIF's) for PUC's by year has been created to simulate changes across time (https://storymaps.arcgis.com/stories/36c01fc9620f4c4e834350f9378d1d1d).

Slider maps were created to compare PUC's by block group in 2015 with 2021 for North Carolina and for Mecklenburg, Wake-Durham, and Forsyth-Guilford Counties. Sliding back and forth between dates reveals visualization of the change in number of block groups identified as PUC's across this time period. In some cases, the difference is quite striking for a 6-year period. Examples for the State and for Mecklenburg County are shown within the map comparisons below.

Four animations are also displayed within the StoryMaps:

- Mecklenburg County Potentially Underserved Block Groups, 2013-2021,
- North Carolina Potentially Underserved Block Groups, 2013-2021,
- Mecklenburg County Potentially Underserved Census Tracts, 2010-2021
- North Carolina Potentially Underserved Census Tracts, 2010-2021

This animation series enables viewing of estimations of annual spatial change in PUC locations across the state and within Mecklenburg County. The changing spatial pattern of PUCs is readily apparent in the annual visualizations, and is most striking at the county level. By scrolling through the years in the StoryMap format, the user can spend as much time on any year as is needed. As previously noted, the availability of the precise poverty variables (data available by block group for 2013-2021 and by census tract for 2010-2021) determined the years selected for mapping PUC's.

In addition to the StoryMaps, maps were created for the following scenarios:

- County Block Group Maps: 2013-2021
- State-Level Block Group Maps: 2013-2021
- State-Level Census Tract Maps (same criteria was used, but at the census tract scale): 1960, 1970, 1980, 1990, 2000, 2010, 2011-2021

Map Comparisons

The NCDEQ method, when comparing resulting maps temporally and spatially, revealed a significant decrease in the number of communities identified as PUC's across time, and a shift in the location of some communities, possibly influenced by gentrification.

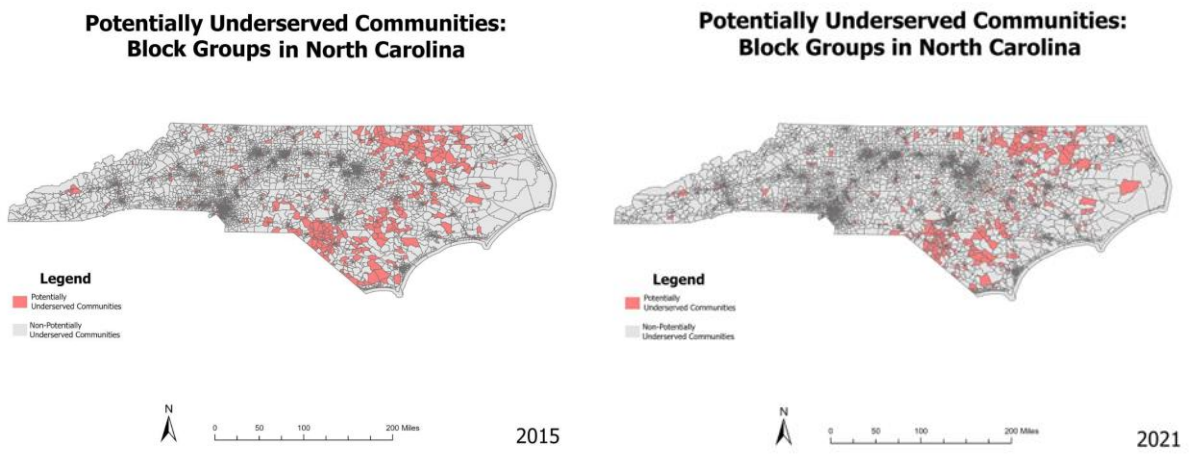


Figure 11: Side-by-Side of Still Images from Animated GIF for Potentially Underserved Communities in North Carolina, 2015 and 2021

As appears in the Figure 11 comparisons (above) the general spatial pattern across the state remains over time, but with fewer block groups identified as PUC's in 2021. PUC block groups decrease in counties to the east of Mecklenburg. New PUC block groups show up, however, in the southeast section of the state. Note that at the State level, block groups are so small in size that they are not visible within the urbanized areas along Interstate 85 (Mecklenburg, Guilford, Forsyth, Durham, Wake), and in other urban

communities where land area per block group is small. For this reason, separate county slider maps were created for the major urbanized counties as well as for the state.

Statewide (Table 1 below), between 2015 and 2021, the number of non-potentially underserved communities (Non-PUCs) increased by 25%, from 4,846 to 6,064, while potentially underserved communities (PUCs) decreased by 20%, from 1,309 to 1,047. The total number of block groups (BGs) rose by 16%, from 6,155 to 7,111. As a result, the percentage of PUCs relative to total block groups dropped by almost 7% from 21.27% in 2015 to 14.72% in 2021.

T*able 1: Chart displaying Change in PUC's/Non-PUC's from 2015 to 2021 in North Carolina*

	North Carolina		
	2015	2021	% Change
Non-PUC's	4,846	6,064	25%
PUC's	1,309	1,047	-20%
Total BG's	6,155	7,111	16%
% PUC's	21.27%	14.72%	-7%

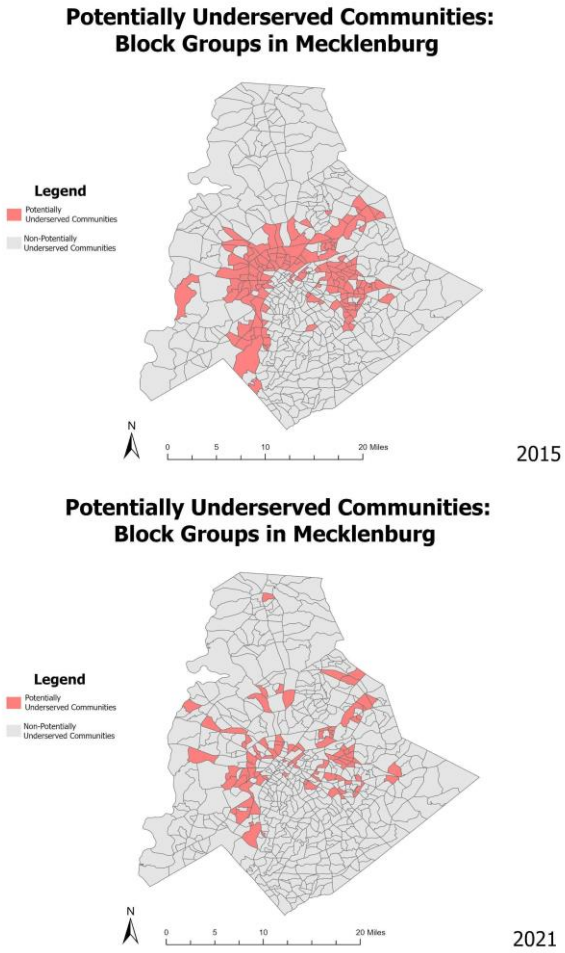


Figure 12. Side-by-Side of Still Images from Animated GIF for Potentially Underserved Communities in Mecklenburg County, 2015 and 2021

In Figure 12 above, several Mecklenburg County block groups identified as PUC's in 2015 did not make the criteria for PUC in 2021. A few new PUC's show up in 2021 that are further from the crescent and towards the edges of the county, including one block group to the far north. Calculations shown in Table 2 below for this time period, indicate that the number of non-potentially underserved communities (Non-PUCs) increased by 29.95%, from 414 to 538, while potentially underserved communities (PUCs) decreased by 39.01%, from 141 to 86. The total number of block groups (BGs) grew by 12.43%, from 555 to 624. Consequently, the percentage of PUCs relative to total block groups dropped by 11.62 percentage points, from 25.41% in 2015 to 13.78% in 2021.

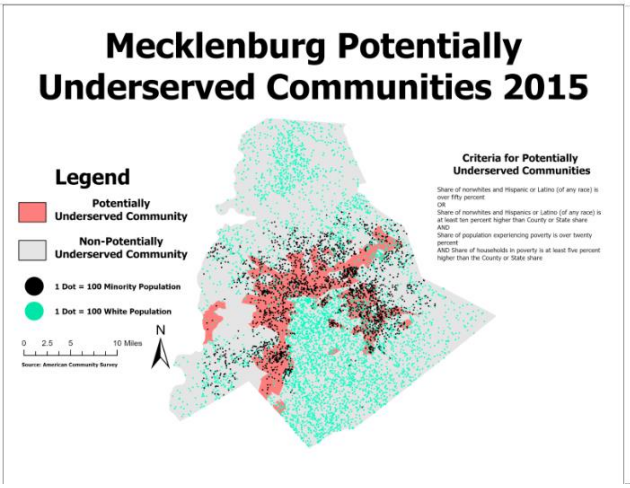
Table 2:

	Mecklenburg County		
	2015	2021	% Change
Non-PUC's	414	538	29.95%
PUC's	141	86	-39.01%
Total BG's	555	624	12.43%
% PUC's	25.41%	13.78%	-11.62%

Chart displaying change in PUC's/Non-PUC's from 2015-2021 in Mecklenburg County

Aim 3: Bright Lining vs. Dot-Density Mapping

The dot mapping technique was used to demonstrate a limitation of relying on bright line mapping alone for identifying Potentially Underserved Communities. Dot mapping of White and Non-White populations were overlaid upon PUC's for 2015 and 2021 in Figure 12 above. These maps are presented as a slider in the Animations Storymap (https://storymaps.arcgis.com/stories/36c01fc9620f4c4e834350f9378d1d1d). While the dots only represent race/ethnicity, not including poverty, the maps illustrate that significant numbers of minorities remain in 2021 within block groups that met the NCDEQ criteria for PUC's in 2015 but not in 2021. Likewise, there is some 2021 migration of White persons into areas along the crescent that were PUC's in 2015. The influx of White population is primarily due to gentrification within these areas (formerly PUC's in 2015). Their numbers alter the ratio of minorities needed to meet the NCDEQ race/ethnicity criteria, thus affecting the overall percentages within these block groups. Yet significant numbers of minorities remain present in 2021. These remaining minorities are still a vulnerable population in need of environmental justice support, but their ratio is diluted in 2021 such that their block groups no longer qualify as PUC's.



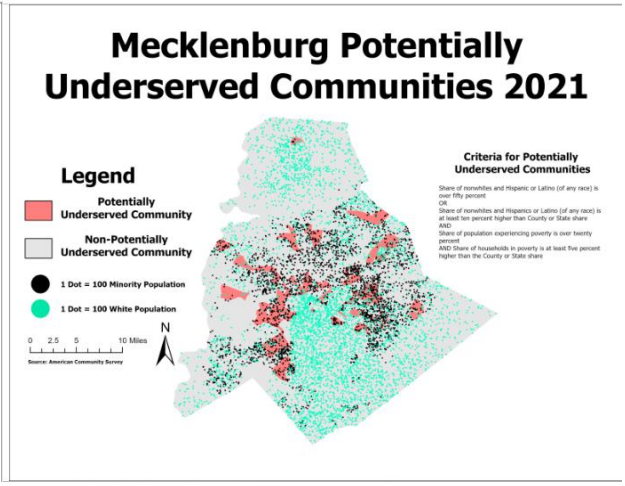


Figure 13: ***Side-by-Side images of Dot Density Map of White and Non-White Population Overlaid onto Potentially Underserved Communities in Mecklenburg County, 2015 and 2021***

Data Limitations

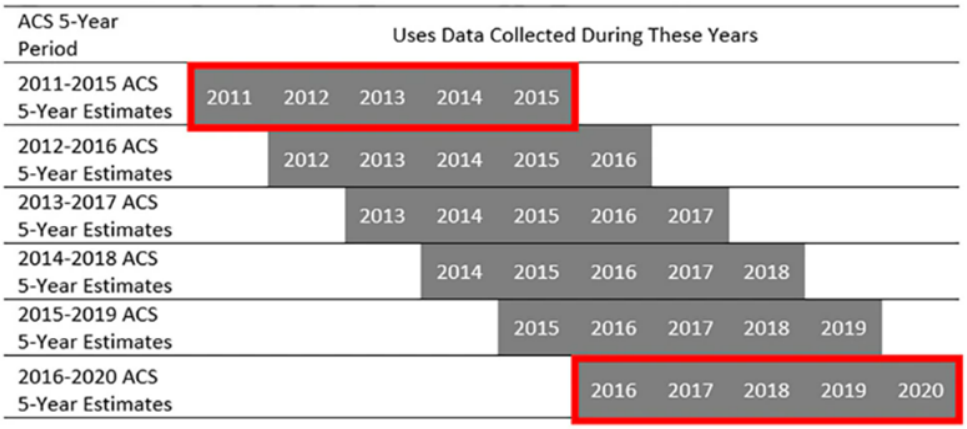
As with any mapping process, there are limitations with the data, the mapping techniques, and the technology. In terms of data, there are several issues with census data that make longitudinal analysis challenging. These include:

- The exact poverty variables used for the NCDEQ method of determining potentially underserved communities' dates back to 2013 for block groups and 2010 for census tracts; however, other poverty variables are present in the census dataset for earlier years and may be useful supplements for understanding the spatial distribution of poverty in earlier years.
- PUC mapping for earlier years can be achieved for race/ethnicity at the level of the census tract; however, data for mapping for 2000 and earlier are available via the decennial census only.
- Race/ethnicity data (categories, e.g., Hispanic, Asian, Native American, etc) are less detailed for 1990 and decades earlier; thus, only 2000 and 2005 will allow for PUC mapping of race/ethnicity components that is precisely comparable to 2010 and beyond. Mapping earlier than 2000 can be done for census tracts for 1990 and earlier decennial dates, but with the fewer available race/ethnicity categories.
- One-year estimates are only available for geographic areas with a population of 60,000 or more.
- 5-year estimates begin in 2005-2009 and are available but with limitations. The 5-year estimates reflect a pooled and weighted average of individual years within a 5-year period. The Census Bureau recommends not using estimates from overlapping 5-year periods. We therefore took our estimates from non-overlapping 5-year estimates (see Figure 3). As indicated in the name, however, these are "estimates" and should be viewed as such when comparing the 1-year map animations.
- Census geographies change year to year and when working with ACS data the Census Bureau recommends "…comparisons across time be made with caution, or not compared at all."[1] Block groups are subdivisions of census tracts and consist of between 600 and 3,000 people each, while census tracts bound geographical areas with an average of 4,000 people each. As population numbers change, boundaries are redrawn to reflect the population requirements for block groups and census tracts. Population increase may result in the subdivision of block groups and tracts; likewise, boundaries can be redrawn to reflect population decrease. In viewing animations, shifting PUC locations reflect changing boundaries as well as population character (race/ethnicity and poverty).
- Note that there are decennial census data for the year 2000 and earlier that are available for mapping within the 2010 census tract geographies. Decennial comparisons for 2010 and earlier for census tracts will therefore be comparable by geography but not necessarily by precise race category.
- The StoryMapping tool is very useful but has its inherent technological limitations. There are limits to map design and placement of text. The base map tends to shift when moving between

dates. The image may appear lighter or darker. Depending on server speed, viewer connection quality, and the viewing platform (phone, tablet, laptop, desktop), the image loading time may be delayed. Please keep these details in mind when viewing the StoryMaps of Animations.

[1] U.S. Census Bureau. (2022). Comparing ACS Data. Retrieved from https://www.census.gov/programs-surveys/acs/guidance/comparing-acs-data.html

Table 2. Non-Overlapping Periods of ACS 5-Year Estimates[1]



[1] Image Source: U.S. Census Bureau. (2022b). Period Estimates in the American Community Survey. Retrieved from https://www.census.gov/newsroom/blogs/random-samplings/2022/03/period-estimates-american-community-survey.html#:~:text=What%20are%20period%20estimates%3F,to%20create%205%2Dyear%20estimates.

Appendix 6: Case Study Briefs

Assessing the Environmental Justice and Historical Impacts of Transportation Decisions in North Carolina:

NC-147/Durham Freeway Impacts on the Hayti Community

CASE STUDY AREA CHARACTERISTICS:

Area: Durham

Region: Central

Area Type: Urban

Community Impacted: Historically Black Community

Transportation Project Period: 1950s - 1970s

County: Durham County



BURDEN CHARACTERISTICS:

- Redlining
- Impacts of freeway construction and expansion on community connectivity and cohesion
- Lack of access to decision-making process.
- After extended period of disinvestment, vulnerability to gentrification and displacement.

Historic Study Area Characteristics

(Pre-Transportation Project)

- Commercial and social hub of Black community
- Many Black-owned local businesses
- Abundant green space
- High community cohesion
- High area connectivity
- High local business ownership
- High local homeownership
- High land use diversity



Study Area Aerial, 1950

Current Study Area Characteristics

(Post-Transportation Project)

- Loss of green space
- Decreased property values
- Low community cohesion
- Low area connectivity
- Low local business ownership
- Low local homeownership
- Low land use diversity
- High vulnerability to gentrification and displacement.



Study Area Aerial, 1972

ITRE

NC-147/Durham Freeway Impacts on the Hayti Community

After project construction, the area showed a DECREASE in:

- Historic Community Population
- Black-Owned Businesses
- Green Space
- Property Values
- Community Cohesion
- Area Connectivity
- Local Business Ownership
- Land Use Diversity

After project construction, the area showed an INCREASE in:

- Vulnerability to Gentrification and Displacement

KEY TAKEAWAYS FOR NCDOT:

- Community awareness and engagement in decision making process.
- Relocation and replacement strategies for homes and businesses affected.
- Impact of regional transportation decisions on local community stability.
- Partnerships with affected communities local governance to align land use decisions with transporation improvements.
- NEPA and requirements for environmental impact statements to consider alternatives mitigating community disruption.

ITRE

Assessing the Environmental Justice and Historical Impacts of Transportation Decisions in North Carolina:

Princeville Case Study, US HWY 64

CASE STUDY AREA CHARACTERISTICS:

Area: Princeville

Region: Eastern

Area Type: Rural

Community Impacted: Town of Princeville

Transportation Project Period: 1990s-2020s



County: Edgecombe

BURDEN CHARACTERISTICS:

- High health vulnerability
- High social vulnerability
- High housing cost burden
- High climate vulnerability

Historic Study Area Characteristics	Current Study Area Characteristics
(Pre-Transportation Project)	*(Post-Transportation Project)*
• Historically African American Community • One of the first towns founded by free African Americans in the United States	• 100% disadvantaged community • Projected to face extreme climate change related risks



Aerial image of Princeville, North Carolina

ITRE



Aerial image of Princeville, North Carolina after Hurricane Matthew (2016), Image from The Washington Post

After project construction, the area showed a DECREASE in:

- Affordable housing
- Trust in federal agencies due to pattern of underinvestment in flood protection

After project construction, the area showed an INCREASE in:

- Flooding due to infrastructure decisions

KEY TAKEAWAYS FOR NCDOT:

Interagency collaboration: The decision-making process that forced a separation between the levee and Highway 64 is still a mystery. No levee system would have been capable of protecting Princeville from Hurricane Floyd, a 1000-year storm. However, some of Hurricane Matthew flooding in Princeville has been attributed to the ungated culverts between the levee and Highway 64. There is a need for more effective, transparent, and well documented decision making between NCDOT and US Army Corps of Engineers, especially in communities at extreme risk of flooding.

REFERENCES:

- McConnell & Associates, P.C. (2017) Town of Princeville, North Carolina: Hurricane Matthew Flood Assessment Study
- LSA Briefing for the Town of Princeville, NC: Land Suitability Analysis for Post-Disaster Housing Relocation, Hurricane Matthew Disaster Recovery and Resilience Initiative September 2018
- US Army Corps of Engineers (2016) Princeville, NC Flood Risk Management
- US Army Corps of Engineers (2015) Public Notice: Modified Design Princeville, North Carolina Flood Risk Management Draft Integrated Feasibility Report and Environmental Assessment
- US Army Corps of Engineers (2015) Appendix D: Princeville, North Carolina Flood Risk Management Integrated Feasibility Report and Environmental Assessment Cost Appendix
- America's oldest Black town, threatened by floods, searches for a Plan B - The Washington Post
- The power of place in disaster recovery: Heritage-based practice in the post-Matthew landscape of Princeville, North Carolina – PSF (berkeley.edu)
- Princeville Collaborative - Conservation Trust for North Carolina (ctnc.org)
- A flood disaster in N.C.: Satellite photos before and after Hurricane Matthew - The Washington Post Angela Fritz, 10/14/2016
- "Building a Resilient Future in Princeville, N.C. (2021)" https://youtu.be/VNkLCw0aGfY, Video Credit: Conservation Trust for North Carolina
- "This Side of the River-The Story of Princeville (2006)" THIS SIDE OF THE RIVER - THE STORY OF PRINCEVILLE (full movie) (youtube.com) Video Credit: The Language and Life Project

Assessing the Environmental Justice and Historical Impacts of Transportation Decisions in North Carolina:

I-26 Connector Impacts on the Burton Street Neighborhood

CASE STUDY AREA CHARACTERISTICS:

Area: Asheville

Region: Western

Area Type: Urban

Community Impacted: Burton Street Neighborhood

Transportation Project Period: 1960s-2020s

County: Buncombe

BURDEN CHARACTERISTICS:

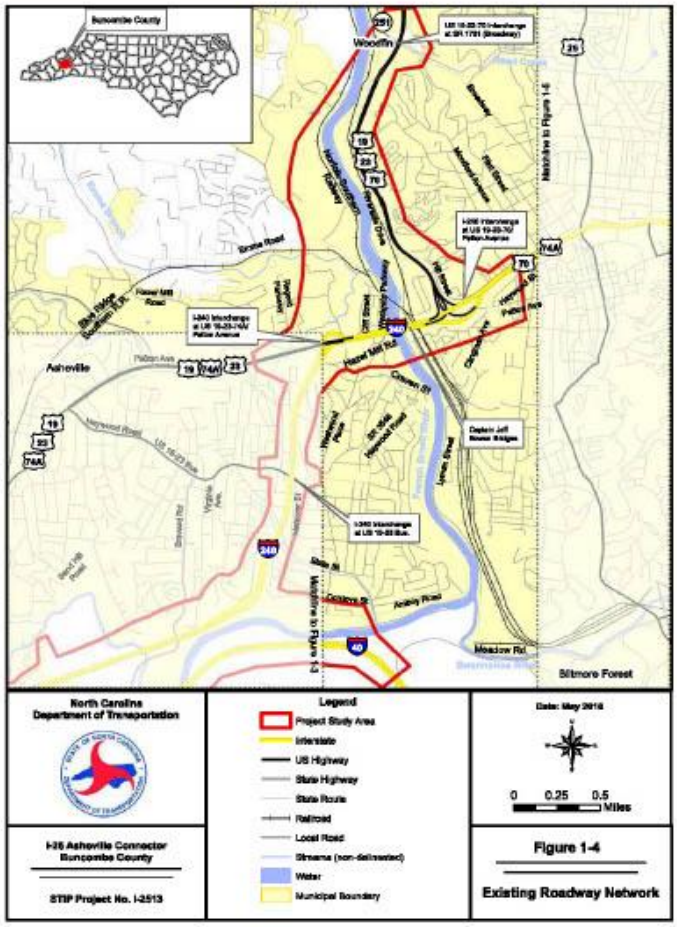
- High poverty
- High disability
- High housing cost burden
- Low transportation safety

Historic Study Area Characteristics	Current Study Area Characteristics
(Pre-Transportation Project)	*(Post-Transportation Project)*
• Historically African American Community	• No longer considered disadvantaged community • Eclectic architectural styles and street layouts • Loss of structures • Hotspot for drug related crime



Aerial image of study area: Burton Street neighborhood, Asheville, NC

ITRE



I-26 Connector through Burton Street neighborhood

After project construction, the area showed a DECREASE in:

African American homeowners and residents

After project construction, the area showed an INCREASE in:

Urban growth, gentrification, and displacement during transportation period

KEY TAKEAWAYS FOR NCDOT:

Mitigating the impacts of extended planning processes: The extended planning processes associated with I-26 widening impacted the Burton Street Neighborhood. The extended planning timetable including a major reset leading to the current approved Environmental Impact Assessment process, did produce a plan that significantly reduced community impacts post project completion. However, the duration of the planning process caused uncertainty and hindered community stakeholders from development efforts. These included challenges in attracting investment in local homes and businesses, and investments of infrastructure like sidewalks and open spaces. Future planning efforts would benefit from collaboration with other agencies and organizations to identify and respond to community needs that may be delayed due to the impacts of eventual freeway development.

ITRE

REFERENCES:

- Asheville Design Center/Western North Carolina Alliance (2010) Burton Street Community Plan (2010)
- NCDOT (2020) 2015 DEIS Reevaluation I-26 Asheville Connector Buncombe County, North Carolina
- Forbes, D. (2014) "Overlooked: Burton Street leaders raise serious concerns about I-26 push", March 25, 2014 Accessed via Overlooked: Burton Street leaders raise serious concerns about I-26 push | Mountain Xpress

Assessing the Environmental Justice and Historical Impacts of Transportation Decisions in North Carolina:

I-77 (I-277) Impacts on West End Community Public Health and Cohesion

CASE STUDY AREA CHARACTERISTICS:



Area: Charlotte

Region: Western

Area Type: Urban

Community Impacted: Historically Black Community

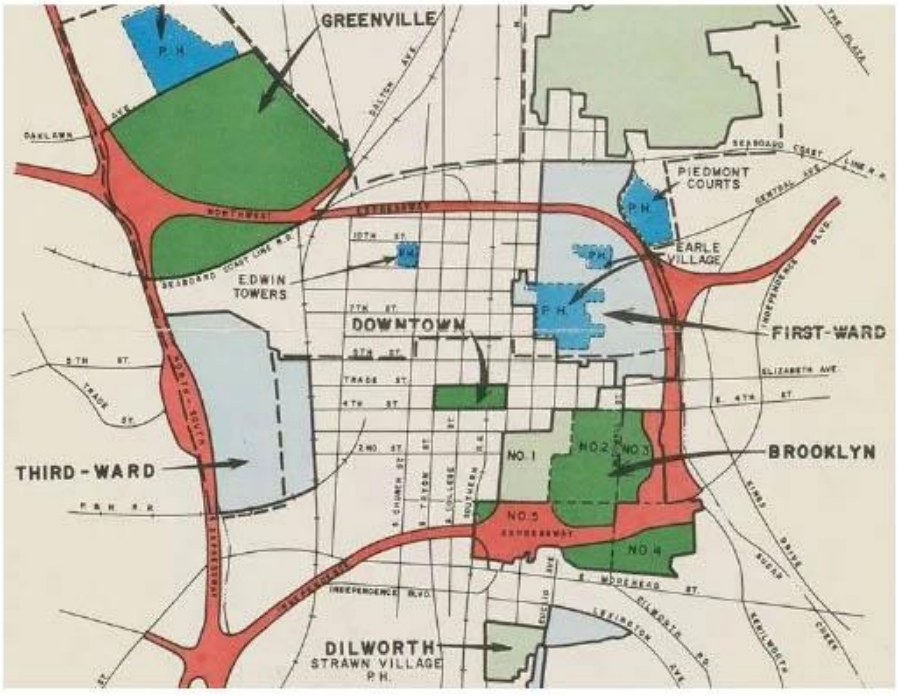
Transportation Project Period: 1960s-1970s

County: Mecklenburg

BURDEN CHARACTERISTICS:

- Disadvantaged/underserved community
- High air pollution
- High impervious surfaces and stormwater runoff

Historic Study Area Characteristics	Current Study Area Characteristics
(Pre-Transportation Project)	*(Project Ongoing)*
• Historically Black Community • Redlined community • High exposure to industry and air pollution • Industry impacts depreciated area land and home values	• Public health priority area (Mecklenburg County) • High rates of chronic disease



Urban Renewal Areas Map, 1972
Image by Charlotte Redevelopment Commission

MITRE

I-77 (I-277) Impacts on West End Community Public Health and Cohesion



I-77 isolates the Oaklawn Park neighborhood, 2022
Photo by Travis Dove

After project construction, the area showed a DECREASE in:

- Community cohesion
- Households
- Local businesses
- Schools and other community institutions
- Air quality

After project construction, the area showed an INCREASE in:

- Air pollution
- Industrial and light commercial land uses
- Impervious surfaces
- Property and home values

KEY TAKEAWAYS FOR NCDOT:

Recognition of how infrastructure decisions can compound on existing land use and development decisions that impact current equitable development opportunities. 20th century urban renewal and the construction of I-77 resulted in the demolition and displacement of hundreds of local households and businesses. Current EIA and EJ protocols require NCDOT to engage affected communities and document community history. But moving forward, NCDOT can consider how infrastructure can support community-driven equitable development strategies. In this case, how infrastructure improvements can enhance promoting and expanding affordable housing access, ownership, and local business development.

Opportunity for partnerships to monitor public health impacts of infrastructure. Air quality directly impacts community respiratory health. Increased automobile traffic has contributed to increased toxic emissions. In this case, citizen science and community engagement were essential to providing evidence of poor air quality. Continued monitoring using collected data as a baseline could help determine long term impacts.

REFERENCES:

- Clean Air Carolina, (2021) Clearing the Air in the Historic West End (story map)
- Charlotte Redevelopment Commission (1972), J. Murrey Atkins Library, UNC Charlotte, Black History of Charlotte Part 4: How Redlining, Blockbusting and 'Urban Renewal' Victimized a Community (qcnerve.com)
- James B. Duke Memorial Library, Johnson C. Smith University, (No date), Charlotte's Historic West End
- Portillo, E. (2022) "Cry Us a River: The Calamity of I-277 in Charlotte—And How We Could Undo It", Charlotte Magazine accessed Cry Us a River: The Calamity of I-277 in Charlotte—And How We Could Undo It - Charlotte Magazine

ITRE

Assessing the Environmental Justice and Historical Impacts of Transportation Decisions in North Carolina:

NC-55/Alston Avenue Widening Impacts on Housing and Local Small Businesses

CASE STUDY AREA CHARACTERISTICS:

Area: Durham

Region: Central

Area Type: Urban

Community Impacted: Black and Latino Communities

Transportation Project Period: 2010s-present

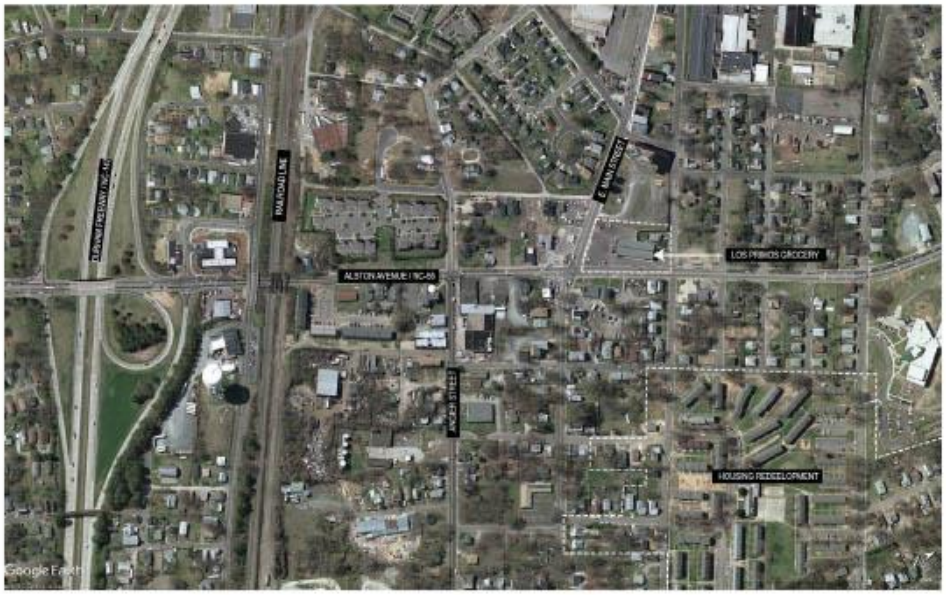
County: Durham



BURDEN CHARACTERISTICS:

- Disadvantaged/underserved community
- High respiratory disease
- High impervious surfaces and stormwater runoff
- High social vulnerability
- High transportation cost

Historic Study Area Characteristics	Current Study Area Characteristics
(Pre-Transportation Project)	*(Project Ongoing)*
• Redlined community • Commercial and social hub of Black Community • High community connectivity • Mixed uses including light commercial and industrial uses	• Increasing Latino and Spanish-speaking communities • Durham Rescue Mission and other social service organization expansion • Decreased local businesses • Increased market rate housing development • Increased area property values

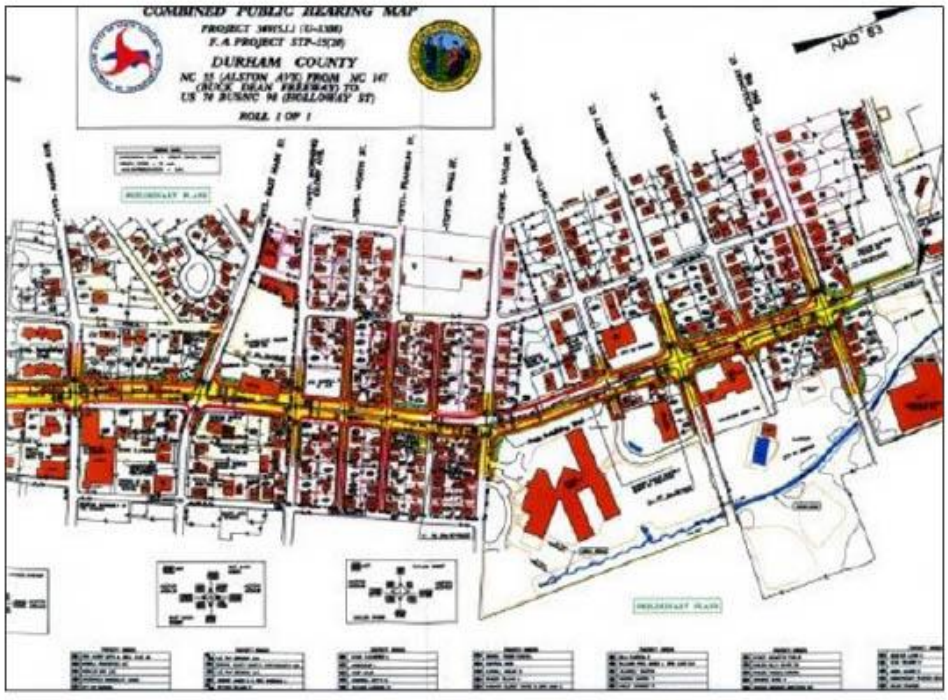


Study area, 2002

ITRE



Study area, 2023



NCDOT Combined Public Hearing Map, 2006

NC-55/Alston Avenue Widening Impacts on Housing and Local Small Businesses

After project construction, the area showed a DECREASE in:

- **Pedestrian and non-motorized mobility across Alston Avenue**
- **Local businesses**

After project construction, the area showed an INCREASE in:

- **Affordable housing due to interagency coordination**
- **Increase in area property values and housing costs**

KEY TAKEAWAYS FOR NCDOT:

The value of effective community engagement.

NCDOT pivoted from the results of an initial EIS that identified multiple environmental justice issues including the loss of multiple homes, businesses, and portions of the Durham Rescue Mission. Part of the pivot was changing community engagement approaches, engaging the local spanish-speaking Latino community, and working to redesign to preserve Los Primos; the only local grocery store in the community (NOTE: Los Primos still closed due to increased property values and rents that displaced this business). Additionally, NCDOT worked with local property owners to acquire land that was taken from Durham Rescue Mission to enable their expansion plans.

The value of interagency collaboration.

Foremost amongst mitigation efforts was countering the loss of affordable housing caused by highway widening. NCDOT worked in coordination with Durham's Housing Authority to incorporate Hope VI funded redevelopment housing, which increased affordable housing in the community, to offset the loss of affordable housing due to highway widening.

REFERENCES:

- U.S. Department of Transportation Federal Highway Administration (No date), Environmental Justice, "Case Studies: Removal of Los Primos Supermarket-Analyzing Impacts and Identifying Alternatives"
- U.S. Department of Transportation Federal Highway Administration and North Carolina Department of Transportation. "Administrative Action Environmental Assessment and Draft Section 4(f) Evaluation." Durham NC 55 (Alston Avenue) from NC 147 (I.L. "Buck" Dean Freeway) to US 70 Business/NC 98 (Holloway Street) Durham County. November 2005.
- U.S. Department of Transportation Federal Highway Administration and North Carolina Department of Transportation. "Administrative Action Finding of No Significant Impact and Final Section 4(f) Evaluation." Durham NC 55 (Alston Avenue) from NC 147 (I.L. "Buck" Dean Freeway) to US 70 Business/NC 98 (Holloway Street) Durham County. June 2007.
- NCDOT (2006) Combined Public Hearing Map, ALSTON AVE WIDENING | Open Durham

ITRE

Assessing the Environmental Justice and Historical Impacts of Transportation Decisions in North Carolina:

Flooding Impacts of I-40 on Rochester Heights Community

CASE STUDY AREA CHARACTERISTICS:



Area: Raleigh

Region: Central

Area Type: Urban

Community Impacted: Historically Black Community

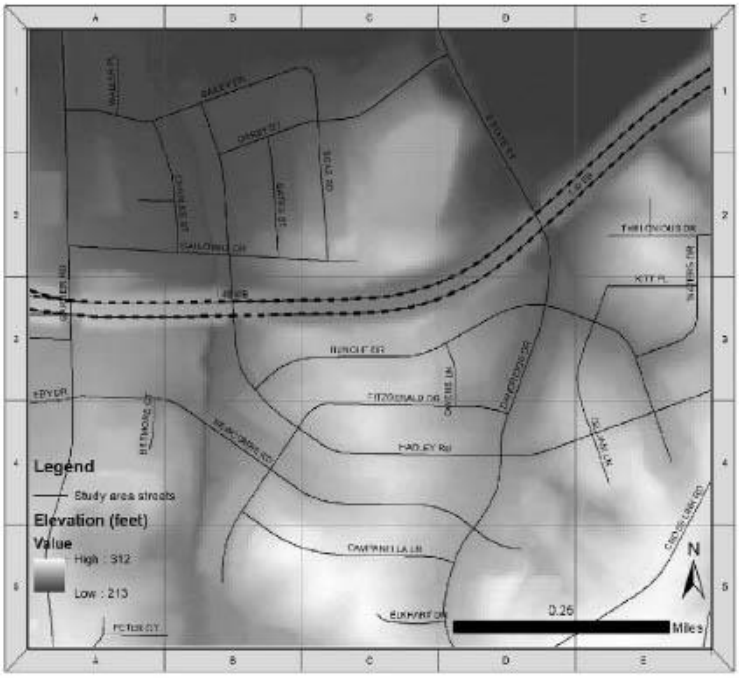
Transportation Project Period: 1960s-1970s

County: Wake

BURDEN CHARACTERISTICS:

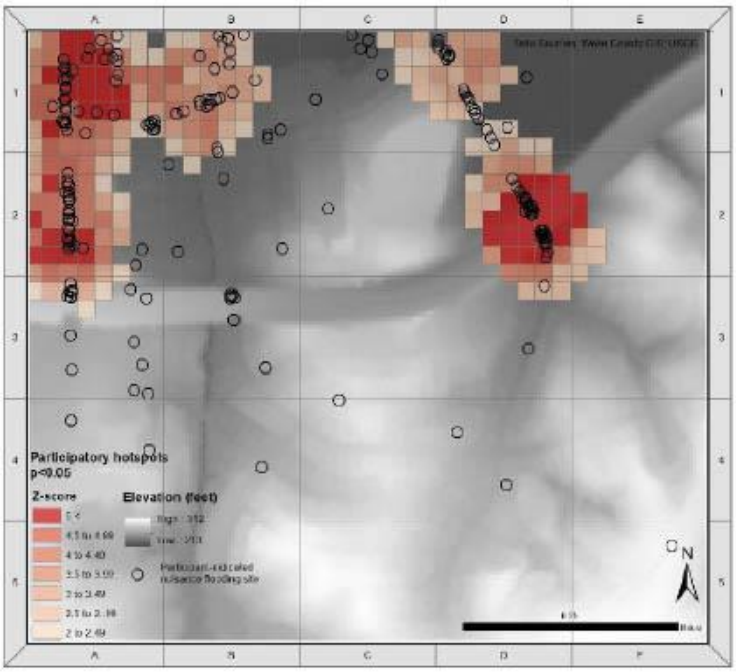
- Built partially in floodplain of Walnut Creek
- Industrial land and water contamination
- High air pollution exposure

Historic Study Area Characteristics	Current Study Area Characteristics
(Pre-Transportation Project)	*(Post-Transportation Project)*
• First post World War II Black subdivision in Raleigh, North Carolina • Disadvantaged/underserved community	• Increasing Latino and Spanish-speaking communities • High percentage of impervious surfaces • High rates of nuisance flooding at community access points • Increased market rate housing development • Increased area property values



Digital Elevation Model of the Rochester Heights Neighborhood, 2020

MITRE



Digital Elevation Model of the Rochester Heights Neighborhood with hotspots of nuisance flooding, 2020

After project construction, the area showed a DECREASE in:

- Pervious surfaces and places for stormwater infiltration

After project construction, the area showed an INCREASE in:

- Impervious surfaces and area stormwater runoff
- Nuisance flooding
- PM 2.5 and Diesel PM levels
- City Parks and Open Space (Walnut Creek Park, Noman and Betty Camp Wetland Education Center)

KEY TAKEAWAYS FOR NCDOT:

Community participation and citizen science.
NCDOT could engage residents in post-construction monitoring of effects of highway infrastructure on area flood risks in flood prone communities. Evidence of recurring nuisance flooding affecting community access that did not reach FEMA disaster thresholds was undocumented before academic research studies.

Partnerships to enhance green infrastructure and nature-based solutions in disadvantaged/underserved communities.
NCDOT could increase partnerships with local agencies and communities to support and enable green infrastructure and nature-based solutions to flood protection and mitigation. In Rochester Heights, the creation of Walnut Creek Park and the Norm and Betty Camp Wetland Education Center both enhanced community resilience but were primarily community driven and city funded. No current efforts address nuisance flooding affecting community access and exacerbated by I-40 and the increase in impervious surfaces in the community.

ITRE

REFERENCES:

- Argintar, S. (2010), Rochester Heights Historic District, National Register of Historic Places, NC State Historic Preservation Office
- Hasala, D., Supak, S., Rivers, L. (2020), "Green infrastructure site selection in the Walnut Creek wetland community: A case study from southeast Raleigh, North Carolina", *Landscape and Urban Planning 196* https://doi.org/10.1016/j.landurbplan.2020.103743
- Raleigh Historic Development Commission (No date), Rochester Heights Historic District

Assessing the Environmental Justice and Historical Impacts of Transportation Decisions in North Carolina:

Public Health Impacts of Air Emissions Near Highways in Robeson County

CASE STUDY AREA CHARACTERISTICS:



Area: Multiple Locations

Region: Central

Area Type: Rural

Community Impacted: Native American Community

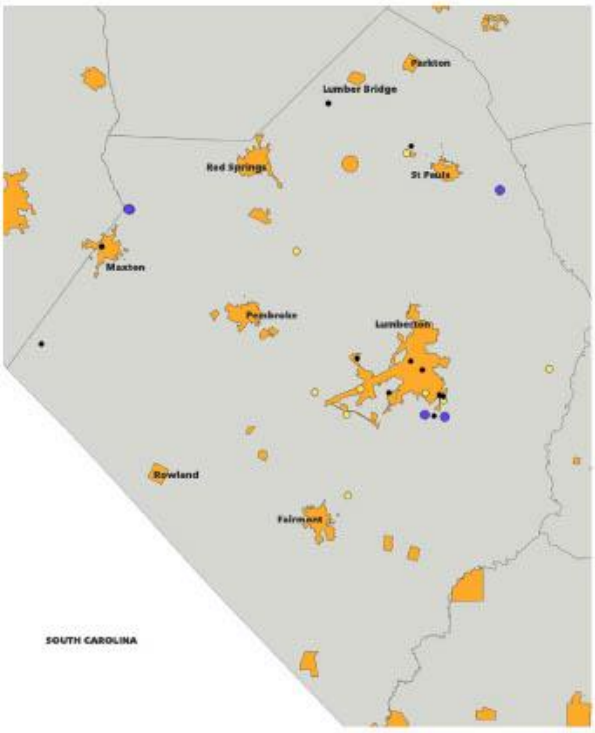
Transportation Project Period: N/A

County: Robeson

BURDEN CHARACTERISTICS:

- Disadvantaged/underserved communities (countywide)
- High poverty
- High social vulnerability
- High health vulnerability
- High transportation costs

Historic Study Area Characteristics	Current Study Area Characteristics
(Pre-Transportation Project)	*(Post-Transportation Project)*
• Traditional lands of the Lumbee and Tuscarora Tribes • Farming and river based local economies	• Increased concentration of animal operations (swine) • Increase in commercial and light industrial uses • High asthma rates



Title V permits for air pollution emitters in Robeson County (based in DEQ data), 2023



Former NC Renewable Power facility, former air pollution emitter that burned poultry waste to sell to Duke Energy, 2023

ITRE

After project construction, the area showed a DECREASE in:

N/A

After project construction, the area showed an INCREASE in:

N/A

KEY TAKEAWAYS FOR NCDOT:

Assessing the impacts of infrastructure on land use changes. Highway construction is in part the result of benefit cost analysis that rewards its impact on economic development. However, economic development that may compound on existing environmental justice issues (truck emissions from travel, layover, idling, etc.) doesn't currently have a mechanism to enable mitigation of negative impacts. Including land use trends more explicitly in benefit cost analysis could enable transportation decisions that reduce EJ burdens including exposure to air pollution.

Interagency collaboration to coordinate equitable truck routing and layover locations. NCDOT could assess the locations of noxious uses and work with local communities do document currently undocumented air pollution generators to determine appropriate mitigation and buffer strategies.

REFERENCES:

- Sorg, L. (2023) "In Robeson County, asthma rates are twice the state average-worsened by air pollution", NC Newsline
- Weaver, A. Air quality research in Robeson County. Freshman Seminar: Environment-ECUIPP Lab: Connecting with communities through environmental research for public health, Chapel Hill, NC, September 12, 2023.

Assessing the Environmental Justice and Historical Impacts of Transportation Decisions in North Carolina:

Impacts of Lakeview Drive East aka "The Road to Nowhere" on Community Cohesion

CASE STUDY AREA CHARACTERISTICS:



Area: Bryson City

Region: Western

Area Type: Rural

Community Impacted: White and Native American Communities

Transportation Project Period: 1940s-1970s (not an NCDOT project)

County: Swain

BURDEN CHARACTERISTICS:

- High poverty
- High transportation cost
- High housing costs
- High public health burden

Historic Study Area Characteristics	Current Study Area Characteristics
(Pre-Transportation Project)	*(Post-Transportation Project)*
• Rural community • Local industrial businesses	• Rural community • Tourism businesses



North Carolina's "Road to Nowhere," (date unknown)
Photo by D. Hass

ITRE



Lakeview Drive blocked by bollards, 2016
Photo by NC DNCR Staff

After project construction, the area showed a DECREASE in:

↓ Local Businesses ↓ Homes ↓ Connection to Ancestral Lands

After project construction, the area showed an INCREASE in:

N/A

KEY TAKEAWAYS FOR NCDOT:

Building community trust after eminent domain. This was not an NCDOT project. It was a US Department of Interior proposal to connect communities displaced by the Tennessee Valley Authority (TVA) creation of Fontana Dam to their ancestral lands and villages. It is referred to as a "broken promise" due to its lack of complete implementation resulting in a cash payment held by the State of North Carolina on behalf of Bryson City. Rules affecting eminent domain have changed since the 1940s. But the significance of implementing mitigation to support community cohesion remains.

REFERENCES:

- Bryson City (No date) "The history of the road to nowhere"
- Swain County Chamber of Commerce (No date) "A Road to Somewhere Special"
- Tennessee Valley Authority (No date) "The Miracle in the Wilderness"
- Morrison, J. (2018) NC's"Road to Nowhere" Ends With $35 Million Payment", WUNC, NC's "Road To Nowhere" Ends With $35 Million Payment | WUNC
- Lakeview Drive blocked by bollards (NC DNCR Staff), 2016, NC DNCR, "Swain County's "Road to Nowhere," Swain County's "Road to Nowhere" | NC DNCR

ITRE

Assessing the Environmental Justice and Historical Impacts of Transportation Decisions in North Carolina:

Wilmington Bypass/I-140 Impacts on Rockhill Community Cohesion

CASE STUDY AREA CHARACTERISTICS:



Area: Rockhill/ Wrightsboro

Region: Eastern

Area Type: Rural

Community Impacted: Black and Latino Communities

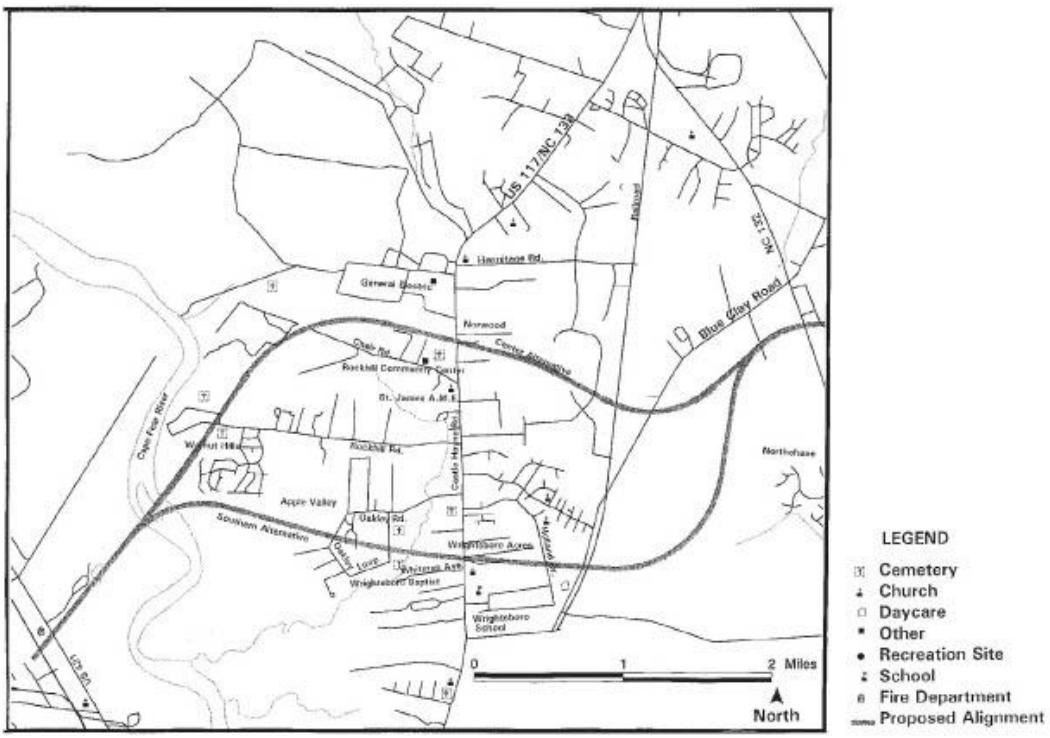
Transportation Project Period: 2000-2010's

County: New Hanover County

BURDEN CHARACTERISTICS:

- High poverty
- High housing cost burden
- High transportation insecurity

Historic Study Area Characteristics	Current Study Area Characteristics
(Pre-Transportation Project)	*(Project Ongoing)*
• Former plantation land • Black and Latino populations	• Increasing Latino population



Wilmington Bypass route alternatives and impacts on Rockhill Lane, 1998

ITRE



St. James AME Church with historic marker (center left of photo), 2024
Accessed via Google Earth Streetview

After project construction, the area showed a DECREASE in:

Homes (displaced) **Community cohesion**

After project construction, the area showed an INCREASE in:

N/A

KEY TAKEAWAYS FOR NCDOT:

- The need for equity in route selection process-Low income, Black, and Latino residents are disproportionately impacted by the preferred and selected alternative.Initially the preferred alternative was through Wrightsboro. However, political power imbalances between Wrightsboro and Rock Hill, as well as Wrightsboro residents influence on decision making favored the protection of wealthier communities and the selection of Rock Hill for freeway construction.
- The need for replicable qualitative data methods that can influence decision making at the time there were no established best practices in documenting community values, particularly the value of Rock Hill AME Church (did not meet integrity standard for State Historic Preservation Office protection). Innovative community engagement efforts, including development of memorial signage and a garden helped establish trust and provide a precedent for future community engagement efforts.
- The agency and effectiveness of technical experts to mitigating freeway impacts on communities-From protection and interpretation of Rock Hill AME Church to the implementation of sound walls, the mitigation of freeway impacts was due to the impacts of effective technical experts that engaged with the local community. Since this project some of their approaches have been encoded into policy (i.e The FHWA Purple Book, etc.). However, the empowerment, effective evaluation, and communication of the effectiveness of these approaches can be more broadly included in upstream project identification, planning, and monitoring.

ITRE

REFERENCES:

- Wilmington Bypass route alternatives and impacts on Rockhill Lane, et al. (1998), "Environmental Justice Evaluation: Wilmington Bypass, Wilmington, North Carolina", Transportation Research Record 1626

Appendix 7: Air Quality Analysis Method Details

To highlight disparities in environmental justice (EJ) concerns and offer useful insights for policy-making, air pollutant emissions from transportation sources were analyzed in the Hayti community case study area as an illustrative example. MOtor Vehicle Emissions Simulator (MOVES) 2024, developed by the U.S. Environmental Protection Agency (EPA), was employed to estimate mobile source emissions. MOVES is used for developing emission inventories for State of Implementation Plans, transportation conformity, and is also recommended for emissions hotspot analysis.

In this work, MOVES project scale, coupled with the Triangle Regional Model (TRM), was used to estimate vehicle fleet emissions at the road link level in Hayti. TRM is a regional travel forecast model that supports regional transportation planning for the Triangle area in North Carolina, including Hayti in Durham County. TRM can predict traffic fleet activity at the road link level for different times of a day and different calendar years. TRM was used to predict hourly traffic speed and volume for different vehicle types, such as single-unit and multi-unit trucks, during the evening rush hours for 1,605 road links in Hayti for the years 2020, 2030, 2040, and 2050, with a 10-year interval. The evening rush hour was selected due to its peak traffic volumes, which typically result in the highest fleet emissions during the day, thus representing worst-case estimates.

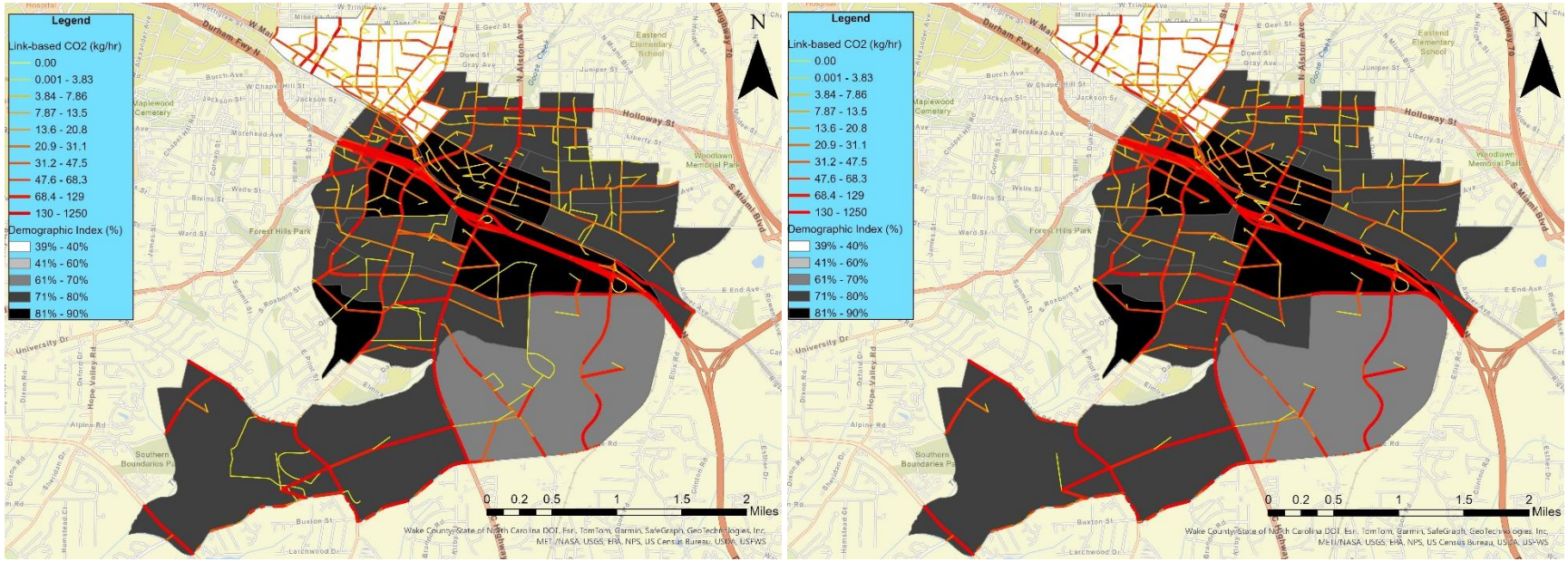
For the MOVES project scale, model inputs include calendar year, vehicle type, link activity, link source fraction, fleet age distribution, fuel type, and meteorology. The model output is vehicle fleet emissions by road links. The data sources for each model input are either case study-specific (e.g., from TRM) or derived from model default settings, as detailed below:

- Calendar year: The baseline calendar year was selected as 2023, the latest calendar year, to ensure a more precise representation of vehicle fleet emissions, especially in the context of the post-pandemic era. In addition, calendar years 2030, 2040, and 2050 were selected to predict future emissions in Hayti and evaluate EJ implications for the case study area;
- Vehicle type: MOVES categorizes vehicles into 13 different vehicle types. In this work, passenger trucks, short-haul combination trucks, and long-haul combination trucks were selected to represent passenger vehicles, single-unit trucks, and multi-unit trucks, respectively. These vehicle types typically have heavier weights within their categories and thus produce larger emissions, representing worst-case estimates;
- Link activity: This includes road link based vehicle fleet activity, including fleet average speed and traffic volume for each vehicle type, provided by TRM. The 2020 traffic activity data predicted by TRM were used to represent traffic activity for 2023, as 2020 is the most recent year available in TRM relative to the present;
- Link source fraction: This represents the fraction of traffic volume for each vehicle type on each road link. For each link, the fraction was calculated by dividing the traffic volume for each vehicle type by the total traffic volume, derived from TRM;

- Fleet age distribution: This represents the age distribution of the vehicle fleet for each vehicle type, capturing recent advancements in vehicle technology and emissions regulations. The fleet age distribution was sourced from MOVES default settings;
- Fuel type: This includes the type of fuel used for each vehicle type, such as gasoline for passenger trucks, and diesel for short-haul and long-haul combination trucks. The fuel type was sourced from MOVES default settings. The model default projections regarding electric vehicle adoptions in the future were also included;
- Meteorology: The MOVES default settings were used to represent the average temperature and humidity for Durham County, North Carolina.

Results for road link-based emission estimates for different calendar years are shown in Figures 7-1, 7-2, and 7-3 for key transportation-sensitive air pollutants, including carbon dioxide (CO_2), nitrogen oxides (NO_x), and particulate matter (PM), respectively. The interpretation of link-based emission estimates is given in the main body of the report under the Air Quality Analysis section.

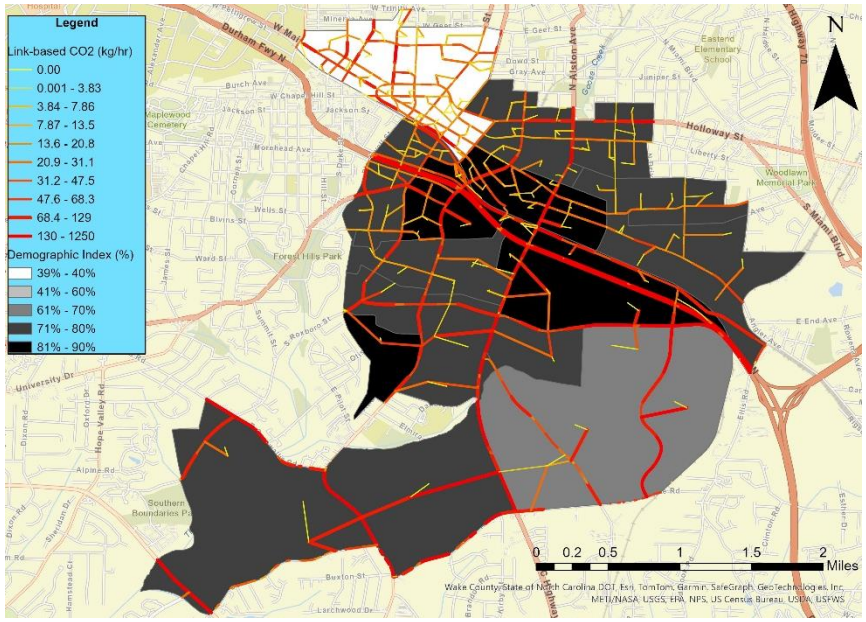
To compare emission estimates among census block areas in Hayti, the link-based fleet emissions were aggregated for each census block area to normalize the effect of census area size. For road links spanning multiple census block areas, fleet emissions were proportionally distributed to each associated area based on their link distance. In Hayti, there are 16 census block areas according to the 2020 American Community Survey. The demographic index, developed by EPA's EJScreen tool, was used to represent socioeconomic status in Hayti. Higher demographic index indicates a larger proportion of residents who are low-income and minority. In Hayti, the demographic index ranges from 39% to 90% depending on the census block area. Results for area-based emission estimates for different calendar years are shown in Figures 7-4, 7-5, and 7-6 for CO_2, NO_x, and PM, respectively. The interpretation of area-based emission estimates across census block areas, as well as trends in emission estimates varied over the years, are given in the main body of the report under the Air Quality Analysis section.



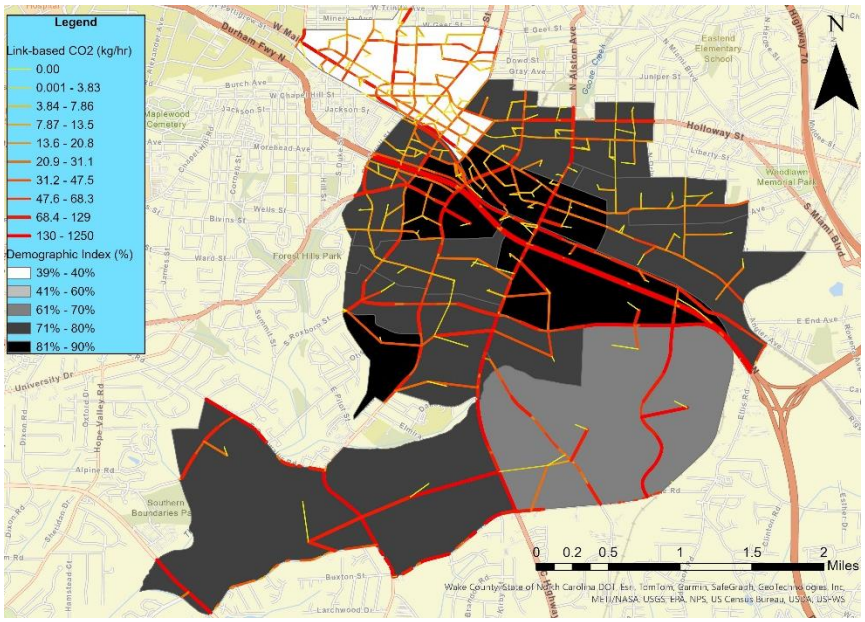
(a) Year 2023 (b) Year 2030

Figure 7-1. Estimated evening rush hour carbon dioxide (CO_2) emissions by 1,065 road links in the Hayti community for: (a) Year 2023; (b) Year 2030; (c) Year 2040; and (d) Year 2050.

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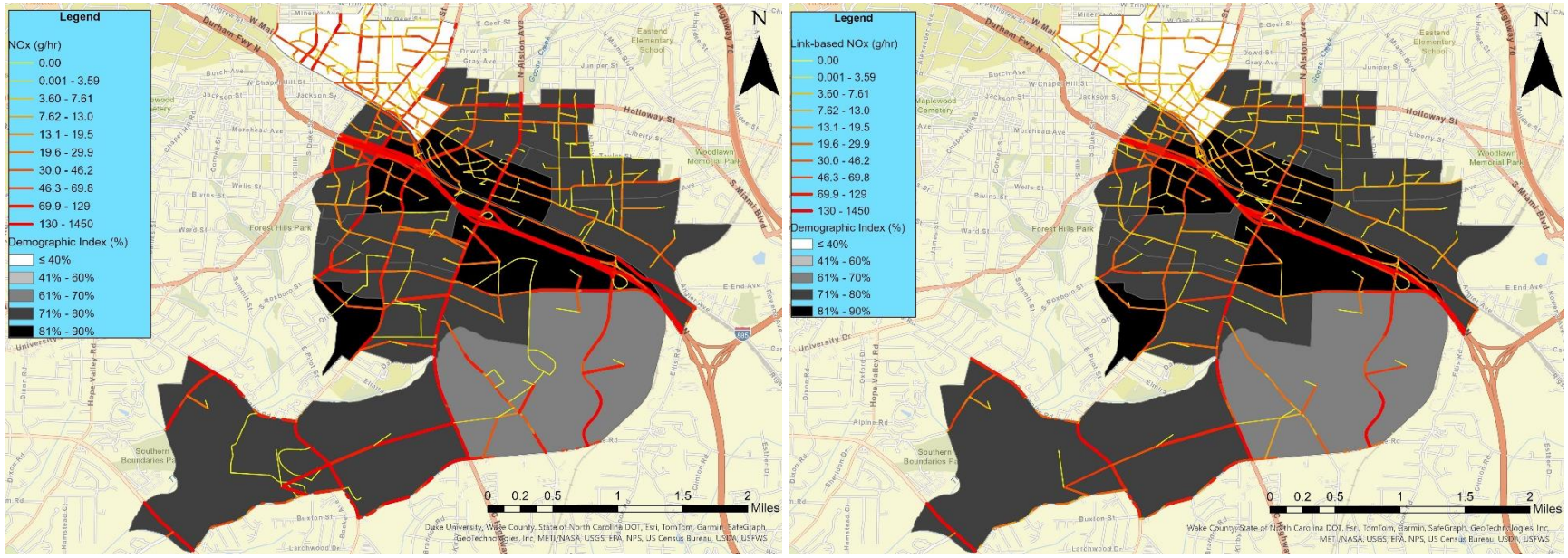


(c) Year 2040



(d) Year 2050

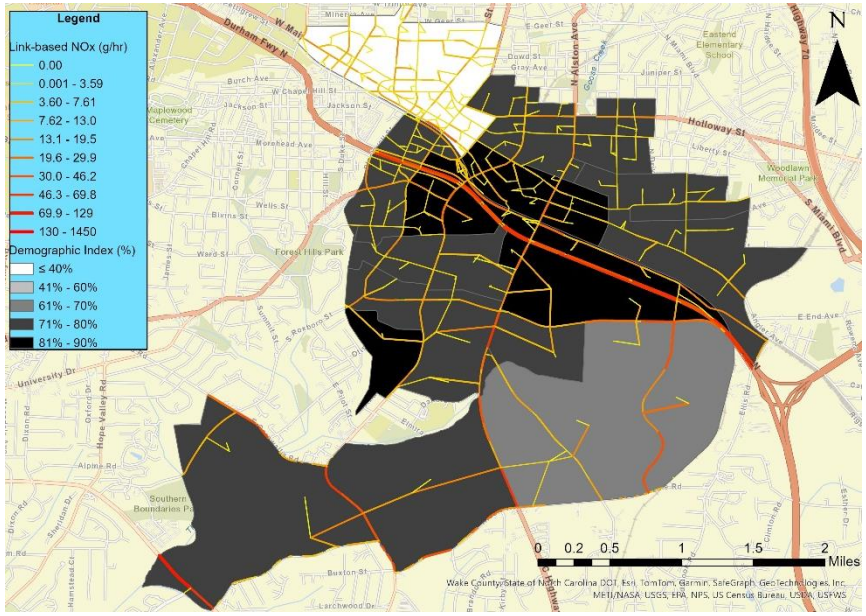
Figure 7-1. Continued.



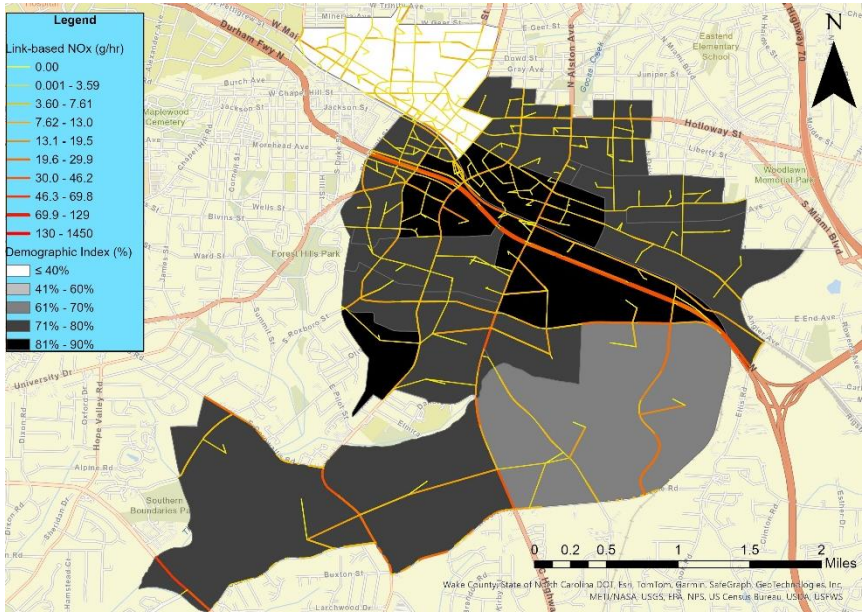
(a) Year 2023 (b) Year 2030

Figure 7-2. Estimated evening rush hour nitrogen oxides (NO_x) emissions by 1,065 road links in the Hayti community for: (a) Year 2023; (b) Year 2030; (c) Year 2040; and (d) Year 2050.

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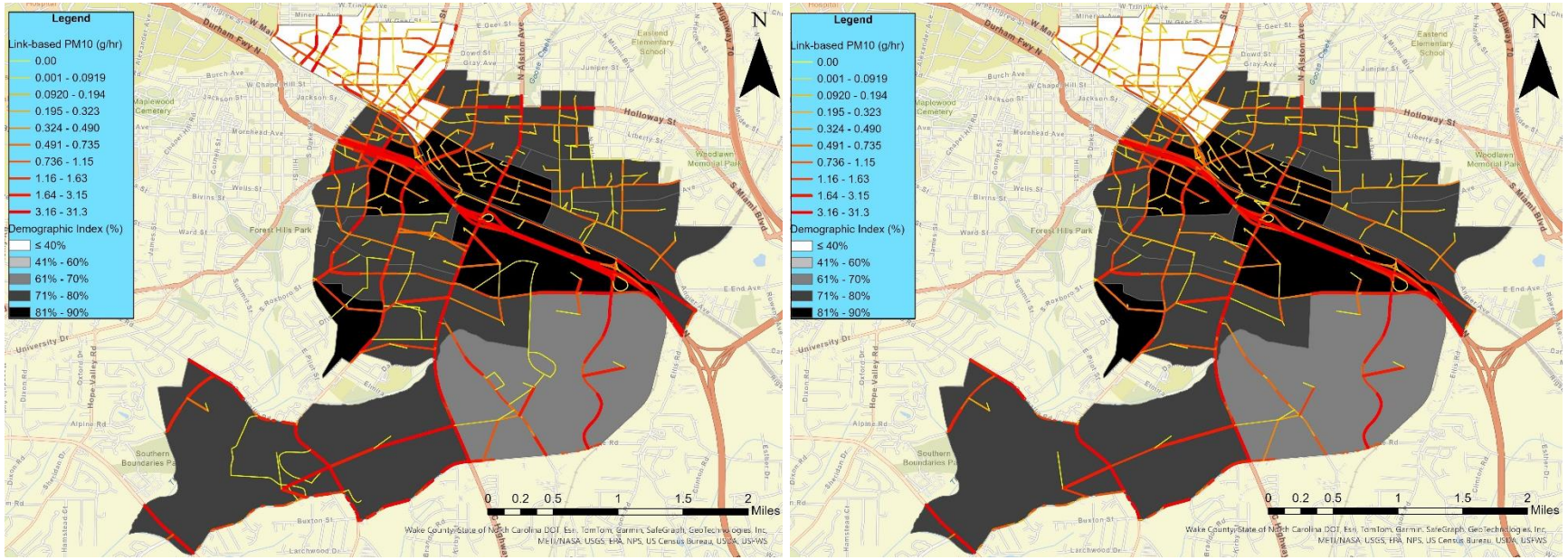


(c) Year 2040



(d) Year 2050

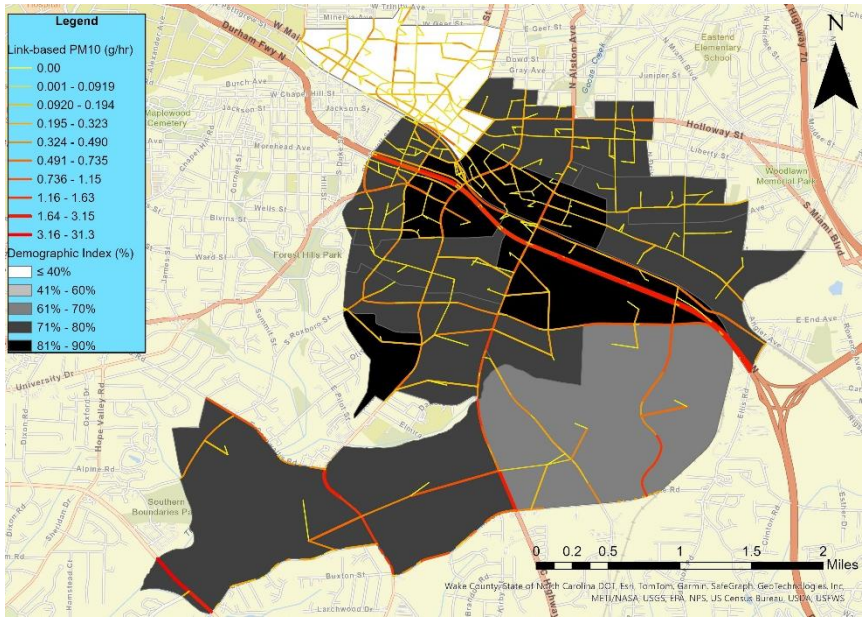
Figure 7-2. Continued.



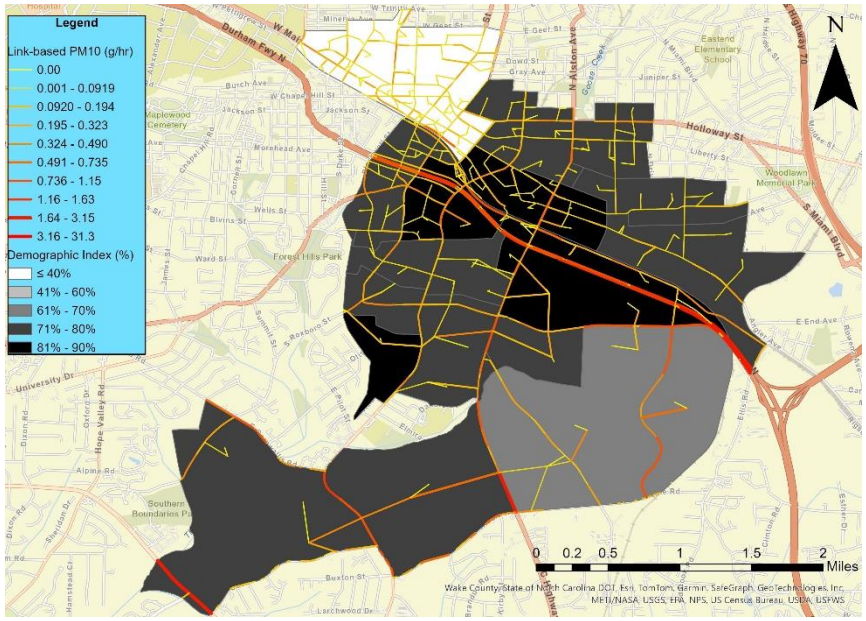
(a) Year 2023 (b) Year 2030

Figure 7-3. Estimated evening rush hour particulate matter (PM) emissions by 1,065 road links in the Hayti community for: (a) Year 2023; (b) Year 2030; (c) Year 2040; and (d) Year 2050.

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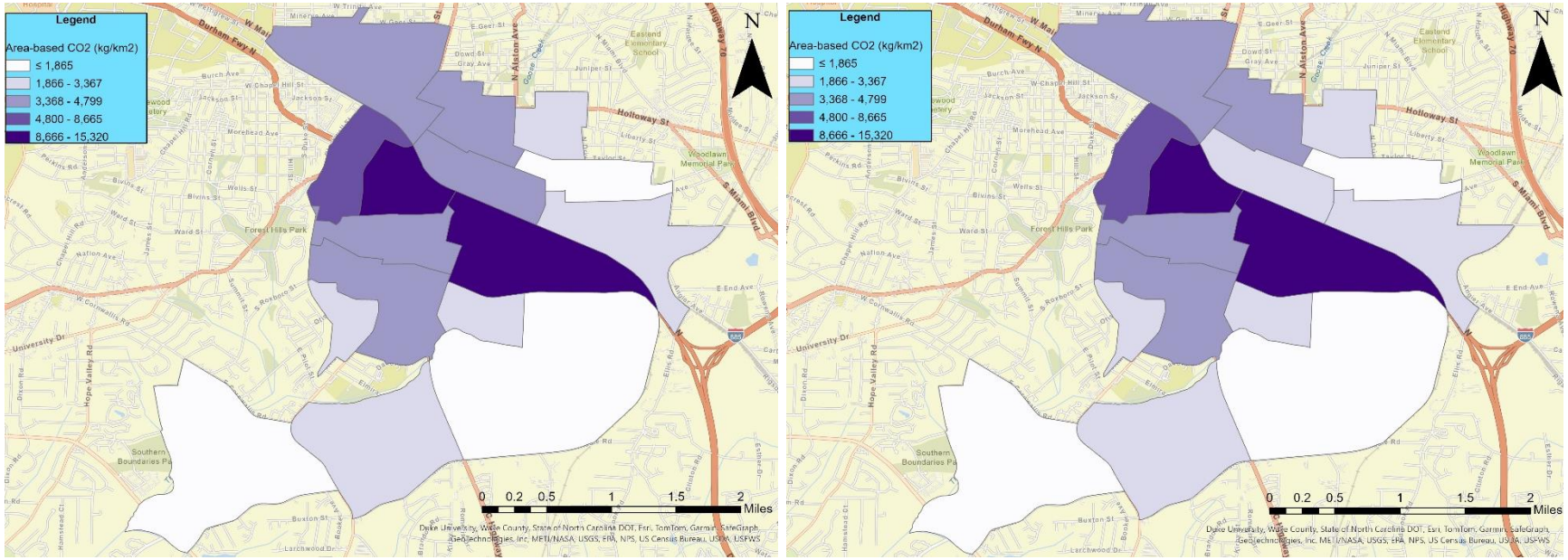


(c) Year 2040



(d) Year 2050

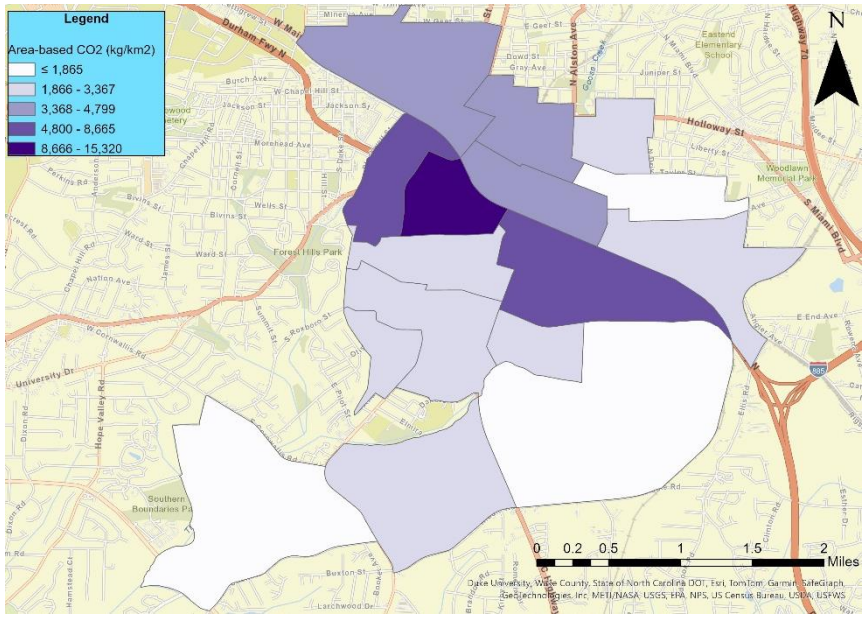
Figure 7-3. Continued.



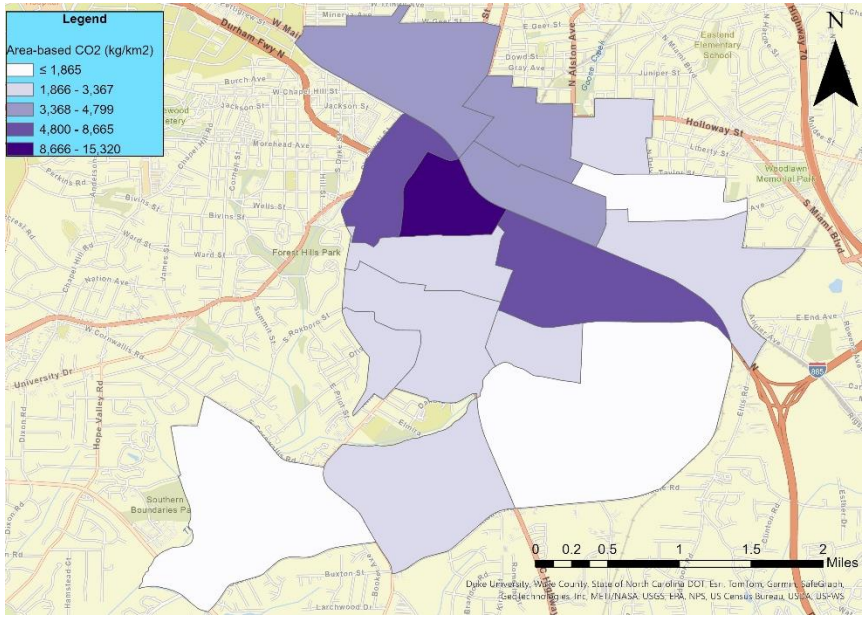
(a) Year 2023 (b) Year 2030

Figure 7-4. Estimated evening rush hour carbon dioxide (CO_2) emissions by 16 census block areas in the Hayti community for: (a) Year 2023; (b) Year 2030; (c) Year 2040; and (d) Year 2050.

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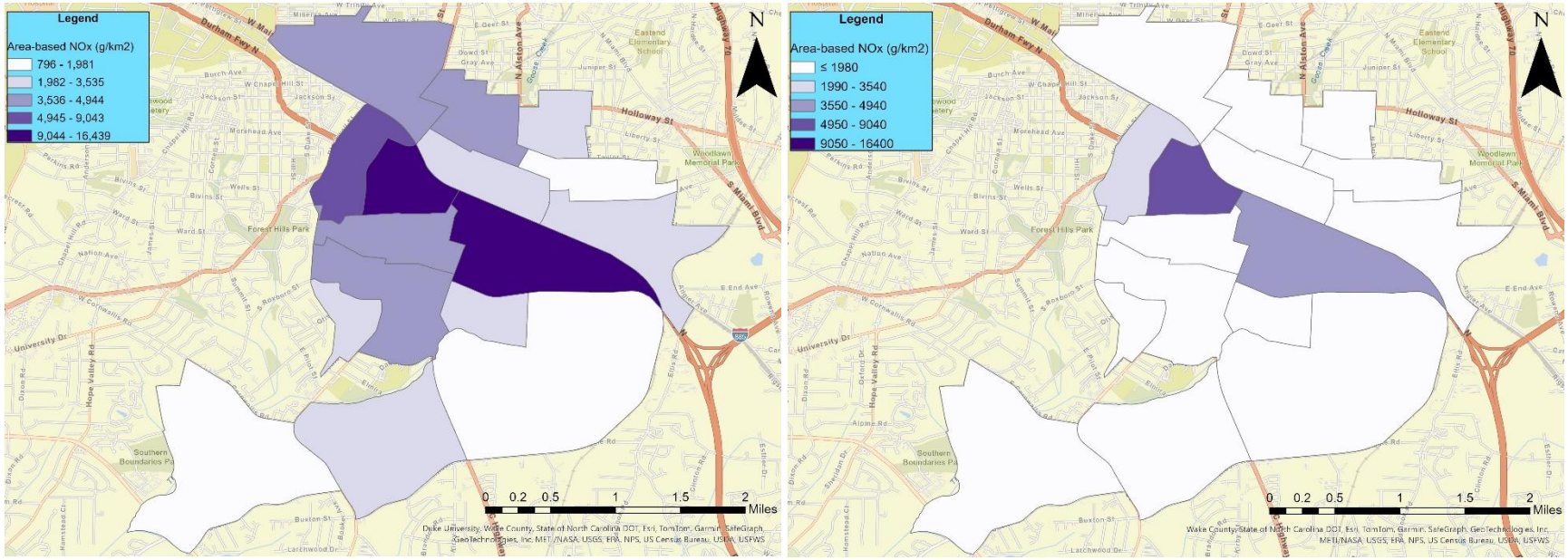


(c) Year 2040



(d) Year 2050

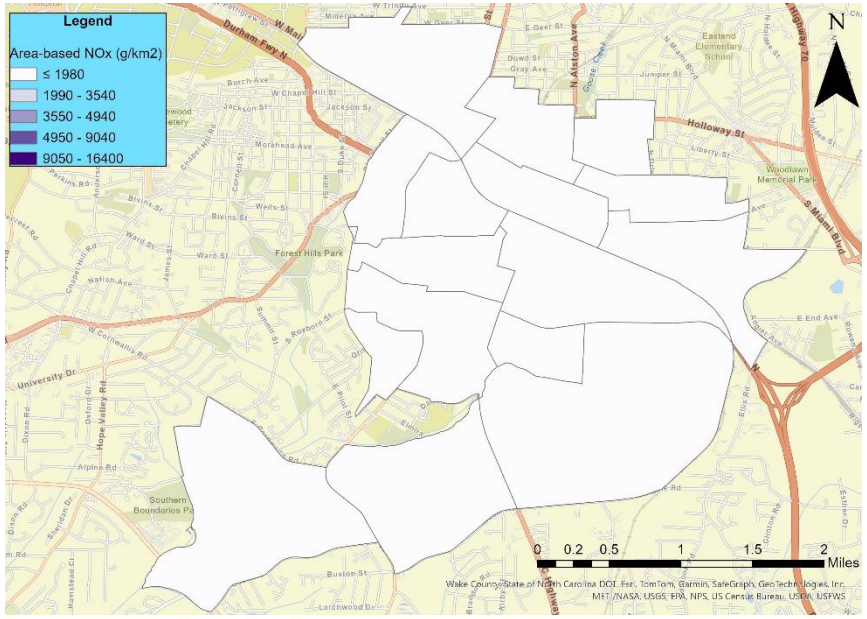
Figure 7-4. Continued.



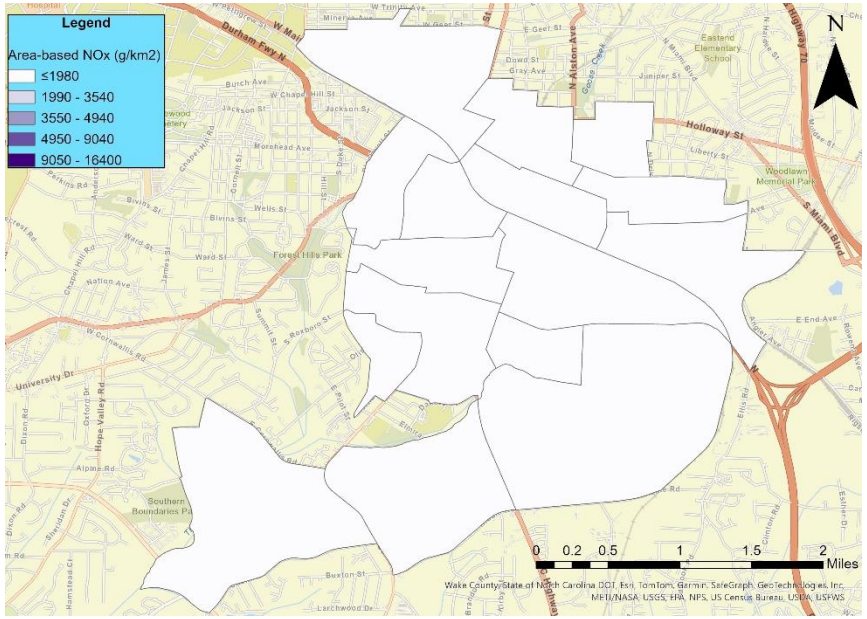
(a) Year 2023 (b) Year 2030

Figure 7-5. Estimated evening rush hour nitrogen oxides (NO_x) emissions by 16 census block areas in the Hayti community for: (a) Year 2023; (b) Year 2030; (c) Year 2040; and (d) Year 2050.

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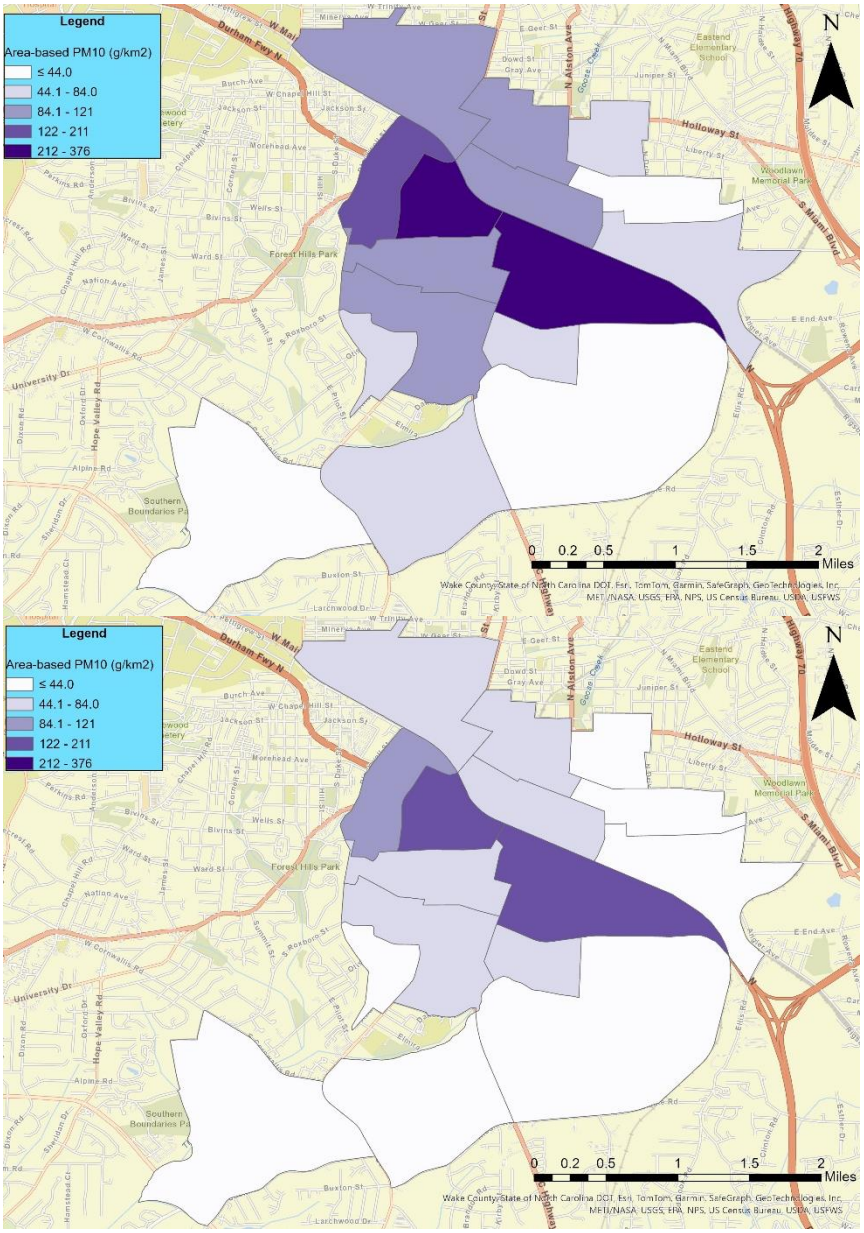


(c) Year 2040



(d) Year 2050

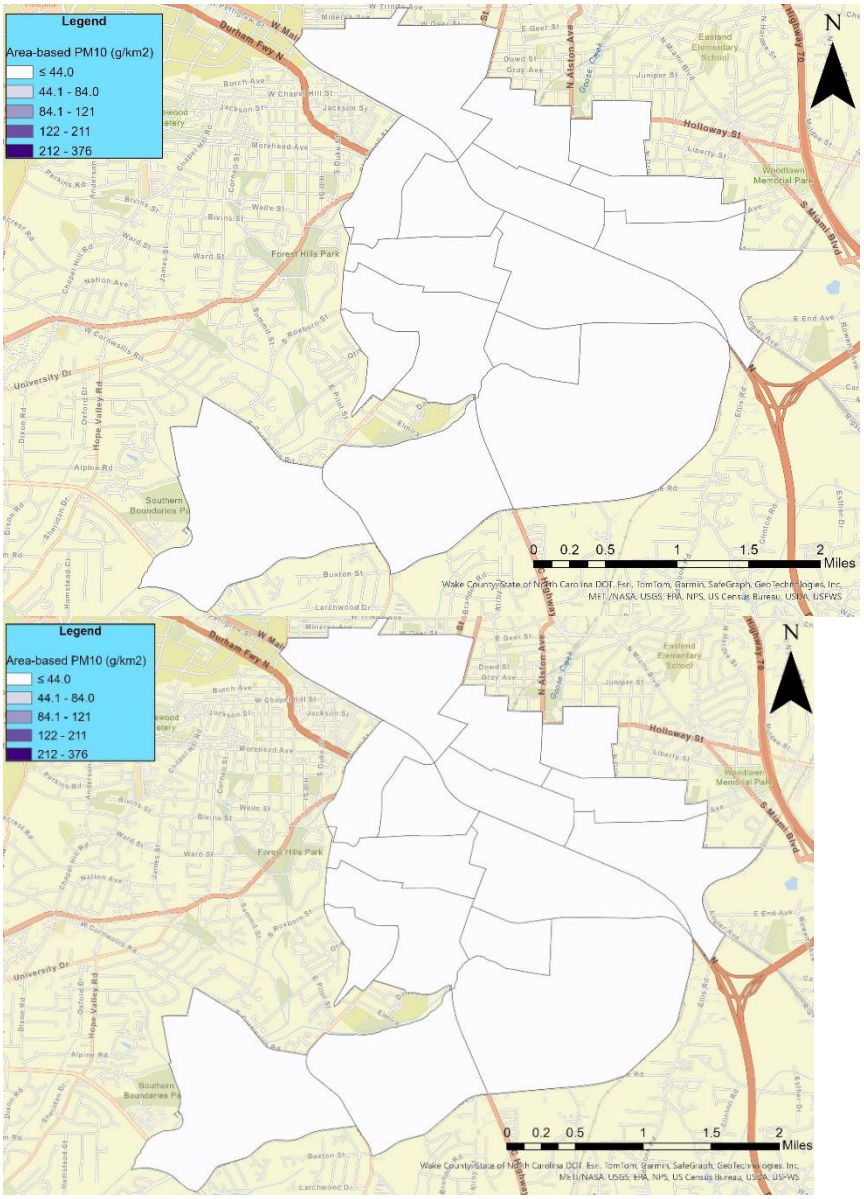
Figure 7-5. Continued.



(a) Year 2023 (b) Year 2030

Figure 7-6. Estimated evening rush hour particulate matter (PM) emissions by 16 census block areas in the Hayti community for: (a) Year 2023; (b) Year 2030; (c) Year 2040; and (d) Year 2050.

Continued on next page.



(c) Year 2040 (d) Year 2050

Figure 7-6. Continued.

Appendix 8: Public Engagement Presentation

This appendix details the Public Engagement Presentation titled "Environmental Justice & Historical Transportation Impacts in North Carolina." Designed with the general public in mind, this presentation aims to foster meaningful engagement by making complex topics accessible to all attendees. The presentation employs straightforward language to ensure comprehensibility and engage a broad audience effectively.

The content centers around three case studies developed in this project that illustrate the impact of transportation infrastructure on communities across North Carolina. These studies highlight not just the challenges faced but also the efforts made towards integrating Environmental Justice goals into future infrastructure projects. Each slide within the presentation is supplemented with speaker notes, providing context and guidance to ensure the presenter can convey the information effectively and engage the audience in a constructive dialogue. To enhance accessibility, all figures included in the presentation are equipped with alt text, making the content more accessible to individuals with visual impairments.

The editable PowerPoint presentation with speaker notes is enclosed in the report, allowing for customization as needed to suit specific audiences or to update content based on the latest findings and community feedback. The presentation slides are provided in the following.

NORTH CAROLINA
Department of Transportation



Environmental Justice & Historical Transportation Impacts in North Carolina

May 24, 2024

1

Agenda

- Purpose
- Environmental Justice: Background & Context
- Three Case Studies in North Carolina
  - Hayti Community
  - Princeville Community
  - Burton Street Community
- Current Trends
- Future Directions
- Conclusion

2

Purpose

- Explore the historical impact of transportation infrastructure projects on communities across North Carolina.
- Utilize insights from three case studies to advance Environmental Justice goals in future infrastructure projects.
- Communicate findings and encourage meaningful public egagement.



Source: NoHat.cc

3

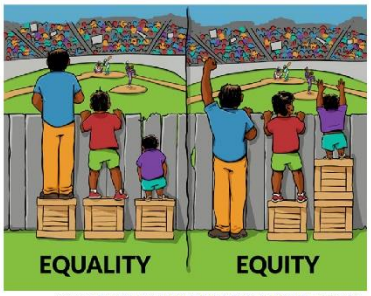
What is Environmental Justice?

- Environmental Justice:
  - The just treatment and meaningful involvement of all people, regardless of **income, race, color, national origin, Tribal affiliation, or disability**, in agency decision-making and other Federal activities that affect human health and the environment [10].
- Goals:
  - Equitable access to a healthy, sustainable, and resilient environment.
  - Fully protected populations from disproportionate and adverse human health and environmental effects and hazards [10].

4

Frequently Used Terms

- **Equity**
  The consistent and systematic fair, just, and impartial treatment of all individuals, including individuals who belong to underserved communities.
- **Disproportionate Impact**
  Situations where there exists significantly higher and more adverse health and environmental effects on minority populations, low-income populations, or indigenous peoples.
- **Meaningful Engagement**
  Providing timely opportunities for the public to share information or concerns and participate in the decision making process. It is essential to fully consider public input as part of the decision making process [10].



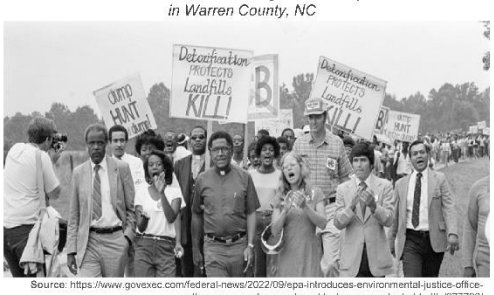
Source: https://interactioninstitute.org/illustrating-equality-vs-equity/

5

Environmental Justice Framework

- **Historical Framework:**
  - The concept of Environmental Justice is rooted in decades of community action and arose from the justice movement [9].
- **Legal Framework:**
  - 1994: Executive Order 12898 [3]
  - 2021: Executive Order 14008 [4]
  - 2021: Bipartisan Infrastructure Law (2021) [6], Justice40 Initiative (2021) [7]
  - 2022: NC Executive Order 246 [11]

1982 Environmental Justice Protests Against a Dump for Toxic Waste in Warren County, NC



Source: https://www.govexec.com/federal-news/2022/09/epa-introduces-environmental-justice-office-mother-movement-remembers-black-women-who-led-battle/377760/

6

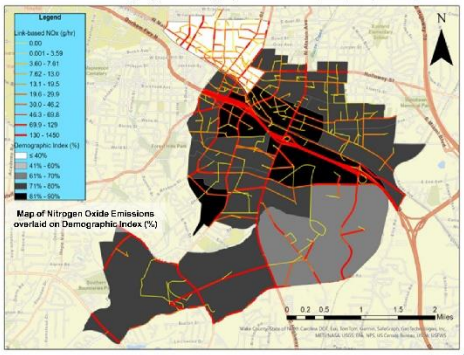
Environmental Justice in Transportation

- **Disproportionate Exposure to Pollution:**
  - Many communities of color and low-income families live near areas where pollution from vehicles and engines is abundant [10].



Source: https://www.ucsusa.org/resources/vehicles-air-pollution-human-health

In Hayti Community, Durham NC:
Areas with higher levels of nitrogen oxide correlate strongly with regions characterized by higher demographic indices of race and poverty



Environmental Justice in Transportation

- **Disproportionate Impact from Infrastructure Development:**
  - Historical transportation projects, such as highway constructions, have often disrupted underserved communities by dividing neighborhoods and exacerbating social and environmental disparities [13].

Home Demolished During Development of NC-247



Source: https://www.p...cdn150.o/wp-conte/uploads/2018/03/DH_Fayetteville_demolition.jpg

Flooding in Princeville, NC following Hurricane Floyd



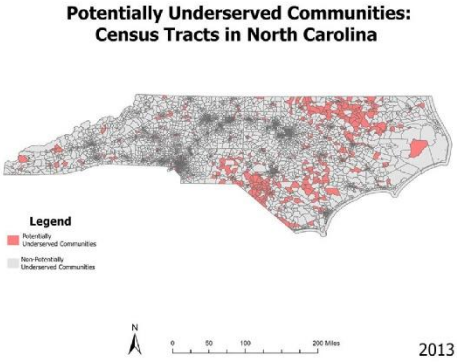
Source: https://openrivers.lib.umn.edu/article/princeville-and-the-environmental-landscape-of-race/

Historical Context: State Level

- **Potentially Underserved Communities (PUCs)** [14]

  According to NCDEQ, PUCs:

  - **Racial/Ethnic composition:** Share of nonwhites and Hispanic or Latino (of any race) is over fifty percent OR Share of nonwhites and Hispanic or Latino (of any race) is at least ten percent higher than County or State share. AND
  - **Poverty rate:** Share of population experiencing poverty is over twenty percent AND Share of households in poverty is at least five percent higher than the County or State share



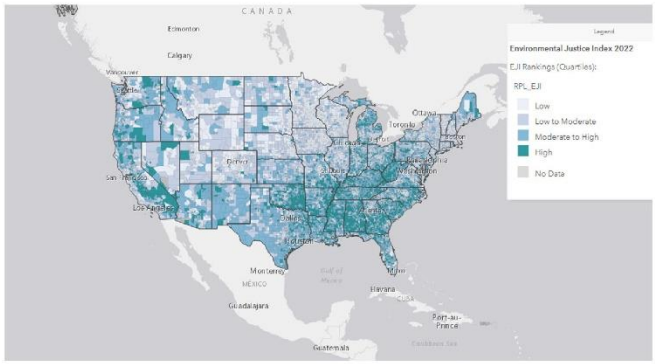
Source: UNC Charlotte, NCDEQ, American Community Survey

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Historical Context: National Level

- Not a North Carolina specific problem.
- CDC EJ-Index.
- USDOT & Justice-40 Initiative [7].

CDC's Environmental Justice Index at the National Scale



Source: https://www.atsdr.cdc.gov/placeandhealth/eji/index.html

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Case Study 1: Hayti Community



- **Background**
  - Black Wall Street.
  - 200+ black-owned businesses.
  - White Rock Baptist Church.
- **Redlining/NC-147 Development**
  - Lack of financial investment.
  - 4,000 families displaced.
  - 500 businesses destroyed.
- **Lasting Impact**
  - Increased exposure to pollutants such as Nitrogen Oxides.
  - Risk of gentrification.

*Hayti Community in **1950***



*Hayti Community in **1972***



Sources: https://www.bullcity150.org/uneven_ground/dismantling_hayti/

Discover the Interactive Story Map of the **Hayti Community**

https://go.ncsu.edu/haytistorymap

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Case Study 2: Princeville Community



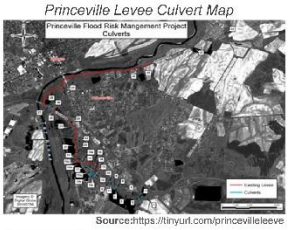
- **Background:**
  - Founded by freed African-American slaves.
  - Located in low-lying land along the Tar River.
- **Flooding:**
  - 10+ major flooding events over the past 100 years.
  - Levee Constructed in 1960.
  - Construction of US Highway 64 compromised levee in the 1990's.
- **Today:**
  - FEMA allocated $40 Million for levee improvements.
  - State provided a 54-acre site to relocate vital town services.

Princeville Before & After Hurricane Matthew



Source: https://tinyurl.com/matthewprinceville

Princeville Levee Culvert Map



Source:https://tinyurl.com/princevilleleeve

Discover the Interactive Story Map of the **Princeville Community**

https://go.ncsu.edu/princevillestorymap

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Case Study 3: Burton Community



- **Background:**
  - Located in West Asheville.
  - First NCAAP Chapter in NC.
  - Agricultural Fair 10,000+ Attendees.
  - Semi-Professional Baseball Team.
- **Redlining/I-240 Development:**
  - Decrease Investment.
  - Increase Crime.
  - Displaced Residence/Connectivity Fractured.
- **I-26:**
  - Goals: Ease Traffic, Connect I-26, I-240, I-40.
  - Community Engagement.
  - Slow Process.

Burton Street and Westwood Place Communities Fractured by I-240



Participants at I-26 Community Design Workshop, January 2010



Source: https://www.mountaintrue.org/wp-content/uploads/2011/08/burton_plan_-small.pdf

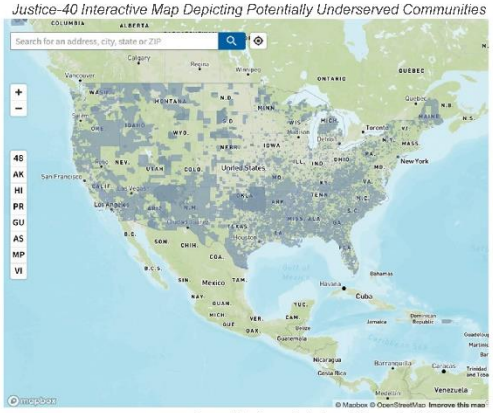
Discover the Interactive Story Map of the **Burton Community**

https://go.ncsu.edu/ashevillestorymap

Current Trends: Justice 40

- **Federal:**
  - Executive Orders 14008 and 14906 [4].
  - 40% of the overall benefits of certain Federal climate, clean energy, affordable and sustainable housing, and other investments flow to disadvantaged communities that are marginalized by underinvested and overburdened by pollution [7].
- **USDOT Goals:**
  - Prioritize Investments.
  - Measure Impact and Improve Effectiveness.
  - Strengthen Communities.

Justice-40 Interactive Map Depicting Potentially Underserved Communities



Source: https://screeningtool.geoplatform.gov/en/#3/33.47/-97.5

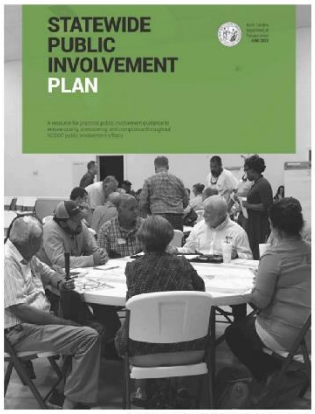
Advancing Equitable Transportation

- Acknowledgement:
  - Recognize that low-income and minority populations have been historically underrepresented in the transportation decision-making process.
  - These populations have been underserved and harmed as a result of transportation outcomes.
- Commitment:
  - We are committed to Environmental Justice and Equity and have developed a proactive approach to ensuring that transportation projects and decisions are carried out with these values at the forefront.
- Proactive Approach:
  - Public Education:
    - Provide essential and objective information about transportation projects, alternatives, and the decision-making process to the public.
  - Build relationships with communities/stakeholders.
  - Specialized public engagement.
  - Incorporating public feedback in transportation decisions.

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Conclusion

- **Environmental Justice Background**
- **History of Past Injustices in NC:**
  - Hayti
  - Princeville
  - Burton Street
- **National Level Policies**
  - Justice-40
  - Executive Order 12898
  - Executive Order 14008
- **State Level Policies**
  - Advancing Equitable Transportation
  - Statewide Public Involvement Plan



Source: https://www.ncdot.gov/projects/public-involvement/Documents/statewide-public-involvement-plan.pdf

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