AN ANALYSIS OF LAND USE PLANNING AND EQUITY ISSUES SURROUNDING HAZARDOUS LIQUID AND NATURAL GAS TRANSMISSION PIPELINES IN NORTH CAROLINA

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Abstract

Anna Christine Osland: AN ANALYSIS OF LAND USE PLANNING AND EQUITY ISSUES SURROUNDING HAZARDOUS LIQUID AND NATURAL GAS TRANSMISSION PIPELINES IN NORTH CAROLINA
(Under the direction of Dr. Daniel Rodríguez)

Hazardous liquid and natural gas transmission pipelines have received limited attention by planning scholars even though local development decisions can have broad consequences if a rupture occurs. In this dissertation, I evaluated the implications of land-use planning for reducing risk to transmission pipeline hazards in North Carolina via three investigations.

First, using a survey of planning directors in jurisdictions with transmission pipeline hazards, I investigated the land use planning tools used to mitigate pipeline hazards and the factors associated with tool adoption. Planning scholars have documented the difficulty of inducing planning in hazardous areas, yet there remain gaps in knowledge about the factors associated with tool adoption. Despite the risks associated with pipeline ruptures, I found most localities use few mitigation tools, and the adoption of regulatory and informational tools appear to be influenced by divergent factors. Whereas risk perception, commitment, capacity, and community context were associated with total tool and information tool use, only risk perception and capacity factors were associated with regulatory tool use.

Second, using interviews of emergency managers and planning directors, I examined the role of agency collaboration for building mitigation capacity. Scholars have highlighted the potential of technical collaboration, yet less research has investigated how inter-agency collaboration shapes mitigation capacity. I identify three categories of technical collaboration, discuss how collaborative spillovers can occur from one planning area to another, and challenge the notion that all technical collaborations result in equal mitigation outcomes.

Third, I evaluated characteristics of the population near pipelines to address equity concerns. Surprisingly, I did not find broad support for differences in exposure of vulnerable populations. Nonetheless, my analyses uncovered statistically significant clusters of vulnerable groups within the hazard area. Interestingly, development closer to pipelines was newer than areas farther away, illustrating the failure of land-use planning to reduce development encroachment.

Collectively, these results highlight the potential of land-use planning to keep people and development from encroaching on pipeline hazards. While this study indicates that planners in many areas address pipeline hazards, it also illustrates how changes to local practices can further reduce risks to human health, homeland security, and the environment.

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1 Introduction

The 380,000 mile transmission pipeline network transports vast quantities of natural gas and hazardous liquids, such refined and unrefined petroleum products, across the United States in large diameter pipes. Hazardous liquid transmission pipelines transport more than 64% of the transportation energy needs for the United States (PHMSA Pipeline Safety Program 2010) and 40% of the total U.S. energy consumed (PHMSA Pipeline Safety Program 2005c). Natural gas pipelines supply 24% of the total U.S. energy products consumed (PHMSA Pipeline Safety Program 2005c). The Energy Information Administration (2006, 65) calculated that between 2005 and 2030, dependence on natural gas will increase 20 percent and dependence on petroleum will increase 34 percent. The higher demand for products delivered by transmission pipelines led the National Petroleum Council to estimate that construction of 38,000 new miles of natural gas transmission lines will be necessary by 2015 to keep pace with demand for natural gas (Transportation Research Board 2004, 19).

The U.S. General Accounting Office (2002, 5) estimated that transmission pipelines are the most secure method of transporting hazardous liquids; pipeline operator error and accidents are fewer than for any other means of transportation (e.g., freight, rail, barge) for hazardous liquids and natural gas. In fact, over 750 tanker truck loads per day would be required to replace one “modest” transmission pipeline, thereby requiring additional risk for drivers and handlers, potential environmental spills, and other losses (Transportation Research Board 2004, 20).

Nevertheless, accidents from transmission pipelines place those within hazards zones at risk should an accident occur. Current land use practices surrounding pipelines vary by community. There are no federal government regulations or suggested legislation available to guide local governments (Cooper 2003). Accidents within urban areas were almost twice as likely to be categorized as "severe" as incidents occurring within rural areas (Transportation Research Board 1988, 17). However, all types of accidents have important implications for both human health and the environment.

Managing land uses in hazardous areas is a task that planners frequently grapple with. Planning scholars have noted the difficulties in inducing local governments to address hazard mitigation (Berke 1998; Burby 2005; Burby & Dalton 1994; Burby & May 1997). One gap is between a community's interest in addressing hazard mitigation and application of resources to accomplish that goal. While several studies have been conducted on how mandates improve planning in hazardous areas (Berke et al. 1996; Burby & May 1997), less research has addressed the factors that induce hazard mitigation planning for hazards that lack a mandate and occur infrequently.

Given the challenges of addressing hazard mitigation for hazards that transect jurisdictional boundaries, scholars have suggested collaborative approaches can build support for long-term policies and practices. However, there is disagreement on how collaboration should occur. Some argue that collaborative planning practices require full stakeholder input to build a lasting consensus (Innes 2004). Others suggest that in the absence of a large disaster event, lack of stakeholder interest in hazard mitigation issues makes generating full stakeholder support difficult (Birkland 1998). Given limited stakeholder interest in hazard mitigation, Pearce (2003, 220) argued that while full-stakeholder consensus-based approaches are appropriate, they are not always feasible. In light of this challenge, scholars have suggested that technical collaborations among groups like planners and emergency managers could provide appropriate support for generating mitigation practices (Godschalk et al. 1998; Pearce 2003, 220). Nevertheless, limited research has categorized the types of collaborations between these groups or characterized how well these collaborations can build capacity for mitigation.

Finally, advocates of social justice point to unequal distribution of risk from hazards. While differences in equality of access to amenities (Hewko et al. 2002; Landry & Chakraborty 2009; Talen & Anselin 1998) and hazards (Anderton et al. 1997; Baden et al. 2007; Fothergill & Peek 2004) stem from various causes, planners have both the opportunity and an obligation to address inequity in their community (Feitelson 2002; Thomas 1996; Thomas & Ritzdorf 1997b).

1.1 Overview and research objectives

The aim of this research is to evaluate how land use planning can reduce risk to transmission pipeline hazards. In order to accomplish this aim, I assess the techniques planners use to mitigate pipeline hazards, investigate how partnerships can build capacity to mitigate pipeline hazards, and explore the characteristics of the communities surrounding transmission pipelines in North Carolina. I consider the following objectives:

1) Identification of the most frequently used tools to address pipeline hazards
2) Examination of the factors contributing to tool adoption
3) Evaluation of factors influential to adoption of different types of policies
4) Description of how collaboration improves knowledge about transmission pipelines
5) Characterization of who lives near the transmission pipeline in North Carolina

6) Assessment of whether vulnerable populations have disproportionate risk from pipeline hazards

1.2 Research implications and contributions

Given the challenges to hazard mitigation and land use planning in hazardous areas, the results of this research have implications for policy, practice, and planning scholarship. First, this research adds to ongoing discussions among land use planning scholars regarding factors contributing to mitigation of hazards and regarding factors influencing growth management. Second, the findings can be generalized to other types of technological hazards. Moreover, given the national interest in, but challenges to protection of critical infrastructure (Clark & Deininger 2000; Gerber et al. 2005; Moteff & Parfomak 2004), the findings are applicable for policymakers considering protection of critical infrastructure and for scholars studying the factors associated with local decisions regarding critical infrastructure management.

Within the disciplines of both planning (Godschalk 2003) and emergency management (Britton 2002) scholars have noted the value of collaboration for long-term hazard mitigation. Pearce (2003, 226) argued that sustainable hazard mitigation requires the integration of emergency management and planning. However, little research has classified the types of collaborations or how specific kinds of collaborations achieve mitigation goals. This research provides evidence that collaboration across disciplines can influence mitigation. I categorize three types of partnerships that planners and emergency managers draw on and discuss how these collaborations build capacity for addressing pipeline hazards.

This research is one of few studies that measure characteristics of people living near pipeline hazard areas. The findings provide policy makers and planners with information about the population living near transmission pipelines in North Carolina. These results suggest that block-groups closer to transmission pipelines were more likely to contain residential construction that was more recently built, a smaller percent impoverished population, and a lower percent minority population than block-groups at a greater distance from transmission pipelines. However, there exist pockets of clustered block-groups that contain high proportions of vulnerable populations such as renters, African-American, and lower-income groups.

1.3 Organization

The remainder of the dissertation is divided into six chapters. The second chapter begins by discussing planning in areas with transmission pipelines. This section describes the implications for planning should an accident occur. I specify the roles that federal government and local communities play in regulating areas with transmission pipelines. Chapter three I highlight the regulatory, incentive, and information tools that land use planners can use to address pipeline hazards, review literature on growth management in hazardous areas, and propose a conceptual framework for the dissertation. The next three chapters each describe a distinct area of research and analysis. In the fourth chapter, I identify the most commonly used tools and I draw on statewide survey data to investigate factors associated with pipeline mitigation tools in North Carolina. Chapter 5 examines the role of collaboration for improving capacity to address transmission pipeline hazards. This chapter relies on interviews with planners and emergency mangers in the Greensboro-Winston-Salem metropolitan area. In the sixth chapter, I rely on 2000 Census block-group data to examine population characteristics in areas near transmission pipelines. For chapters four through six I detail the research design, study area, data collection, and analysis used at the beginning of the chapter. The remainder of each chapter describes the findings and conclusions. The final chapter, chapter 7, summarizes the contributions of the research, highlights the implications for policy and practice, and provides recommendations for future research.

2 Planning surrounding hazardous liquid and natural gas transmission pipelines

The USA Patriot Act identifies hazardous liquid and natural gas transmission pipelines as critical transportation infrastructure and deserving of additional security considerations (Public law 107-56 *USA Patriot Act* 2001) The approximately 180,000 miles of natural gas and 200,000 miles of hazardous liquid transmission pipelines range from 2 to 42 inches in diameter (PHMSA Pipeline Safety Program 2005a, 2005b). Transmission pipelines carry over 35 different hazardous products such as refined and unrefined petroleum products, home heating oil, and natural gas (PHMSA Pipeline Safety Program 2005d). Since September 11, 2001 the federal government has logged multiple terrorist threats against transmission pipelines (Parfomak 2006, 3). However, rupture is more likely to be caused by other factors; terrorist attacks do not even register as a cause of pipeline failure by the Office of Pipeline Safety. Regardless of the source of the accident, transmission pipeline ruptures can have a major impact on humans, the environment, and local and regional economies.

Understanding local land uses and human exposure near transmission pipelines has implications regardless of what triggers the rupture. Inappropriate development, such as high-density housing, would be equally affected given a rupture due to a terrorist attack, nearby excavation, or pipeline corrosion. While the federal government has studied protection of transmission pipelines from terrorist acts (Mead 2001; Parfomak 2006, 7), according to the Transportation Research Board (2004), research evaluating the role of local land use planning near pipelines is limited. Hazard mitigation, defined by Godschalk (2003, 136) as “action taken to reduce or eliminate long-term risks to people and property from hazards and their effects," has the potential to decrease the risk of pipeline hazards. Local land-use planning plays a strong role in terrorism hazard mitigation (Godschalk 2003, 138) and in mitigation of risk from other types of hazards (Burby et al. 1999). Mileti (1999, 155) maintains that "no single approach to bringing sustainable hazard mitigation into existence shows more promise at this time than increased use of sound and equitable land-use management". Given that land-use planning decisions are historically decided at the community-level, local choices have a large impact on pipeline security and community safety.

2.1 Pipeline accidents and planning implications

A 1988 Transportation Research Board report noted that "because development has not yet intruded on most transmission pipelines, land use measures offer an important opportunity for preventive action" (Transportation Research Board 1988, 5). Given that urban areas expanded greatly in many areas of the country since the 1988 report (Fulton et al. 2001), it is likely that many pipelines have more development nearby than they did in 1988. In spite of this expansion of risk, the Transportation Research Board (2004) found little research documenting the types of tools local planners use to reduce development encroachment on transmission pipelines.

Pipeline ruptures highlight the role of local decisions. A recent evaluation of transmission pipeline incidents from 2002-2005 found statistically significant temporal and spatial variability for pipeline rupture for both hazardous liquid and natural gas transmission pipelines (Simonoff et al. 2008).[1] Outside-force accidents, such as damage by third-party excavation, have historically been one of the most common causes of pipeline accidents. For

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[1] Incidents are reported separately for natural gas transmission pipelines and hazardous liquid transmission pipelines. Reporting requirements for transmission pipelines began in 1971 and changed in 1986 and 2002.

natural gas transmission pipelines during the 2002-2007 years, the top causes of rupture were vehicular damage and third-party excavation (Simonoff et al. 2008, 388). Between 1986 and 2001, damage caused by outside force accounted for over 27% of all onshore hazardous liquid transmission pipeline events (PHMSA Office of Pipeline Safety 2005). Eighty-percent of the outside force incidents during this time were caused by third-party damage. For natural gas incidents during this same period, 34% were caused outside force damage.[2] Outside force accounted for 40% of all gathering and transmission line accidents between 1971-1985 (Transportation Research Board 1988, 8). A large number of accidents caused by damage from excavators or third parties suggest that new development near pipelines could play a role in pipeline ruptures and highlight the importance of land use planning for areas surrounding pipelines.

Pipeline accidents have caused on average few fatalities; however, a single incident can have devastating consequences for the environment, individual communities, and local economies. Acute ruptures illustrate the potential damage from construction. A 1993 rupture of a 36-inch pipeline in Reston, Virginia caused the release of 407,700 gallons of diesel fuel into a nearby creek. The pipeline rupture caused threats to the quality of drinking water for Northern Virginia, Maryland, and the District of Columbia. The National Transportation Safety Board (2004, 15) concluded that the likely cause of the pipeline crack and subsequent rupture was construction of a nearby medical complex where over 200 contractors had worked in the previous year. An accident in Bellingham, Washington caused three deaths, eight injuries, over $45 million in property damage, and significant environmental damage (NTSB 2002, 1). Pipeline damage by a contractor during construction of a water-treatment

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[2] For natural gas incidents the outside force damage category is not broken-down into specific types.

plant and operator error were factors affecting the subsequent rupture (NTSB 2002, 18; U.S. General Accounting Office 2000). Two accidents near Fredericksburg, Virginia caused the city to lose its water supply for a week in 1980 and again in 1989. Even though neither of the Fredericksburg accidents caused fatalities, the environmental and public health consequences were enormous (Pates 1996a, 1996b). Both Fredericksburg accidents occurred miles outside the City of Fredericksburg, but upstream from the City's water supply reservoir illustrating regional consequences of pipeline ruptures.

A recent accident in San Bruno, California indicated the relevance of planning near transmission pipelines. The pipeline rupture released over 47 million standard cubic feet of natural gas resulting in a fire that destroyed 37 homes, killed 8 people, and injured scores more (NTSB 2010). While the cause of the accident is still under investigation by the National Transportation Safety Board (2010), the accident's repercussions indicated the importance of planning in areas with pipelines hazards. According to the Associated Press, the accident involved a pipeline installed in the 1950s, prior to development of the densely populated subdivision that surrounded it (Burke & Dearen 2010). Land use planning decisions regarding the location and density of homes that surrounded the 30-inch pipeline apparently post-dated the installation of the pipeline.

In addition to acute accidents, long-term chronic spills also have human health and environmental implications. Chronic hazards can cause contaminated drinking water and long-term environmental damage. Neighborhoods surrounding tank farms, the locations of large storage tanks which hold transmission pipeline products for redistribution into smaller pipelines, have had critical concerns regarding ground water contamination and harmful air emissions (Reddic & Cuykendall 1995). Chronic spills near Charlotte, NC in the 1990s

(Sherrill et al. v. Amerada Hess Corporation et al. 1995) and in North Carolina, Georgia, and Virginia from 2000-2006 (Ames & Young 2008) were the subject of lawsuits against several pipeline and tank farm operators. The defendants in the Sherrill case argued that chronic spills caused damage through leaks, spills, and emissions (Sherrill et al. v. Amerada Hess Corporation et al. 1995). However, these types of claims have been largely unsuccessful as class action lawsuits due to difficulties classifying damage at the group level (Vennos & Ray 2006), and as individual lawsuits due to limited household resources.

Consequences for human lives and the environment are not the only effects of pipeline accidents; reduction in pipeline-transported goods can have economic impacts as well. Hurricane Katrina illustrated the reliance of local economies on pipeline products. Gas prices in the Eastern United States jumped by as much as $0.65/gallon in the wake of Hurricane Katrina due to reduced amounts of products transported through East Coast transmission pipelines (Federal Trade Commission 2006).

2.2 Planning approaches to addressing pipeline hazards

Management of transmission pipelines hazards can be divided into the following two areas: (1) the pipeline; and (2) the land uses surrounding the pipeline. The federal government regulates transmission pipeline construction, design, maintenance, personnel, and inspections (49 CFR 192, 195). Federal authorities have prevented attempts by state and local governments to impose additional safety requirements, regulate pressure, or control contents of interstate pipelines due to concerns about interference with interstate commerce (Pates 1996a, 10-16). State governments can obtain authority to regulate intrastate pipelines as long as the state requirements meet minimum federal inspection regulations, are compatible with regulations from the U.S. Office of Pipeline Safety, and the state is a certified agent for inspections and administrative duties (Noll & Hildebrand 2004, 25; Transportation Research Board 2004, 26).

Management of development near transmission pipelines has the potential to address inappropriate development, yet federal regulations do not control land uses within close proximity of transmission pipelines. Authority for managing pipeline hazards rests largely with local governments who manage land uses surrounding transmission pipelines with powers bestowed from individual states through enabling statues or regulation (Juergensmeyer & Roberts 2003, 47-49). Thus, although the same pipeline crosses multiple jurisdictions, varying land use management practices surround the pipeline.

Growth management and control techniques implemented by local governments provide one of the most important areas where changes could prevent harm to humans and the environment from transmission pipeline rupture. However, local limitations may reduce effectiveness of growth management in areas with pipeline hazards. Many communities find hazards associated with transport corridors more difficult to address than fixed-facility hazards (Andrews 1987; Rogers & Sorensen 1989, 57-58). Therefore the Transportation Research Board's (2004, 12) calculation that pipeline accidents occur "almost daily" is perhaps not surprising. Yet, according to the Executive Director of the Association of Oil Pipelines (Cooper 2003, 3), "there is no recognized national standard reference to guide decision making by local boards, councils, or individual officials responsible for the public interest." In spite of these difficulties, land use planning and growth management techniques play a key role in reducing vulnerability to hazards (Burby et al. 1999).

3 Land use management in hazardous areas

Communities use growth management tools to achieve the type of development appropriate for their community based on their abilities and interests. Management of development is both a technical and political process (Berke, Godschalk et al. 2006, 449). While communities use growth management to address various long-range community goals and changes, it can also reduce inappropriate development in hazardous areas. Burby and May (1997, 116) observe that "reducing or mitigation human and property losses inevitably involves the management of the physical development of a community. Such management applies both to public infrastructure and to private development."

Communities have a variety of policy tools available to address development changes. Although this research does not quantify effectiveness of the available tools, understanding the factors that predict tool use can help decision makers encourage policies that promote active management until a future study can determine each tool's value. Likewise, understanding the characteristics of communities that adopt specific classes of policies can help state or national-level policymakers target aid to communities most in need of assistance.

Growth management programs generally consist of a mix of regulatory, incentive, and informational/educational strategies (Bengston et al. 2004; Burby & May 1997, 123; Kaufmann-Hayoz et al. 2001; Olshansky & Kartez 1998, 170; Schwab 1998, 117). Under a regulatory approach, local governments use tools such as zoning, special ordinances, or building setback requirements to control growth near transmission pipelines at the community-level. Using an information approach, jurisdictions expect developers and individual landowners to use publically available data, such as easements, maps, or deed restrictions, to identify locations of transmission pipelines. With the information approach there is an assumption that the development review process will highlight and address pipeline hazards at the site-level. Local governments use incentives to encourage developers and landowners to apply alternatives to development in hazardous areas. Incentives can be applied at either the community or site-levels.

Planning scholars have studied factors that influence adoption of growth management tools for various purposes. This chapter first describes land use tools appropriate for managing land use near transmission pipeline hazards, then goes on to discuss influences to adoption of growth management tools generally. Drawing from the literature, the chapter concludes with a discussion of a conceptual model that to addresses growth management in areas with transmission pipeline hazards.

3.1 Description of tools to mitigate pipeline hazards

I identified land-use planning tools appropriate for mitigating pipeline hazards through a review of literature on growth management in hazardous areas, a non-profit pipeline damage prevention group booklet (Common Ground Alliance 2003), and pipeline regulatory documents (see Table 3.1). In this section I briefly discuss each tool and its application to transmission pipeline hazard mitigation. I categorize the types of tools into three categories- information, regulatory, and incentive tools.

Table 3.1, Public information, regulatory, and incentive policies for managing land use near transmission pipelines

Policies for managing land use near transmission pipelines
Public Information Tools
Areas subject to pipeline hazards identified with signs
Maps of transmission pipeline locations
Illustration of transmission pipeline easements on subdivision plats
Excavators required to notify state one-call center prior to beginning excavation
Transmission pipeline disclosure required in real estate transactions
Media campaign to alert people to the presence of pipelines
Regulatory Tools
Low-density zoning surrounding pipelines
Transmission pipeline zoning overlay district
Special transmission pipeline hazard ordinance
Fire resistance requirements in the building code
Minimum building setback requirements for buildings adjacent to transmission pipelines
Restrictions on the location of critical facilities near transmission pipelines (*e.g.*, fire and police stations, public schools).
Deed restrictions for property with pipeline easements
Watershed protection ordinance with provisions for transmission pipelines
Environmental impact statements for new developments near transmission pipelines
Berms and/or containment ponds adjacent to hazardous liquid pipelines
Mandatory open space dedication requirements
Incentive Tools
Density bonuses for moving development away from pipelines
Transfer of development rights from areas near transmission pipelines to less hazardous areas

3.1.1 Information tools

Information tools provide policy makers and citizens with information about pipelines, pipeline locations, and potential hazards. There are several information tools that involve identification of pipeline locations. Signs identifying locations of transmission pipelines are required of pipeline operators (49 CFR 192.707, 195.434), yet communities may or may not be aware of this information source or use it when making decisions about new development. Mapping and visualization tools play an important role pre-disaster mitigation planning (Deyle et al. 2008; Lovett et al. 1997; Morrow 1999; Wood & Good

2004). Use of maps help planning departments identify where pipelines are within the community. According to Haynes et al. (2007, 136) hazard location knowledge can change perception of hazard risk. In addition to community-scale map information, site-specific information such as an illustration of pipelines on a subdivision plat can provide specific information that impacts built environment decisions and long-term hazard vulnerability. Olshansky (2001, 179), however, indicated that maps of earthquake hazard zones did not necessarily induce higher quality development. In addition to identification of hazard areas, maps can be used to trigger additional review of potential development that falls within a hazard zone.

Other information tools can be tied to real estate. Required disclosure of pipeline locations or easements during real estate transactions provides new owners with information about areas of the property with potential hazards, reducing potential drawbacks of expired deed restrictions. Research by Palm (1981) on earthquake hazard disclosure revealed little impact on homebuyer preference. However, research on flood hazard disclosure by Troy and Romm (2004) indicated that disclosure of floodplain risk reduced home sales prices.

One-call centers are set-up at the state-level to provide anyone planning to dig near underground utility lines one phone number to call in order to locate all underground utilities. According to Noll and Hildebrand (2004, 31-32) state one-call centers act as an organizational agent for all owners of underground utilities in the area of the proposed excavation. The one-call center notifies all utility owners so they can mark the area where the utility is located within the proposed dig area.

The Common Ground Alliance (2003, 51-56), a non-profit organization dedicated to reducing underground utility damage, proposes education campaigns to reduce inappropriate excavation of transmission pipelines. These campaigns could include targeted mailings, various forms of advertising, and press releases.

3.1.2 Regulatory tools

One of the original purposes of land use regulation was to improve public health by keeping dangerous or noxious land uses away from residential areas (Burby & Okun 1983; Frank & Kavage 2008; Maantay 2001). A wide number of types of growth regulation tools are available to local governments. According to Perry and Haynes (1993, 92) governments have the ability to "exert pressure and enforce their requirements through planning, zoning, and permitting processes" near transmission pipelines. However, some tools may be more frequently used than others.

According to Maantay (2002b, 572) the most common tool for regulating land use is zoning. For transmission pipelines, higher density development near a pipeline puts more people at risk. Lower density zoning surrounding the pipeline can reduce potential risk to people regardless of type of pipeline rupture since fewer people will be located near the accident site. Schwab (2010, 48) states,

> Zoning ordinances are among the planner's most effective tools for limiting damage from hazards. They have the ability to restrict development in hazardous areas to land uses that will not suffer extensive disaster losses, and they can encourage growth in safe locations. They achieve this by specifying the location, type, amount, density, and characteristics of development permitted in mapped zoning districts.

Holway and Burby (1990, 211) found zoning permissiveness in floodplain areas to be statistically associated with potential for development within the floodplain. Special zoning overlay districts have been put in place for several natural hazards (Olshansky & Kartez 1998; Olshansky 2001; Schwab 2010, 48-49). According to Bengston and colleagues (2004, 278) low-density zoning has been effectively used to protect open space and environmental quality. However, lower density zoning practices have led to exclusion (Pendall 2000). Other zoning practices have resulted in minority and lower-income communities at higher risk from toxic hazards (Boone & Modarres 1999; Maantay 2001).

Zoning overlay districts with standards for development in the right-of-way would enact targeted zoning for specific hazard areas. Although pipeline rights-of-ways generally have restrictions on practices allowable within the right-of-way (Noll & Hildebrand 2004, 45), the age of many transmission pipeline easements affects the restrictions within the right-of-way. According to the Transportation Research Board (1988, 58) older easements "were quite general; they rarely stipulated appropriate land uses in the right-of-way and made little provision for removal of encroachments." A zoning overlay for the right-of-way can ensure appropriate development standards while allowing flexibility (Schwab 1998, 127). However, Stevens (2010, 367) noted potential for statistically significant variation in hazard overlays due to planner discretion.

Building and construction standards can help communities reduce vulnerability to the effects of pipeline hazards. Use of building codes and fire safety standards ensure development meets specific criteria to withstand hazards. Building standards have improved resistance to earthquake hazards (Olshansky 2001, 181) and flood hazards (Stevens et al. 2009). Burby (1998, 270) suggested that building or construction standards can be part of an overall approach to reducing community hazard vulnerability. However, lack of enforcement of building codes left many vulnerable to hurricane hazards in Florida during Hurricane Andrew (Olshansky & Kartez 1998, 187-188).

Restrictions on locations of buildings can keep them out of the hazard zone (Schwab 2010, 56). Restricting the location of facilities such as schools, fire and police stations, nursing homes or other important public facilities can reduce evacuation needs and keep important personnel out of hazard areas. Required setbacks for building within the coastal flood or erosion zone are common in coastal states (Deyle et al. 1998, 128). Communities often integrate restrictions for location of critical facilities into operation and comprehensive plans (Schwab 2010, 44,48). Additionally, Schwab (2010, 48) suggested that restrictions on new buildings built using capital improvement funds can redirect new critical facilities outside of hazard areas.

A variety of environmental protection regulations are available. Several pipeline ruptures have expelled hazardous liquids into nearby rivers and water supply reservoirs (NTSB 2002, 2007; Pates 1996a). Given the potential damage to a community’s water supply or to other fragile environmental areas from a pipeline accident, communities might enact a watershed protection ordinance that contains references to potential pipeline hazards, require environmental impact statements for development that could occur within close proximity to a pipeline, require use of containment ponds or berms to reduce pipeline runoff, or mandate open space dedication close to the pipeline with new developments. Local governments have used watershed protection ordinances to keep a variety of nuisances away from waterways inside the community and within extra-territorial jurisdiction areas (Tarlock 2002, 166-168). Required use of environmental impact statements is becoming commonplace (Steel & Lovrich 2000, 8). Steel and Lovrich (2000, 12) calculated that counties use environmental impact statements for both private and public projects. Berms and containment ponds are commonly put in place to address stormwater peak discharge (Berke et al. 2003, 408), but could also serve a second purpose of containing liquid pipeline spills. Open space dedication can be accepted in the form of a conservation easement (Godschalk et al. 1998, 90) or through a subdivision exaction (Juergensmeyer & Roberts 2003, 274).

Deed restrictions have been used for a variety of purposes, including restricting development near hazards. The City of Houston, Texas relies on deed restrictions and other information tools to manage land use in the absence of zoning (Qian 2010). However, Qian (2010, 39) noted that deed restrictions can expire or be ignored leading to minority and low-income residents living near landfills, heavy industry, and areas with high toxicity.

3.1.3 Incentives

Communities may offer incentives to developers to locate development away from undesirable areas. Density bonuses have been used for conservation of land (Pejchar et al. 2007) and can be adapted for mitigation of hazards. In addition, Schwab (2010, 53) illustrated that in the absence of actual incentives, local governments can write subdivision regulations with sufficient flexibility so as to promote induce clustering density for hazard mitigation purposes.

A transfer of development rights (TDR) from hazardous to non-hazardous areas is a way to reduce density in a hazardous area without infringing on a landowners right to develop. TDR involves creation of a sending (where lower density is desired) and receiving zone (where higher density is desired). According to Schwab (1998, 142) transfer of development rights are applicable to all hazards and administered in jurisdictions of many sizes across the U.S. However, Juergensmeyer & Roberts (2003, 376) note some jurisdictions encounter organizational limitations to using TDR programs such as impediments to creation of appropriate sending and receiving zones for development credits. In North Carolina, local governments are authorized by the General Assembly to use transfer of development rights or “severable development rights” (N.C. Gen. Stat. § 136-66.10 - .11). However, the statue authorizing this tool limits the use to pre-designated transportation right-of-ways rather than a broad application that could involve hazard mitigation.

3.2 Influences to growth management policies and practices

Research on growth management suggests that factors at various levels affect local decisions to address hazards. Federal, state, and community-level factors can influence community-wide policies and site-specific decisions. Porter (1997, vii) defines growth management as “public efforts to resolve issues and problems stemming from the changing character of communities”. Growth management encompasses activities that guide development activities and can be considered a process as much as the specific tools used for planning. According to Porter (1997, 12), “growth management should be viewed as a community’s collection of plans, programs, and regulations that will accomplish the community’s development objectives”. Nonetheless, these activities and techniques must be interconnected together to generate effective growth management (Porter 1997, 13).

Growth management policies and practices that address hazardous areas have a purpose beyond community character and development objectives; these policies and practices can reduce vulnerability to disasters. According to Godschalk and colleagues (1989, 23) under a development management approach “the type, location, rate, public cost, and quality of development and redevelopment within hazard areas are managed so as to promote sound urban patterns while reducing exposure of people and property to risks”. This section provides an overview to the influences to growth management in hazardous areas.

3.2.1 National influences

Growth management practices in hazardous areas are influenced by national policies. Platt (1999), in a review of federal reconstruction assistance for natural disasters, found that post-disaster federal relief with few strings attached undercut efforts to incorporate hazard mitigation and land use planning near natural hazards. Likewise, Burby and colleagues (1999, 247) note that federal policies addressing loss of life and property damage from natural disasters "have yet to recognize the importance of planning as the cornerstone of effective local hazard mitigation". Burby and colleagues assert that several federal programs, (e.g. the national flood insurance program that provides insurance for flood losses) encourage rather than discourage construction in hazardous areas. Land use planning, in these cases, is impaired by federal policies that suggest that an area is not hazardous. Since disaster mitigation planning often incorporates both natural and technological hazards simultaneously (Alexander 2005; Lindell & Perry 1992; Perry & Lindell 2003; Quarantelli 1992), the lack of impetus to mitigate natural hazards has repercussions for mitigation of technological hazards as well.

In addition to hazard relief policies, many other federal policies influence local land use planning. These policies have a variety of repercussions for local planning in hazardous areas. Kaiser, Godschalk, and Chapin (1995, 10) note, "Because of the complexity and competition within the federal establishment, federal policy affecting local land use is often fragmented and inconsistent". May and Deyle (1998, 59) concur, describing the patchwork federal system as "awkward and inconsistent in design". There is no one federal program that addresses land use planning, instead a plethora of programs address individual aspects of different issues. These programs range from major environmental laws (e.g., the Clean Air Act, the Clean Water Act, Costal Zone Management Act, and others (see Porter 1997, 86-

87)), to federal housing subsidies, community development programs, transportation programs (Kaiser et al. 1995, 11), and mandates for specific types of planning (e.g., Superfund Amendments and Reauthorization Act Title III) (Mileti 1999, 149).

May and Williams (1986) describe two dilemmas of shared governance that influence mitigation: political and implementation dilemmas. The political dilemma connotes the difficulty of addressing mitigation. Mitigation is less politically popular than post-disaster relief, thus the emphasis of federal policy making tends to focus on relief rather than mitigation (May & Williams 1986, 3). The implementation dilemma acknowledges that for policies to be effective they require the support of many levels of government. While federal funding can indirectly influence preparedness, the federal government has little direct control over how effectively local governments and individuals address mitigation. Moreover, According to May and Williams (1986, 6), the local decision makers that control implementation place mitigation policies low on their priority list.

For transmission pipelines the disconnect between local priorities and federal policies for pipelines is also indicative of a passive federal approach to local mitigation of pipeline hazards. Federal policies address transmission pipeline issues relating to interstate commerce. Local policy makers lack the ability to preempt federal policies relating to control of pipeline contents, pressure, and safety (Pates 1996a, 10-16), all of which would affect flow of contents contained in transmission pipelines. While federal regulations for transmission pipelines do not regulate local land use decisions, regulations do consider differences in areas surrounding transmission pipelines. In 2003 and 2004, the federal government adopted integrity management regulations for liquid transmission lines in unusually sensitive areas (e.g.: drinking water areas, areas with endangered species) and for both liquid and gas transmission lines in high consequence areas.[3] In these areas, pipeline operators are required to put forth additional work to ensure that pipeline failure does not occur. These measures include special valve installation, additional training for emergency management personnel, extra maintenance programs, damage prevention programs, hiring of specially qualified staff (49 CFR 192.935, 195.452). These regulations directly effect pipeline operators. However, changes or suggested considerations for local land use planning were not included as a part of these new regulations, illustrating a passive federal approach to addressing local mitigation of transmission pipeline hazards. This passive approach leaves states and local governments largely without guidance or mandates for planning near transmission pipelines.

3.2.2 State-level influences

Empirical research on adoption of growth management policy tools has addressed how state-level influences, such as a mandate for creation of a comprehensive plan, affect local policy adoption. Comparisons of how different states influence and direct local land use planning provide insight into the role of state governments. According to Bollens (1992, 455), "among the primary reasons for the transference of growth policy authority from local to state government has been the unwillingness or inability of local governments to deal adequately with growth issues that transcend municipal boundaries". Study of state-level mandates illustrate the challenges to inter-governmental management of land uses and the approaches state governments have taken to induce local management of growth.

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[3] High consequence areas surrounding natural gas transmission lines consist of areas within 200 meters of either side of the transmission pipeline with higher population density (containing at least one building with over 20 people regularly using it), or buildings with people who it may be difficult to evacuate (such as schools, nursing homes, or hospitals) (49 CFR 192.903) High consequence areas for hazardous liquid pipelines include waterways that are likely to be commercially navigated, populated areas, and any area designated as a unusually sensitive area (49 CFR 195.450).

In a study of multiple states with and without state-level mandates for planning to address natural hazards Burby and May (1997) found mandates to be influential for adoption of development management techniques for hazardous areas. They conclude that single purpose mandates were statistically significant and positively associated with the total number of development management techniques, total number of land use controls, and site design standards. However, single-purpose mandates were negatively associated with knowledge enhancement techniques. The total number of development management techniques and the number of building standards were both positively associated with a single-purpose mandate, yet not statistically significant (Burby & May 1997, 121-124).

How a mandate is constructed influences the local growth management outcomes stemming from the mandate. Bollens (1992) in a study of 13 statewide growth management mandates identified three types of state mandates (preemptive/regulatory, conjoint, and cooperative). He concluded that state growth management programs were evolving from a regulatory to a more collaborative framework. Burby and May (1997, 95) identified that facilitative aspects of mandates positively influence local growth management implementation through building local commitment and capacity for planning. Berke (1998, 84), in a review of state growth management literature, observed that "stimulating local response to natural hazard risks is noticeably difficult". He concluded that state policies should use a mix of approaches to induce local hazard mitigation, but that regulatory approaches with the full partnership of local governments offers the best long-term option.

Others have reviewed how state growth management reduce or manage actual growth within a state. Anthony (2004) in a comparison of density in states with and without state-level mandates for planning found that state-mandates did not have a statistically significant influence on changes in density. Carruthers (2002), in a wider review of growth management outcomes that included density, urbanized areas, property value, infrastructure expenditures and population change, concluded that state mandates were effective. However, he qualified that finding by noting that state mandate consistency and enforcement mechanisms influenced the outcome of the mandate.

Participation has helped craft state mandates and made local programs stronger. Innes (1992) detailed how group processes in three states, New Jersey, Florida, and Vermont had limited success in improving growth management at the state-level. She concluded that group processes have much more potential for improving growth management than illustrated in practice. Research by Brody and colleagues (2003) highlighted the potential that state mandates for local participation in growth management can have for improving involvement. The authors concluded that state mandates can make important contributions for inducing participation, but differences in objectives for participation have divergent outcomes. Mandates that required systemic participation, targeted relevant stakeholders, used a range of types of participatory techniques, and equipped stakeholders with relevant information were better prepared to improve planning outcomes (Brody, Godschalk et al. 2003).

3.2.3 Community-level influences

Nonetheless, while state-level influences are important, state policies work in tandem with local decision makers. Local governments are important partners in addressing hazards. Developing an understanding of factors that influence use of growth management tools can aid policy adoption and reduce hazard risk.

Many planning issues lack a mandate requiring local governments to address the issue or may not have broad stakeholder support for planning (May 1991b), thus understanding factors influential to local policy adoption can provide policymakers with important information. Moreover, even in the presence of a state-mandate for planning, there can be high local variability. Deyle and Smith (1998) found local plan content included as a result of a state mandate to be uneven; both how the state went about requiring implementation and local conditions facilitated plan content.

Several themes within the growth management literature provide insight into local factors that address growth management for various types of hazards. Table 3.2 illustrates factors associated with growth management adoption in hazardous areas. Researchers have also identified connections among variables that influence growth management. While the table highlights the direct relationships, I discuss both the direct and indirect relationships in the sections below.

Table 3.2, Factors associated with growth management in hazardous areas

Factor	Conceived as	Source
Capacity	Organizational capacity; agency capacity; staff size; proportion staff to community population; land use plan quality; land use plan recommendations; staff enforcement style; staff interaction style; staff professionalism	(Berke, Backhurst et al. 2006; Brody et al. 2010; Burby & Dalton 1994; Burby & May 1997, 1998; Laurian et al. 2004; May & Burby 1996)
Commitment	By planners, by staff; by planning agency; by developers; local commitment	(Burby & May 1997, 1998; Laurian et al. 2004; May & Burby 1996; May & Williams 1986)
Community characteristics	Economy; economic type (e.g., tourism based) population size; population density; population growth rate; education; wealth; demand for land in hazard area; community development pressures; development interest; resource protection; site alternatives in non-hazard area; size of development (acres, # lots); size of hazard area; size of hazard area; proportion community in hazard area; recent hazard loss; catastrophic hazard loss	(Anthony 2004; Berke, Backhurst et al. 2006; Berke et al. 1989; Brody et al. 2010; Burby & Dalton 1994; Burby & May 1997, 1998; Feiock et al. 2008; Godschalk et al. 1989; Laurian et al. 2004; May & Burby 1996; Stevens et al. 2010)
Collaboration/ stakeholder participation	Stakeholder involvement; local activism; pressure from local groups	(Bengston et al. 2004; Burby 2003; Godschalk et al. 2003)
Government coordination	Horizontal integration; vertical integration	(Bengston et al. 2004; Berke et al. 1989; Bollens 1992; May et al. 1996; May & Williams 1986)
Political pressure	Political demands; pressure from local groups; local priorities (mitigation priorities); type of local government administration (e.g., commission, commission-administrator)	(Berke et al. 1989; Burby & Dalton 1994; Burby & May 1997, 1998; Feiock et al. 2008; Godschalk et al. 1989)
Risk perception	Individual risk perception; specific community group perception of risk; awareness building; lack of interest	(Berke, Backhurst et al. 2006; Berke et al. 1989)

3.2.3.1 Capacity

Due to of the local nature of land use planning, capacity to implement planning programs may be paramount in achieving planning goals and reducing vulnerability to a disaster. Scholars have identified local planning capacity as a predictor of plan quality (Berke et al. 1999; Burby & May 1998), environmental plan implementation (Laurian et al. 2004), ecosystem management (Brody, Highfield et al. 2003), use of development regulations (Dalton 1989), and as a factor in reducing hazard risk (Godschalk 2003; May & Birkland 1994; Reddick 2008; Scanlon 1999). Lack of local capacity has been associated with a lower likelihood of implementation of hazard mitigation (Brody et al. 2010; Handmer 1996). Others have linked local administrative capacity to commitment and action for homeland security preparedness (Gerber et al. 2005) and to improved public and private relationships for infrastructure investments (Nunn 2003).

3.2.3.2 Commitment

Research on implementation of natural hazards policies suggests that variations in commitment to policy goals can lead to differences in policy adoption. Dalton and Burby (1994) established that planning agency commitment increased the number of hazard mitigation techniques adopted by a locality. May (1991a) found building commitment of local officials to hazard mitigation was a positive factor for improving earthquake mitigation, but that commitment existed in tandem with capacity to institute and enforce regulation. According to Norton (2005) local commitment played a statistically significant role in fostering higher quality plans and in the implementation of plan policies. Commitment can be generated through state mandates for planning (Berke & French 1994), influence of local economic advocates, and local concerns about environmental sensitivity (Norton 2005). Lindell and Meier (1994) found commitment to planning led to improved planning outcomes, which compensated for lack of experience with the hazard. Brody and colleagues (2010) found that commitment by planning agencies had a statistically significant relationship to non-structural mitigation for flood mitigation, but not structural mitigation. May and colleagues (1996, 199-201) suggest political, psychological, and practical barriers to commitment explain differences in local commitment to hazard mitigation.

However, others determined that commitment was not an influential factor. Brody (2003) found that commitment had no statistically significant effect in explaining change in plan quality over an 8 year period. Commitment to hazard planning was likewise not statistically significant in a study of the influence of planning mandates on hazard mitigation aspects of comprehensive plans; however, the authors suggested a state-wide plan mandate compensated for lack of commitment (Berke et al. 1996, 90).

Mixed results regarding local commitment to mitigation may be due to the relationship between commitment and capacity variables. Burby and May (1997) found plans generated due to state mandates for planning to indirectly address commitment to natural hazard mitigation. The plans built local citizen knowledge and led to demands for political action about natural hazards (Burby & May 1997, 109-113). This combination built capacity that encouraged commitment to hazard mitigation. Likewise, May and colleagues (1996) concluded that in the absence of coercive mandates, generating local interest by constituents (as form of capacity building) can improve policymaker commitment to environmental management outcomes. Berke (1998), in a review of state approaches to growth management to reduce natural hazard risks, found the influences of building capacity or commitment for risk reduction depended on the policy environment. May and Birkland (1994, 932), in a study of earthquake risk reduction, suggest that there is a critical level of capacity that must be generated before a similarly high level of commitment to mitigation can be achieved. These studies suggest a complex relationship between capacity and commitment.

3.2.3.3 Community context

Scholars have found community contextual factors influential for the setting of agendas (Birkland 1998), policy quality (Berke et al. 1996; Norton 2005), and policy adoption (Berke et al. 1989; Brody et al. 2006). Previous research has indicated communities of color and lower-income communities have historically borne the burden of higher risk from hazards (Wisner et al. 2004) and had a higher risk of exclusion due to land-use regulation practices (Pendall 2000). In contrast, wealthier communities were more likely to implement growth management (Berke et al. 1996; Brody et al. 2006). Communities experiencing rapid growth (Norton 2005; Protash & Baldassare 1983) and those with a higher density (Brody et al. 2006; Kaplan et al. 2008), had a greater likelihood of adoption of growth management policies.

Although there is limited available literature on population characteristics of those living near transmission pipelines, the legal literature illustrate that there are people living within close proximity of transmission pipelines who have experienced negative effects of pipelines. Reddic and Cuykendall (1995) documented that neighborhoods surrounding tank farms, the locations of large storage tanks which hold transmission pipeline products for redistribution into smaller pipelines, have had concerns regarding ground water contamination and harmful air emissions. However, these types of claims have been largely unsuccessful as class action lawsuits due to difficulties classifying damage at the group level (Vennos & Ray 2006), and as individual lawsuits due to limited household resources.

Equity researchers have indicated that social processes have left specific groups more vulnerable to the effects of hazards. Ritzdorf (1997) notes that many communities have used zoning to exclude. Zoning "is a very effective way for communities to create legal barriers that support a hierarchy in which some human beings are privileged and others are subordinated because of their class, race, and gender characteristics" (Ritzdorf 1997, 56). An historical study of the City of Commerce, California illustrated how zoning adopted by the Los Angeles County Regional Planning Commission in the 1920s and 1930s led to growth patterns that placed large numbers of minorities within close proximity of one of the "highest concentrations of toxic industries in the county" (Boone & Modarres 1999, 166). The authors note that "Commerce, as a city with hazardous sites, is very much a product of zoning" (Boone & Modarres 1999, 182). Even after courts struck down exclusionary zoning practices, Collin, Beatley, and Harris (1995, 336) asserted that it did not bring to an end to exclusionary practices. Municipalities changed their practices and used tactics such as special districts, minimum lot size, and other techniques to keep lower-income housing out.

Other social forces, such as unequal enforcement of environmental protection laws can negatively affect vulnerable communities. Bullard (2000, 99) asserted that discrimination affects environmental decisions. Unequal enforcement of environmental protection laws produces differential exposure for minorities. In the 1990s the U.S. General Accounting Office (2000, 5) noted that the Office of Pipeline Safety reduced "the proportion of enforcement actions in which it proposed fines from about 49 percent to about 4 percent" for transmission pipeline operators. Although the GAO did not state how or why these changes occurred, the shift may have affected some communities more than others.

Environmental decisions made by local planners can also produce discriminatory land uses since “zoning spatially allocates wealth, prestige, and opportunities in American communities” (Ritzdorf 1997, 56). Differences in local planning decisions led polluting industries to be located in areas that were vulnerable or allowed polluters leniency in already vulnerable areas. Several studies concluded that polluting industries are more likely to expand in areas with lower income or minority residents, suggesting that firm location and expansion behavior may play a role in market forces. Maantay (2002b) in a study of industrial land use change in New York found that industrial zones were more likely to be expanded in areas with higher percentages of low-income or minority populations than other areas. Likewise, Hamilton (1995) observed that commercial hazardous waste facilities were more likely to expand in areas with higher percentages of minorities. He suggested that firm expansion in these areas was linked to lower potential for costs related to local opposition to expansion plans.

Market forces may leave vulnerable residents unable to leave. Bullard (2000, 6) stated, “Racial barriers to education, employment, and housing reduce mobility options available to the black underclass and the black middle class.” Similarly, Greenberg and Schneider (1994) found mobility options for residents living near remediated Superfund sites to be hindered by lack of resources. Although remediation improved neighborhood quality ratings, residents with longer tenures were more likely to continue to rate the neighborhood poorly, suggesting that residents with longer neighborhood tenure lacked the means or opportunity to move from the contaminated neighborhood.

Research on home sales prices in areas near transmission pipeline ruptures indicated that pipeline hazards could have an effect on homeowner mobility and financial resources.

These differences may make more of an impact on already vulnerable populations. Simons' (1999) found that a transmission pipeline rupture in Maryland reduced home sale values along a pipeline easement by 4-5 percent (for non-contaminated homes) compared to all other homes within 2 miles. Similarly, in an analysis of home sales near a second Maryland transmission pipeline rupture that contaminated a waterway, residential home sales in the community declined 10% in the aftermath of the spill (Simons et al. 2001).

The hazard area and experience influence local decisions about mitigation. Birkland (1998) suggests recent accident experience might act as a focusing event and bring community attention to the hazard. In a study of coastal hazards, Godschalk and colleagues found (1989, 218) recent storm loss statistically significant and positively associated with adoption of development management for coastal storms. Brody and others (2010) identified recent loss to be statistically associated with non-structural mitigation and total 5-year loss to be statistically significant and positively associated with adoption of structural mitigation. The proportion of the community in the hazard area has been statically significant and negatively associated with adoption of mitigation measures (Brody et al. 2010; Burby & Dalton 1994). This research suggests hazard mitigation is part community awareness (such as through recent loss) and having a critical proportion of the community at risk of loss from the hazard.

3.2.3.4 Collaboration to improve mitigation outcomes

There is agreement that collaborative practices present one of the most salient methods for coming to agreement. Planning problems intractability stems from the "wicked" nature of many planning problems (Rittel & Webber 1973). Yet collaborative practices can counter some of the barriers to planning that wicked problems enact. Innes and Booher

(1999a, 415) state that "consensus building by its very nature challenges typical thinking about success and failure". This modification to typical thinking can help with difficult planning problems because, according to Rittel and Webber (1973, 161), "The formulation of a wicked problem *is* the problem."[4] Participants in collaborative processes jointly articulate the problem and generate a framework for the solution (Innes 1996, 466). Using consensus building, Innes and Booher (1999a) highlight how stakeholders can achieve high-quality agreements, generate tangible planning products, and build relationships that create social capital for addressing future problems.

According to Innes (1996, 466) one of the benefits of collaborative practices is that the planner is not personally responsible for identification of the public interest; a group of stakeholders outline the policy objectives and actions to reach those ends. This follows Forester's (1989, 143-145) call for communicative planning that generates a mutual understanding that is comprehensible, sincere, legitimate, and accurate. Innes (2004, 13) highlights how collaborative practices generate power that is shared rather than a zero-sum game where one groups wins and one loses. Healey (1998, 1537) identified the power of collaborative practices as a way to transform thinking by "reshaping policy agendas and mindsets". Using this approach, collaborative practices can produce "creative solutions to seemingly intractable issues" (Innes 2004, 9).

3.2.3.4.1 Challenges to collaborative planning in hazardous areas

Local decisions about growth near technological hazards have far reaching implications. Given the homeland security concerns associated with many large-scale technological hazards, appropriate local planning near these areas is critical. According to

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[4] Italics in original

Eisinger (2006, 541), cities were given wide latitude to make decisions about homeland security. However, Mileti (1999, 160) stated that local governments consider hazard mitigation a very low priority and something that "can take a back seat to more pressing local concerns such as unemployment, crime, housing and education."

In spite of the association of wide-ranging stakeholder participation with growth management accomplishments (Innes 1996; Leach 2006), development management near technological hazards has a history of poor public participation and barriers to collaborative planning. Stakeholder involvement is generally low for hazard mitigation planning in general (Godschalk et al. 2003) and worse for technological hazards (Greenberg et al. 1994; Lindell & Perry 2001). Lindell and Perry (2001, 184) highlighted how across the United States community interest in obtaining information from local emergency management committees about technological hazards in their community was negligible. Obtaining full stakeholder participation for collaborative planning practices remains difficult in the absence of interested stakeholders.

When public participation for planning in areas with technological hazards has occurred it has been derailed due to limited public understanding of risks involved, poor communication by experts to lay people, and unrealistic expectations for the planning process (Binney et al. 1996; Merkhofer et al. 1997). In siting of nuclear plants Williams (1997) found meaningful citizen involvement was placed subservient to expert opinion. Nonetheless, for most planning in areas with technological hazards the problem is not disrupted participation, but lack of interest in participating in planning to reduce hazard risk.

The hazard zones for many natural and technological hazards cross jurisdictional boundaries making their effects harder to mitigate solely by one jurisdiction. Priorities of different local and regional organizations and agencies could make an overall mitigation strategy difficult to achieve (Light 2004), thus collaborative practices provide an opportunity for coming to agreement on workable solutions. Studies have highlighted the effects of regional collaboration (or lack of collaboration) on chemical plants (Ibitayo et al. 2004) and fire hazards (Goldstein et al. 2010). Regional planning for ecosystem corridors (Brody, Highfield et al. 2003) and watershed boundaries (Imperial 2005; Leach 2006; Margerum 2002b) is becoming common. These issue-specific planning areas have regional implications for both resource protection and hazard control.

Critical infrastructure such as transmission pipelines has an additional impediment to achieving full stakeholder participation that many natural hazards do not. In the aftermath of September 11, information about locations of many technological hazards was classified from the general public. In light of public security concerns in the wake of 9/11/2001, Comfort (2002, 106) concluded that systematically improving inter-agency capacity for learning from each other can improve long-term ability for local government to address public security risks. However, while transmission pipelines have experienced terrorism threats (Parfomak 2006), accident reports suggest the threat to pipelines from inappropriate development is more likely. Nonetheless, improving capacity through collaboration can do more than simply address public security.

May (1991b, 196) suggests that some policy issue areas are problematic for democratic governance and reliant on technical experts, such as planners. May (1991b, 194) describes these “policies without publics” as issues which lack serious political conflict, have weak networks of supporters, whose solution is dominated by technocrats, or where personal benefit is limited so as to reduce incentives for individual participation. Examples of policies without publics are those which entail public risk (e.g., earthquakes, chemical hazards), but lack a large focusing event to generate public interest in policy creation (May 1991a, 264). Technological hazards are especially likely to lack agenda-setting pro-change support in the absence of a focusing event such as a large oil spill (Birkland 1998).

3.2.3.4.2 Technical collaborative planning in hazardous areas

According to Porter (1997, 13) “successful approaches to growth management depend as much on administrative and consensus building leadership as on specific policy or regulatory techniques and provisions”. Scholars in several disciplines have noted the need for collaborative efforts among agencies dealing with aspects of hazards as a means of improving mitigation and response (Britton 2002, 44; Godschalk 2003, 142; Haimes 1999, 157). Collaboration between specific groups can create effective connections that improve planning outcomes. According to Pearce (2003, 214-215), collaboration between emergency managers and planners can leverage community skills to increase resilience and long-term sustainability. Within the literature on collaborative planning, there is little focus on technical collaboration, yet these collaborations happen at both local and regional levels and can have an effect on local growth management.

While some claim that without full stakeholder participation building a consensus will likely fail (Innes 2004, 7), others suggest that a full range of stakeholders may be only part of the solution. Pearce (2003, 220) argued that “although a consensus-based approach to sustainable hazard mitigation is always desirable, it may not always be possible”. Godschalk and others (1998) saw a role for both technicians and collaborative stakeholder groups. These authors envisioned technicians leading information generation and technical policy creation. These practices would then be followed with citizen participation for adoption of appropriate policies and for policy evaluation (Godschalk et al. 1998, 93-94).

Technical collaboration can build capacity for addressing pipeline hazards through sharing of knowledge, effective practices, and strategies to overcome implementation hurdles. Pearce (2003, 226) argued integration of emergency management and community planning groups can lead to sustainable hazard mitigation. This conclusion is supported by McGuire's (2006) review of recent literature on collaboration among governmental agencies; the review suggests that traditional bureaucracy is unprepared to address many of the challenges facing local governments. Boin et al. (2003, 103) suggest learning from organizations and networks within the same region provides the opportunity for increasing resiliency. Likewise, Lindell and Perry (1996), in a study of earthquake induced hazardous material releases (including transmission pipeline spills) after the Northridge, California earthquake, suggest that hazardous material spills in general could be better mitigated through increasing coordination among governments, emergency managers, community agencies, and public health officials. In a related study on hazardous material spills after the Northridge earthquake, Lindell and Perry (1997, 151) found, "Two of the three most significant petroleum spills were in urban areas where crude oil combined with water from ruptured mains, a highly mobile mixture that significantly increased the environmental threat," illustrating the importance of coordination with industry and other regional groups.

Recent planning literature has drawn attention to the effectiveness of communities of practice for improving awareness and communicating about specific planning issues (Goldstein & Butler 2010; Schweitzer et al. 2008). Wenger and Snyder (2000, 142) define communities of practice as voluntary, self-selecting groups formed to share information and best practices. In contrast to the full participation models, Wenger and Snyder (2000, 140-141) highlight the flexibility of size, membership, and diversity of communities of practice. Research on the types of informal collaborations could provide guidelines for improving these types of collaborations for use by planners.

Hazard researchers have illustrated the salience of building administrative and organizational capacity to address mitigation. Burton and others (1993, 160) observed that a profession staff with an interest in enhancing hazard mitigation can improve adoption of hazard mitigation. Gerber and colleagues (2005, 201) found that differences in local administrative capacity can be tied to homeland security policy improvements. Brody and others (2010) observe that organizational capacity correlated with improved structural and non-structural hazard mitigation in Texas and Florida. Much of this technical capacity can be improved through collaboration with counterparts in nearby jurisdictions that face similar mitigation challenges.

Growth management can benefit from techincal collaboration due to the influence of staff. Rosener (1982, 341) observed that planning commission decisions to deny development permits were more likely if there was a planning staff recommendation to reject the permit. Likewise, Fleischmann and Pierannunzi (1990, 847) found that the single strongest predictor of a rezoning request was the recommendation by planning staff. Koontz (2005, 475) noted that jurisdictions with high growth pressures were especially likely to rely on recommendations of planning staff. An informed administrative staff can provide better suggestions.

Prater and Lindell (2000) highlight the importance of agenda-setting and how technical experts such as planners and emergency managers have the ability to keep hazard mitigation on the agenda. Both planners and emergency managers can improve hazard mitigation through what Boin et al. (2003, 103) call “prevention learning,” or knowledge sharing through networks that generate information on how to reduce the likelihood of an accident. Fischhoff and colleagues (2000, 135) suggest that the problems of hazard management are too broad for one discipline alone. Emergency managers have specific skills that could provide collaborative knowledge to improve planning decisions about development near transmission pipelines, yet the role of emergency managers is often overlooked (Petak 1985, 3). For both emergency managers and planners knowing the potential hazard risk can improve decisions about new development near pipelines. Given the potential impact that planners and emergency managers can have on hazard mitigation, using collaboration to generate capacity to address technological hazards may improve overall community safety and security.

3.2.3.5 Governmental coordination

Coordination across jurisdictional boundaries presents challenges to achieving hazard mitigation goals. Many hazards, including transmission pipeline hazards, transect multiple jurisdiction boundaries. This cross-border passage requires mitigation practices to be put in place by multiple governments. Vertical integration addresses hierarchical governance structures, frequently this involves how higher levels of government convince subgovernments to participate in policy. Horizontal integration addresses coordination among governments at the same policy level. Horizontal coordination can pose challenges for regional collaboration, interagency cooperation, and lasting measures to address hazards. An absence of horizontal coordination can equate to conflicting policies in neighboring jurisdictions that undermine policy effectiveness. However, coordinated horizontal cooperation can lead to innovative planning that addresses regional concerns (Porter 1997, 39-40).

Higher levels of government may encourage or coerce lower levels of government into participation in policy implementation (May & Williams 1986). Mandates from higher levels of government can provide either coercive means or cooperative incentives to improve capacity and commitment of other levels of government to address the policy goal. May and Williams (1986, 180) observed a shared governance implementation dilemma: while there is a federal interest in generating local capacity and commitment to federal goals, the major subnational interest is to have access to federal funds with the ability to reshape federal policy to address local special interests and political needs. The conflict in policy importance to different levels of government also occurs between state and local governments. Like the federal government, states have used both cooperative and coercive policies to encourage or mandate local participation in environmental policies that address hazards (Burby & May 1997). May and colleagues (1996) found that cooperative policies can lead to local ownership of environmental policies. Yet reluctant local partners that do not adhere to policy goals can also result from cooperative agreements among vertical partners (May et al. 1996, 218). Thus, cooperative policies are not always appropriate.

Horizontal cooperation among local governments presents many challenges. Lack of horizontal coordination can lead to fragmented growth that outsources detrimental effects of growth to areas within the region, but outside of the local government area. Bollens (1992) categorized this fragmented growth as type I growth management. He refers to type II growth management as the type that occurs when local governments refuse to incorporate less desirable land uses, such as affordable housing, that are critical to regional growth

(Bollens 1992). These two types of regional growth management problems illustrate some of the challenges to horizontal coordination. The voluntary nature of many regional agreements presents an additional hurdle to regional planning. According to Porter (1997, 229) voluntary agreements for regional planning can and often are ignored by local governments.

Obstructions to horizontal decision-making processes can influence in hazard exposure at regional levels. Transportation corridor hazards pose more difficulties for local jurisdictions than fixed-facility hazards (Andrews 1987; Rogers & Sorensen 1989, 57-58), perhaps because of the likelihood of multi-jurisdictional involvement. Scholars attribute regional decision-making processes to hazard exposure for lower-income and minority populations (Krieg 1998; Pulido et al. 1996). These case studies suggest that local differences in growth management decisions and economic power affect who receives benefits (e.g., access to desirable areas) or suffers hazard consequences (e.g., being restricted to hazardous areas) at a regional level.

Empirical studies also suggest detrimental effects of uncoordinated regional planning. Land use controls can lead to exclusion of lower income and minority populations through lower availability of affordable housing (Pendall 2000). Landis (2006) found regional movement of growth to less regulated communities as a result of growth management and control measures implemented within one community in a region. Lack of a regional perspective in land use planning has been faulted for uneven availability of affordable housing, fiscal disparities among communities, and low quality public schools (Rusk 2000, 90). Berke and colleagues (1989) found intergovernmental cooperation to be positively associated with adoption of land use planning measures for earthquake hazards.

Collaborative practices present opportunities to create support for both vertical and horizontal cooperation. According to Innes and Booher (1999a, 414) the collaboration involved for creation of regional plans can have lasting social capital improvements, leading to better informed policy makers and unexpected positive policy outcomes even in the absence of binding plans. This collaboration can provide policy makers with information that changes local policy direction even without coming to a lasting regional agreement. Nonetheless, May and Williams (1986) point out the role of collaboration for shared governance can be tenuous. Local governments can opt out of collaborative programs, leaving higher levels of government with problems for policy continuity or with a need to fall back to more coercive approaches (May & Williams 1986, 123).

3.2.3.6 Political pressures

Implementation of growth management polices takes place in a political system. Godschalk and colleagues (1989, 171) observe that "the effectiveness of development regulations depends both on the stringency of the measures enacted and the resources and political will invested in enforcing and implementing those measures". Norton (2005) found commitment by elected officials to planning outcomes is complex. Development pressures, environmental sensitivity of the area, community make-up, the role played by advocacy groups, and individual characteristics were statistically associated with elected official commitment to planning outcomes. Elected officials in turn influence the quality of land use plans and their use within the community. Feiock and others (2008) found differences in adoption of impact fees associated with electoral representation. However, electoral and appointment differences did not influence adoption of urban growth boundaries, transfer of development rights programs, or incentive zoning.

Political pressure to address hazards can influence adoption of growth management techniques. Burby and Dalton (1994) found political pressure to reduce hazards to be statistically associated with measures to limit development in hazardous areas. Likewise, Burby and May (1997) identified elected official support to be statistically associated with adoption of growth management techniques. Berke and others (1989) did not find the political support statically associated with adoption of earthquake policies. Likewise, Fleischmann (1989, 344) argued that limited citizen participation in rezoning cases makes political implications less important.

3.2.3.7 Perception of hazard risk

Research on risk perception has had mixed results regarding how perception of risk influences action to reduce risk. Lindell and Perry (1992, 30) observed that for local governments to effectively "formulate, adopt, and implement" a response to environmental hazards, both citizens and officials of the community need to be aware of the hazard and perceive that it poses a threat to the community. Gerber & Neeley (2005) found that a perception of risk by local citizens generates support for government actions to address mitigation of that hazard. While studies rank technological hazards and transportation infrastructure high on the list of homeland security concerns by local government leaders (Baldassare & Hoene 2002; Reddick 2007), implementation of hazard mitigation ranks low on the list of local government concerns (Burby 2006, 178-180). Others found that risk perception for natural and biological hazards does not translate into hazard preparedness spending (Krueger et al. 2009). The type of hazard also impacts how it is addressed (Slovic 1987), as different types of risks lead to a range of support for hazard adjustments (Fischhoff, Slovic, Lichtenstein et al. 2000). Technological hazards and hazards where exposure to harm was not usually voluntary was more likely to be rated as having higher risk than more common or voluntarily-assumed risks (Starr 1969). Some suggest that risk perception is not enough; local governments are unlikely to provide more regulation for addressing low-risk high-consequence hazards without a "focusing event," such as a large and costly earthquake for earthquake hazards, as an incentive to change behavior (May 1991a, 265). While research on risk perception indicated that low frequency hazards might lack local initiative to mitigate the hazard, the literature also suggested that a perception of risk from the hazard is a necessary ingredient for implementing hazard mitigation.

3.3 Conceptual model

I draw from previous studies looking at growth management and hazard mitigation to generate a conceptual model that addresses influences to land use planning in areas with transmission pipeline hazards (Figure 3.1). Using this model, I study three aspects of land use planning in areas with pipeline hazards. First, I examine how capacity, commitment, community context, and risk perception influence tools communities use to mitigate pipeline hazards. Second, I extend work on collaborative practices in hazardous areas to deepen analysis of technical collaborative practices and how these processes influence mitigation. Third, I use an equity lens to focus evaluation of community characteristics in areas with pipeline hazards. Using this three-pronged approach, I include many of the factors included within the literature on growth management and extend scholarly understanding of these factors into new areas.

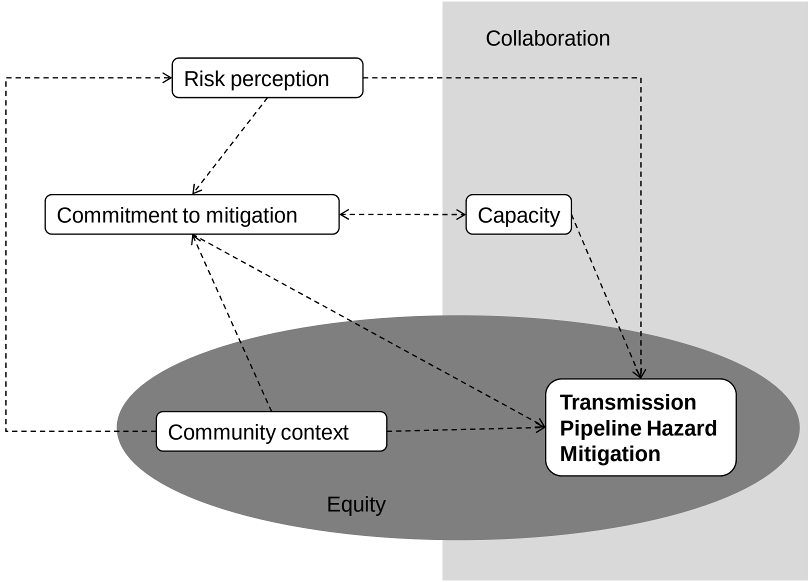

Figure 3.1, Conceptual model for mitigation of transmission pipeline hazards

The conceptual model illustrates the areas I draw on for analysis of transmission pipeline mitigation. I examine the following four constructs in an empirical analysis: (1) perception or risk from pipeline hazards; (2) commitment to mitigation; (4) local capacity for planning; and (4) community context. In moving to understand the implications of how local factors affect mitigation, I draw on literature on collaboration to consider how communities transfer knowledge and build capacity to address pipeline hazards. Given the role of community context in shaping the mitigation outcomes, I use an equity lens to focus discussion of those living nearby the transmission pipelines.

As identified in the literature above, several other areas have been included in research addressing other types of hazards. Due to resource constraints and data limitations all variables that might possibly influence mitigation of transmission pipelines hazards could not be included within the study. I focus on the community-level factors and omit state and national influences due to data access constraints that limited data availability to a single state (North Carolina). Given the inability to compare states, vertical coordination differences in federal-state relationships and state-local relationships were not addressed. Since the policy environment is contained within one state, North Carolina, the research design should control for state influence. Decisions made at the national and state-levels should theoretically be applied similarly across the state. Effects from national and state influences could be addressed within a future study if multi-state data were made available.

Likewise, local policies that might influence transmission pipeline mitigation indirectly are not included. These could be regulatory policies within comprehensive plans or land use plans that apply broadly to development and as a by product influence development near transmission pipelines. I expect that discussion of some of these polices would have become apparent during the interviews, but the influence of these policies is not necessarily controlled within the empirical analyses.

Political influences to mitigation of pipeline hazards were also omitted. Political constraints to dealing with many hazards present challenges to many type of hazards. However, elected officials are unlikely to have heavy pressure from constituents to address pipeline hazards. Given the extremely low interest that most policy makers and their local constituents have in transmission pipelines, this factor was not included.

4 Land use planning tools to mitigate transmission pipeline hazards

Critical infrastructure such as hazardous liquid and natural gas transmission pipelines has received little attention by planning scholars even though local development decisions have far-reaching consequences for homeland security, environmental damage, and human exposure. Given the limited attention to pipeline hazards in the literature, there is little information available for practicing planners available on the types of tools commonly used to address these hazards. Likewise, while the planning literature has explored factors contributing to growth management in areas with other types of hazards natural and technological hazards, it is unclear if factors influencing growth management near pipeline hazards is similar. Transmission pipeline hazards may be different from other technological hazards in that their underground location leaves them largely invisible. Moreover, the literature on risk perception suggests that different perceptions of risk from natural and technological hazards may mean that communities address pipeline hazards differently than the natural hazards that have been the focus of much of the literature on factors contributing to adoption of growth management tools. This chapter attempts to remedy some of the deficits in information about transmission pipelines. After describing the methods, I present descriptive information about the tools that survey respondents use and illustrate the results of regression analyses on factors associated with use of tools to mitigate pipeline hazards. I follow the findings with policy implications and provide suggestions for improving mitigation of transmission pipeline hazards and other similarly low-profile hazards.

In order to improve understanding of the drivers that propel local protection of transmission pipeline infrastructure I examine how the following four constructs influence use of mitigation tools: (1) risk perception; (2) commitment to mitigation; (4) local capacity for planning; and (4) community context (see Figure 3.1). I propose the following hypotheses:

- H1. Risk perception will be positively associated with adoption of pipeline mitigation tools
  - H1.1. Given the risk that pipeline ruptures pose to the environment, perception of risk by environmental groups will be positively associated with use of mitigation tools
  - H1.2. Since it is in the interest of pipeline operators that local governments reduce encroachments on transmission pipelines, perception of risk by pipeline operator groups will be positively associated with use of mitigation tools
  - H1.3. Due to the potential property damage associated with a pipeline rupture, risk perception by individuals will be positively associated with use of mitigation tools

- H2. Many communities use a multi-hazard approach to address hazards, so I expect commitment to mitigation will be positively associated with adoption of pipeline mitigation tools

- H3. Local capacity for planning will be positively associated with adoption of pipeline mitigation tools
  - H3.1. Since use of a comprehensive land use plan has been associated with improving environmental outcomes and with adoption of growth management, I expect having a land use plan will be positively associated with use of mitigation tools
  - H3.2. Information improves a community's knowledge about the potential effects of transmission pipeline ruptures, so I expect access to information to be positively associated with use of mitigation tools
  - H3.3. Although the literature illustrates both positive and null effects of hazard maps on use of mitigation tools for natural hazards, I expect that knowing where a pipeline is located will be positively associated with use of mitigation tools.

- H4. Community context will be positively associated with use of mitigation tools.
  - H4.1. Given the potential that vulnerable groups have been frequently associated with proximity to hazards, I expect that planners will be cognizant of the potential negative effects on these communities and use mitigation tools to reduce the effects on lower-income communities
  - H4.2. I expect that the growth rate will be positively associated with use of tools.

H4.3. Communities with higher density will have more people potential at risk from pipeline ruptures, so I expect growth rate will be positively associated with use of growth management tools to address pipeline hazards

H4.4. A recent accident could act as a catalyst for change, so I expect that having had recent accident will be positively associated with use of mitigation tools

The results suggested that although jurisdictions use few pipeline mitigation tools, differences in risk perception, commitment, capacity, and community context influenced tool adoption. Total tool use was statistically significant and positively associated with perception of risk by environmental and pipeline industry groups, commitment to hazard mitigation, and community capacity to address pipeline hazards. However, variables for perception of risk by individuals and percent lower-income residents were statistically significant and negatively associated with total tool use. The remaining community context variables did not display statistically significant association with total tool use. Factors influencing use of regulatory tools were different than those influencing information tools. Too few communities used incentives to allow for statistical analysis of the factors influencing adoption.

4.1 Methods

4.1.1 Study area

I selected the state of North Carolina as the study area. North Carolina is transected by a major pipeline corridor that extends from Texas/Louisiana to New York. This corridor contains both liquid and natural gas transmission pipelines that run within close proximity of each other. The pipeline corridor is one that has received attention due to serious pipeline accidents (NTSB 2009; Pates 1996a, 1996b) and chronic leaks (Ames & Young 2008). North Carolina has recently experienced high population growth, potentially leading to more people near formerly rural pipelines as urban areas expand. The projected growth areas for several North Carolina metropolitan areas impinge on pipeline corridors. Dependence on energy products in North Carolina increased at almost twice the population growth rate between 1977 and 2000 (State Energy Office 2005, 7). Since 1990 reliance on pipeline products (specifically natural gas and petroleum products) increased while use of coal and renewable fuels both decreased (State Energy Office 2005, 8).

4.1.2 Sample selection

The analysis uses the community as the unit of analysis. Spatial data obtained from the U.S. Office of Pipeline Safety were used to identify jurisdictions in North Carolina at risk from pipeline hazards. Due to accuracy limitations in the digital pipeline location data (U.S. Department of Transportation 1999), I identified communities transected by a pipeline hazard buffer. The buffer took into consideration fluctuations in accuracy of individual segments of the pipeline data and potential impact area of liquid and natural gas transmission pipelines.

Between November 2008 and January 2009 a mail-in mail-back survey, following Dillman's (2000) survey response methodology, was distributed to planning directors in 121 North Carolina municipalities and counties transected by the hazard buffer (Appendix A). Planning directors were asked to provide information about their local government.[5] Although the questionnaire was addressed to the planning director, respondents were instructed to consult others if they felt they could not answer a question appropriately. Of the 121 jurisdictions surveyed, 85 (70%) returned usable surveys. No statistically significant differences in the population characteristics were identified between participating and non-participating jurisdictions.

4.1.3 Measurement of variables

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[5] Respondents were identified with the help of the North Carolina League of Municipalities and the Association of County Commissioners. In jurisdictions where the planning director did not participate in one of these two organizations, I used the community's website or called to identify the appropriate person.

The dependent variable is a count variable of the total number of tools each jurisdiction has in place to address pipeline hazards (see Table 4.1). I also use a count of information tools and regulatory tools as separate dependent variables. Several scholars have used a count of total tools to measure frequency of use of certain planning tools (O'Connell 2009), count of total development restrictions (Feiock 2004) or measurement of use of each class of restriction (Feiock et al. 2008; O'Connell 2009). Others have chosen to take a count of total tools or policies in use and generate an index (Brody et al. 2006; Brody et al. 2010; Burby & May 1997). Planners were asked to identify their jurisdiction's use of 19 potential tools to mitigate pipeline hazards in their community. Tools included in the survey list were identified in the growth management literature, a non-profit pipeline damage prevention group booklet (Common Ground Alliance 2003), and pipeline regulatory documents.

I measured risk perception through the frequency with which environmental groups, pipeline industry groups, and individuals asked for information about pipeline hazards, participated in meetings about pipelines, or requested that action be taken to address pipeline hazards. These three variables were measured as a count of the total types of participation. Others have measured risk perception by asking about resource concerns for that hazard (Gerber et al. 2005), directly polling affected individuals (Burby 1999; Gregg et al. 2004; Johnston et al. 2005), or using a count of forms of public input on the issue (Snary 2004). I chose to use a measure of community input into the planning process in order to measure community-level interest rather than a direct poll of individuals.

Table 4.1, Measurement and data sources for variables included in the regression analyses

Variable name	Measurement	Data source
Dependent variables		
Total tools	Count of tool use	Survey
Information tools	Count of tool use	Survey
Regulatory tools	Count of tool use	Survey
Independent variables		
Risk Perception		
Environmental groups	Count of inquires	Survey
Pipeline industry groups	Count of inquires	Survey
Individuals	Count of inquires	Survey
Commitment		
Commitment by planning agency	Additive index of mitigation scores	Survey
Capacity		
Land use plan	Dichotomous (1=Yes)	Survey
Access to information about pipelines	Additive index of information sources	Survey
Agency knows pipeline location	Dichotomous (1=Yes)	Survey
Community Context		
Low-income households (%)	Continuous	2000 Census data
Population change 1990-2000 (%)	Continuous	1990 and 2000 Census data
Density (100 persons/sq. km.)	Continuous	2000 Census data
Recent pipeline accident	Dichotomous (1=Yes)	Survey

To measure commitment to mitigation, I created an additive index comprised of scores for mitigation of floods, winter storms, tornadoes, hurricanes, wildfires, industrial hazardous material releases, highway hazardous material releases, and rail hazardous material releases, and commitment to pipeline hazard reduction.[6] Multiple-hazards are frequently incorporated into a single plan or strategy for addressing overall mitigation (Alexander 1993, 2005) as opposed to single stand-alone plans for individual hazards. Using

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[6] Mitigation for all hazards ranged on a five-point scale from no effort to high effort. For pipelines, the five-point scale ranged from no concern to high concern. The index was calculated by summing the score for all hazards and normalizing the summated score by dividing by the total number of items (similar to indexes created by Berke et al. 1996; Brody et al. 2006).

one strategy for multiple hazards increases efficiency and improves the likelihood that a plan will cover unexpected hazards (Alexander 2005, 162), thus commitment to one hazard will likely improve mitigation of others.

The mitigation index provides a thorough view of a jurisdiction’s commitment to mitigation of both natural and technological hazards. Scholars have measured commitment through an index that looks at planning agency commitment to hazard mitigation goals and progress toward achieving them (Berke et al. 1996), to adoption of specific programs for hazard mitigation (Burby & May 1998), or to planning generally (Norton 2005). The indexes by Berke and colleagues (1996) and Burby and May (1998) address commitment to mitigation of multiple hazards similar to the index used for this paper.

Capacity was measured using three factors following discussion in the literature. First, respondents reported whether the jurisdiction had a land use plan in place (1= yes). Second, an additive index was created based on the sources of information a community accessed about pipeline hazards.[7] Third, awareness of the locations of transmission pipelines within the jurisdiction were measured. Planners were asked, “Is your planning agency aware of any hazardous liquid or natural gas transmission pipelines in this jurisdiction?” Responses were categorized as a dummy variable (1 = yes).

I quantified community context variables by measuring socioeconomic characteristics of the jurisdiction and recent pipeline accident history. First, community socio-demographic characteristics were matched to survey jurisdictions using U.S. Census of Population data for 2000. The Census data were used to calculate percent low-income households and population density. Low-income households were measured as the percent of households earning under $20,000 per year. Others have measured wealth as median home value (Berke et al. 1996;

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[7] The information index was created following a similar methodology as the commitment index (see note 4).

Burby & May 1997; Cutter & Solecki 1996) aggregate median household income (Brody et al. 2010), or percent in poverty (Cutter & Solecki 1996). I chose to focus specifically on the percent lower-income residents due to suggestions that lower-income residents have more challenges than their wealthier peers in addressing hazards of place (Cutter & Solecki 1996; Squires & Kubrin 2005). Population growth between 1990 and 2000 was measured using Census of Population data for 1990 and 2000. For municipalities that did not appear in the 1990 Census, the county growth rate was used. Finally, to measure previous transmission pipeline accident history, planners were asked to report if their jurisdiction had experienced a transmission pipeline accident within the last 5 years (1=yes). Birkland (1998) suggests that technological hazards are especially likely to lack agenda-setting pro-change support in the absence of a focusing event such as a large oil spill. I expected that a recent rupture could act as a focusing event.

4.1.4 Data analysis

I use cross-tabulations to visualize differences in use of information, regulatory, and incentive tools. I calculated non-parametric Kendall's tau-c correlations to examine the relationship between the commitment and risk perception variables and between the commitment and capacity variables.[8] A Wilcoxon (Mann-Whitney) rank-sum test was used to evaluate statistically significant differences in perception of risk by environmental groups, pipeline industry groups, and individuals in areas with and without recent pipeline accidents.

Poisson and negative binomial regression were used to examine the effects of the independent variables on use of tools to mitigate pipeline hazards. Pearson's goodness of fit test was used to test for overdispersion in Poisson models (Long 1997). Negative binomial

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[8] I use Kendall's tau-c to test these relationships because the variables are ordinal and many do not have a normal distribution.

alpha test, AIC and BIC tests, and Vuong tests were conducted to confirm the preference of Poisson or negative binomial regression over zero inflated Poisson, and zero inflated negative binomial models. During model building, models were compared using likelihood ratio tests. Unadjusted (bivariate) relationships between each independent variable and the outcome variable were compared, prior to evaluating adjusted relationships. I use a 0.1 statistical significance level to assess statistical associations between variables. This level is an arbitrary choice (Rea & Parker 2005, 144). I consider 0.1 more appropriate than .05 based on the sample size.

4.2 Findings

4.2.1 Tools used to mitigate pipeline hazards

Communities in North Carolina use few tools to mitigate transmission pipeline hazards. Ten jurisdictions (12%) use no tools identified on the survey and one jurisdiction uses 17 of the 19 tools listed. Illustration of transmission pipeline easements on subdivision plats was the tool most likely to be in use with 74% of the jurisdictions using this tool (Table 4.2). No respondents indicated use of transmission pipeline zoning overlay districts. The average number of tools in use is 4.5 (Table 4.3).

Table 4.2, Frequency of use for tools utilized to mitigate transmission pipeline hazards (n=85)

	Tool	Reported usage frequency	
		%	#
1	Illustration of transmission pipeline easements on subdivision plats	74	63
2	Areas subject to pipeline hazards identified with signs	69	59
3	Excavators required to notify state one-call center (ULOCO) prior to beginning work	66	56
4	Fire resistance requirements as set by Section 7 of the North Carolina State Building Code	52	44
5	Maps of transmission pipeline locations	39	33
6	Minimum building setback requirements for buildings adjacent to transmission pipelines	28	24
7	Mandatory open space dedication requirements of developers to provide buffers between transmission pipelines and development	18	15
8	Transmission pipeline disclosure required in real estate transactions	17	14
9	Low density zoning surrounding pipelines	15	13
10	Watershed protection ordinance with provisions to protect transmission pipelines from possible third-party damage	15	13
11	Deed restrictions for property with pipeline easements	15	13
12	Environmental impact statements for new developments near transmission pipelines	11	9
13	Media campaign to alert people to the presence of pipelines	11	9
14	Restrictions on the location of critical facilities near transmission pipelines (*e.g.*, fire and police stations, public schools).	8	7
15	Berms and containment ponds adjacent to hazardous liquid pipelines that traverse subdivisions in order to contain spills and prevent damage to buildings	5	4
16	Density bonuses or other incentives for developers that move development away from pipelines	4	3
17	Transfer of development rights from areas near transmission pipelines to less hazardous areas	4	3
18	Special transmission pipeline hazard ordinance	1	1
19	Transmission pipeline zoning overlay district with standards for pipeline rights-of-way	0	0

Table 4.2 illustrates distinct categories among the tools. Four tools were used by over half of the local governments. Two tools were used by a quarter of respondents or more. The remaining tools received infrequent use. The four most frequently used tools required little effort by planners. Tools one, three, and four required a landowner or developer to follow

guidelines set out by the planning agency. A local government can adopt these three tools regardless of knowledge about transmission pipelines location or hazards associated with pipelines. Tool two, signs identifying pipeline hazards, is put in place by the pipeline operator. Although signage is a federal requirement and implemented by the pipeline operator (49 CFR 192.707, 195.434), given that almost two-thirds of planning departments do not have maps of transmission pipelines (tool five) signs supply important information. However, according to Noll and Hildebrand (2004, 32) use of signage alone can be misleading since signs only indicate approximate locations and pipelines may bend at an angle underground between markers.

The second grouping of tools included maps and building setbacks. These tools require more effort from planning departments than the most widely used group. Maps of transmission pipeline locations were used by over a third of respondents (39%). The remaining communities may not use maps due to the arduous process required to obtain locations of transmission pipelines. The U.S. Office of Pipeline Safety has digital maps of pipeline locations, yet these locations were classified after September 11, 2001. Local governments can petition the federal Office of Pipeline Safety's National Pipeline Mapping System to receive this information, yet busy local government staff may lack time for this step or be unclear how to apply for the information. Building setback requirements, used by 28% of respondents, require knowledge of potential pipeline hazards and forethought about potential risk to building inhabitants from a pipeline rupture. The limitations on knowledge about pipeline locations and potential hazards to nearby buildings suggests a discord between homeland security for protection against terrorist threats and homeland security that uses local planning to influence growth management and hazard mitigation policies.

The average community employs fewer than five tools (see Table 4.3). Apart from the six tools discussed above, fewer than 20% of communities use each of the remaining tools. Many of these infrequently used tools require more substantial information about pipeline hazards. Given that there is not model legislation available for creation of policies regulating development near pipelines (Cooper 2003, 3), detailed knowledge of pipeline hazard zones would facilitate pipeline-appropriate buffer areas, watershed protection ordinances, or restrictions on location of critical facilities.

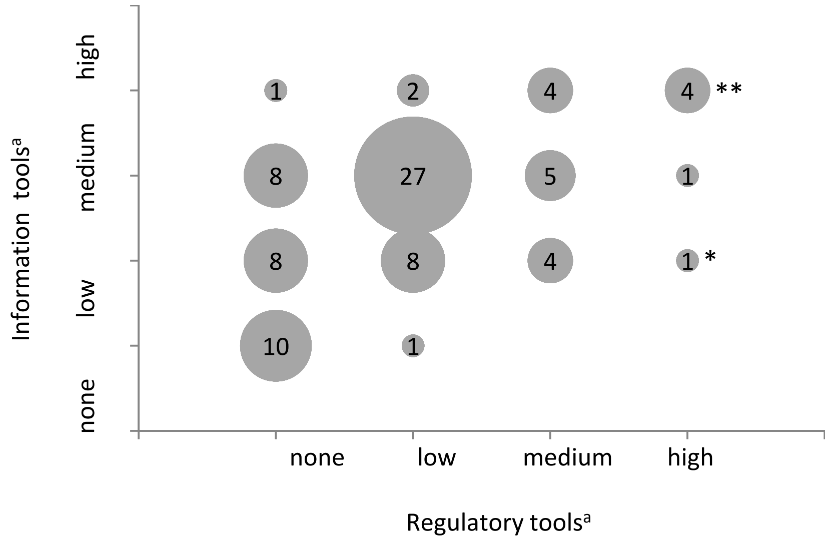
Table 4.3, Descriptive statistics for variables used in regression analyses (n=85)

Variable name	Mean	Std. Dev.	Minimum	Maximum
Tools to mitigate pipeline hazards	4.5	3.1	0	17
Risk Perception				
Environmental groups	0.1	0.3	0	2
Pipeline industry groups	0.2	0.6	0	3
Individuals	0.2	0.6	0	3
Commitment				
Commitment by planning agency	2.9	0.8	1	4.8
Capacity				
Land use plan	0.9	0.3	0	1
Access to information about pipelines	1.1	1.8	0	9
Agency knows pipeline location	0.8	0.4	0	1
Community Context				
Low-income households (%)	23.1	8.3	6.0	44.8
Population change 1990-2000 (%)	21.4	15.1	-4.1	78.4
Density (100 persons/sq. km.)	3.5	3.2	0.1	16.1
Recent pipeline accident	0.1	0.3	0	1

4.2.1.1 Regulatory, information, incentive tool use

Communities in North Carolina use a mix of both regulatory and public information tools. Most communities use a moderate number of public information tools and few regulatory tools (Figure 4.1). The relatively higher use of information tools suggest that there may be more impediments to use of regulatory tools than to use of information tools. A second reason may be that the degree of power a governing body has to invest into regulation is higher (Vedung 1998). Given the low priority that many local governments attribute to hazard mitigation (Burby 2006, 178-180) a government may also lack interest in investing in regulation. Vedung (1998, 40) notes that policy decisions generally move from the least coercive to most coercive, which may be another explanation for why most communities use more information than regulatory policy tools.

Few communities use incentives. Those that do also employ higher numbers of regulatory and information tools. Three communities using both high regulatory and high information tools used one incentive tool. One additional community using both high regulatory and high information used two incentive tools. One community using high regulatory and low information tools also used an incentive tool. The fairly trivial use of incentives (5 communities total) is consistent with conclusions by Dalton and Burby (1994, 450) who found limited use of incentives to govern land use in hazardous areas.



* 1 community using 1 incentive; ** 3 communities using 1 incentive, 1 using 2 incentives;
^{a} none= 0, low=1-2 tools, medium = 3-4 tools, high=5+ tools

Figure 4.1, Comparison of tools used to mitigate transmission pipeline hazards, showing communities using regulatory, information and incentive tools

4.2.2 Connections between commitment, capacity, and perception of risk

Although pipelines are considered critical infrastructure by the federal government, descriptive statistics suggest that few communities take pipeline hazards seriously. Local governments observe little participation from environmental groups, individuals, or pipeline operators in planning to address pipeline hazards (Table 4.3) suggesting a low perception of risk from pipeline hazards. Risk perception did not display a statistically significant correlation with agency commitment to hazard mitigation (Table 4.4) as others found (May 1991a). I speculate that this difference may be due to the extremely low interest by stakeholders or a result of variable measurement. I measured commitment to mitigation generally rather than to one specific hazard.[9] Given the low perceptions of risk, consideration of Burby's (2003) finding that planners can significantly influence participation for issues without publics seems especially relevant to pipeline hazards.

Table 4.4, Kendall's tau correlations of agency commitment with risk perception and capacity variables (n=85)

	Kendall's tau-b	
Variable	Coef.	p-value
Risk Perception		
Environmental group interest	0.1	0.4
Pipeline industry interest	0.1	0.2
Interest by individuals	0.1	0.2
Capacity		
Have land use plan	0.0	1.0
Pipeline information access (index)	0.2**	0.0
Agency knows pipeline location	0.1	0.4

*p<.1, **p<.05, ***p<.01

I found statistically significant correlations between one capacity variable, access to information, and commitment to mitigation (Table 4.4). This correlation points toward the

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[9] Cronbach's Alpha, a measure of scale reliability, produced a coefficient of 0.85 for the commitment index. The alpha score suggests that the scale provides a good measure of commitment.

connections between technical proficiency and commitment. This finding would support May's (1991b) assertion that for policies without publics commitment by experts drives policy adoption. Likewise, it might suggest the need for collaboration among groups such as emergency managers and planners that access different types of hazard knowledge (Pearce 2003) or with industry or business groups (Lindell & Perry 1996). Nonetheless, few accessed available information about pipelines. I found a mean information score of 1.1 on a 10-point scale (see Table 4.3) signaling weak diffusion of information about transmission pipeline hazards.[10]

Risk perception did not display statistically significant differences for either environmental groups or individuals in areas where an accident had recently occurred compared to areas with no accidents (Table 4.5). However, risk perception was statistically different for pipeline operators in areas with and without recent accidents. The statistically significant higher interest from pipeline operators post-accident follows May's (1991a, 265) suggestion that focusing events increase perception of risk and action on it. The federal government and trade groups have suggested communication between pipeline operators and local land use planners as a preventative measure for reducing accidents (Common Ground Alliance 2003, 14; Noll & Hildebrand 2004, 32-33; Transportation Research Board 1988, 5). However, pre-accident involvement may be less than these groups expect, leading to a need for creation of more effective interagency collaboration (McGuire 2006) or regional technical collaboration to increase resilience (Boin et al. 2003).

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[10] Cronbach's Alpha, a measure of scale reliability, produced a coefficient of 0.81. The alpha score suggests that the scale provides a good measure of information. Sources were identified through pipeline reports and a web search of possible pipeline information sources.

Table 4.5, Comparison of mean perception of risk for communities with or without accidents in last 5 years using Wilcoxon (Mann-Whitney) test

	Accident	No accident	z
n	7	78	
Environmental group	0.0	0.1	0.5
Pipeline industry	0.7	0.2	-2.4**
Individuals	0.6	0.2	-1.2

*p<.1, **p<.05, ***p<.01

4.2.3 Regression Results

Negative binomial regression predicting the number of tools used to mitigate pipeline hazards revealed statistically significant associations between the dependent variable and select independent variables measuring perception of risk, commitment, capacity, and community context. Table 4.6 shows the results of the multivariate regression analysis for use of all tools (see Appendix B, Table B1 for bivariate results).[11] Several measures of goodness-of-fit suggest that the full model (Model 4) is preferred. The Likelihood-ratio alpha test indicated preference of all models over Poisson models. The pseudo-R^2 indicates all four models are more appropriate than a constant only model and that Model 4 was preferred to Models 1-3.[12] Akaike's Information Criteria and Bayesian Information Criteria tests indicate that the full model (Model 4) shows improvement over the truncated models.

I expected the total tools variable to measure sophistication to manage pipeline hazards; however, the results do not address differences in effectiveness of individual tools. Thus, some communities may use one or two tools more effectively than other communities use several tools. In addition, another underlying factor may play a role in predicting tool

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[11] A Pearson's goodness of fit test indicated overdispersion such that a negative binomial regression model was more appropriate than a Poisson model (Long 1997).

[12] The pseudo-R^2 criterion is a measure between 0 and 1 of the improvement of the full model over a constant-only model (Long 1997, 104-109). The pseudo- R^2 is similar to an R^2 criterion for ordinary least squares regression that shows a ratio of improvement with addition of variables (Kutner et al. 2005, 354-355). However, according to Long (1997, 107), interpretation of the pseudo R^2 for count variables should be considered within the context of the model as it can provide the impression of incorrect positive or negative results.

usage. Nevertheless, the results of this study illustrated the relevance of risk perception, commitment to mitigation, capacity for planning, and community context for addressing pipeline hazards.

In the review of the risk perception literature I found cases both supporting (Gerber & Neeley 2005) and challenging (Krueger et al. 2009) the influence of risk perception on hazard mitigation. In the negative binomial regression models I found similar results (Table 4.6, Models 1, 4). Risk perception by individuals had a negative influence and risk perception by environmental and pipeline operator groups had a positive influence on use of mitigation tools. One might expect that environmental groups play an influential role in increasing mitigation tools due to the potential for environmental degradation from pipeline accidents. Others have found environmental groups to be influential factors in adoption of growth management regulation (Burby 2003; O'Connell 2009). Individuals not associated with any particular group are likely landowners or others interested in limiting government development restrictions. Individual land owners have been characterized as focused on individual rights rather than government regulation within the growth management literature (Jacobs 1999).

Table 4.6, Multivariate negative binomial regression models predicting the number pipeline mitigation tools in use

	Model 1				Model 2				Model 3				Model 4			
Independent Variables	Exp. Coef.		Std. Err.	z	Exp. Coef.		Std. Err.	z	Exp. Coef.		Std. Err.	z	Exp. Coef.		Std. Err.	z
Risk Perception																
Environmental groups	1.55	**	0.3	2.2									1.49	**	0.3	2.2
Pipeline industry groups	1.31	**	0.2	2.2									1.31	***	0.1	2.5
Individuals	0.68	***	0.1	-2.5									0.63	***	0.1	-3.2
Commitment																
Commitment to mitigation					1.21	**	0.1	2.2					1.16	**	0.1	1.8
Capacity																
Land use plan									1.58	*	0.4	1.7	1.50	*	0.4	1.6
Access to pipeline information									1.15	***	0.0	3.6	1.13	***	0.0	3.6
Know pipeline location									1.53	**	0.3	2.3	1.49	**	0.3	2.3
Community Context																
% Low income households	0.98	**	0.0	-2.1	0.98	**	0.0	-2.1	0.98	**	0.0	-2.0	0.98	**	0.0	-2.2
Population change 1990-2000	1.00		0.0	0.6	1.00		0.0	-0.5	1.00		0.0	0.0	1.01		0.0	1.1
Density (100 persons/sq. km.)	1.04	**	0.0	2.0	1.02		0.0	1.0	1.01		0.0	0.6	1.02		0.0	1.1
Recent pipeline accident	1.13		0.3	0.5	1.13		0.3	0.5	0.98		0.2	-0.1	0.99		0.2	-0.1
Constant	5.87	**	2.0	5.2	4.30	***	1.8	3.5	2.87	**	1.2	2.4	1.72		0.8	1.2
Summary Statistics																
Number of observations	85				85				85				85			
LR statistic	16.76				10.99				22.43				38.61			
P (alpha) ~=0	0.00				0.00				0.00				0.03			
Pseudo R2	0.04				0.03				0.05				0.09			

*p<0.1; ** p<0.05; *** p<0.01

The statistical significance of the commitment variable (Table 4.6, Models 2, 4) emphasizes the role planning agencies play in addressing mitigation of transmission pipeline hazards. This finding supports previous research indicating the value of commitment for achieving land use planning goals (Burby & Dalton 1994; Norton 2005).

The statistical significance of several capacity variables mirrors previous literature on the influence of capacity for reducing hazard risk (Godschalk 2003; May & Birkland 1994; Reddick 2008; Scanlon 1999), and highlights the relevance of knowledge as an attribute of capacity. The statistical significance of the knowledge index variable points out the importance of access to information by planners. Holding all other variables constant, knowing the location of the pipeline increased tool adoption by 49% (exponentiated coefficient= 1.49). A land use plan would similarly increase adoption of tools by 50% (exponentiated coefficient. = 1.50). Improving ease of access to mapping information through knowledge of its availability and steps required to obtain it in conjunction with better information for how to address development near pipeline hazards could positively influence local land use planning to mitigate pipeline hazards.

One community control variable, percent low-income residents, was a statistically significant and negative predictor of tools used to mitigate pipeline hazards. Considering the large range (6 to 45%) in percent low-income residents within the survey communities, the influence is not trivial. A 10% increase in low-income residents would correspond with a 21% decrease in use of tools, holding all other variables constant.[13] Others have found community wealth matters for implementation of growth management (Berke et al. 1996; Brody et al. 2006), so the result was not surprising. The association of the percent lower-

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[13] Unexponentiated coefficient for income = -0.023, and $e^{-0.023X10}$ = 0.79, or a 21% percent decrease.

income residents variable with decreased tool use suggests the need for additional research on attributes of residents living near transmission pipelines and continued evaluation of how equity issues in planning are relevant for hazards.

When tool use is split by type of tool (regulatory or information), the results provide additional insight into tool usage (Tables 4.7 and 4.8). For information tools there was no indication of over-dispersion, so Poisson regression was used. Diagnostics for models of regulatory tools indicated over-dispersion so I use negative binomial regression.[14] The perception of risk by environmental groups was a statistically significant and positive predictor of regulatory tool usage, but not a statistically significant predictor of use of information tools. With an exponentiated coefficient of 2.16, the effect on regulatory tool use is much higher for than the effect on total tool use (116% compared to 49%, from Table 4.6). Individuals were statistically significant and negatively associated with regulatory tools only, yet the difference in effect on regulatory and total tool use was less dramatic (55% compared to 37%, from Table 4.6). Unlike environmental groups and individuals, risk perception by pipeline industry groups was statistically significant and positively associated with both information and regulatory tools. The results suggest that the perception of risk by environmental groups may be a key to adoption of more restrictive land use policies in hazardous areas. Given the potential impact a pipeline rupture could have on the environment, perhaps environmental groups are more likely to push for adoption of stronger restrictions rather than tools identifying the hazard due to the potential impact on reducing environmental contamination. Individuals association with regulation tool use was not

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[14] Diagnostic tests indicate zero inflated Poisson and zero inflated negative binomial models were inappropriate for both information and regulatory models.

surprising given Downs' (2005, 372) suggestion that regulation of growth runs contrary to the economic interests of landowners.

Commitment was statistically significant and positively associated with use of information tools, but not with use of regulatory tools. These findings may suggest that commitment by planning agencies has limitations in terms of policy results. Although this research did not take into consideration the role of political capital, I speculate that tools regulating land uses require more political capital and community support to implement. Strong and colleagues (1996, 14) claim that regulation is the cause of most disputes between property owners and government agencies. Likewise, Feiock et al. (2008) demonstrated that elected or appointed status of commissioners can have an influences on use of some types of growth management tools. Given that information tools do not necessarily involve long-term changes to a site's development potential, these techniques may be easier to implement.

Capacity for planning was a statistically significant factor in all models. Access to information about pipeline hazards was consistently a statistically significant and positive predictor. Having a land use plan and knowing the location of the pipeline were statistically significant and positively associated with total use of tools and use of information tools, but not statistically significant for regulatory tools. Previous studies used a measure of the quality of a land use plan with regards to hazards (e.g., Burby & May 1997; Nelson & French 2002), yet this study evaluated only if a community had a land use plan due to indications in the exploratory study that few land use plans would address pipelines specifically. Others have also found that policy quality may not indicate likelihood of growth management success (Deyle et al. 2008). Future research might take into consideration general plan quality as well as quality for the specific policy issues to better evaluate the impact of a land use plan.

Table 4.7, Multivariate negative binomial regression models predicting the number of regulatory tools in use

	Model 1				Model 2				Model 3				Model 4			
Independent Variables	Exp. Coef.		Std. Err.	z	Exp. Coef.		Std. Err.	z	Exp. Coef.		Std. Err.	z	Exp. Coef.		Std. Err.	z
Risk Perception																
Environmental groups	2.22	***	0.6	2.8									2.16	***	0.6	2.9
Pipeline industry groups	1.47	**	0.3	2.1									1.47	**	0.3	2.2
Individuals	0.51	***	0.1	-2.6									0.45	***	0.1	-3.0
Commitment																
Commitment to mitigation					1.17		0.2	1.1					1.12		0.1	0.9
Capacity																
Land use plan									1.39		0.6	0.8	1.28		0.5	0.6
Access to pipeline information									1.17	**	0.1	2.5	1.16	***	0.1	2.7
Know pipeline location									1.17		0.3	0.5	1.23		0.3	0.8
Community Context																
% Low income households	0.98		0.0	-1.3	0.97		0.0	-1.3	0.98		0.0	-1.2	0.98		0.0	-1.2
Population change 1990-2000	1.01		0.0	0.9	1.00		0.0	-0.2	1.00		0.0	0.2	1.01		0.0	1.4
Density (100 persons/sq. km.)	1.05		0.0	1.5	1.02		0.0	0.6	1.01		0.0	0.3	1.03		0.0	0.9
Recent pipeline accident	1.15		0.5	0.4	1.10		0.5	0.2	0.92		0.4	-0.2	0.97		0.4	-0.1
Constant	1.82		1.0	1.1	1.81		1.3	0.9	1.38		1.0	0.4	0.72		0.5	-0.5
Summary Statistics																
Number of observations	85				85				85				85			
LR statistic	15.34				4.02				9.44				24.06			
P (alpha) ~=0	0.00				0.00				0.00				0.03			
Pseudo R2	0.05				0.01				0.03				0.08			

*p<0.1; ** p<0.05; *** p<0.01

The statistical significance of percent low-income residents that was identified in the regression results for total tools was not consistently associated with regulatory and information tool use. The percentage of lower-income residents was statistically significant and associated with use of information tools, but not regulatory tools. The statistical significance of this variable may signal a community-level need for assistance with planning. Findings from earlier research indicate that wealthier communities have a higher likelihood of implement growth management (Berke et al. 1996; Brody et al. 2006). The results of the regression analysis provided support for these earlier findings. I speculate that less wealthy communities have fewer resources to address hazards. Department staff may have limited time to devote to investigation of hazard boundaries if the information is not already available to them. Likewise, local interest groups with objectives other than development management may have stronger clout within these communities.

4.2.4 Study limitations

The results of the analysis conducted in chapter have several limitations. First, measurement of several variables could be improved with additional resources. The perception of risk variable does not directly measure hazard risk by the groups involved. I expect that interest in developments with pipelines hazards by each of the three groups in the study indicated a perception that pipelines have high risk. However, direct surveys of these groups would provide a better indication of the quality how this variable measures risk perception from pipeline hazards. Likewise, I was not able to disaggregate the differences in perception of risk from natural gas or liquid pipelines. The environmental repercussions from these two types of pipelines are quite different. There may be differences in risk perception from different types of pipelines.

Table 4.8, Multivariate Poisson regression models predicting the number of information tools in use

	Model 1				Model 2				Model 3				Model 4			
Independent Variables	Exp. Coef.		Std. Err.	z	Exp. Coef.		Std. Err.	z	Exp. Coef.		Std. Err.	z	Exp. Coef.		Std. Err.	z
Risk Perception																
Environmental groups	1.06		0.2	0.3									0.95		0.2	-0.2
Pipeline industry groups	1.23	*	0.1	1.9									1.23	*	0.1	1.8
Individuals	0.84		0.1	-1.2									0.81		0.1	-1.4
Commitment																
Commitment to mitigation					1.22	**	0.1	2.5					1.16	*	0.1	1.8
Capacity																
Land use plan									1.61	*	0.5	1.7	1.64	*	0.5	1.7
Access to pipeline information									1.12	***	0.0	3.1	1.12	***	0.0	2.9
Know pipeline location									1.86	***	0.4	3.2	1.72	***	0.3	2.8
Community Context																
% Low income households	0.98	**	0.0	-2.2	0.98	**	0.0	-2.2	0.98	**	0.0	-2.0	0.98	**	0.0	-2.1
Population change 1990-2000	1.00		0.0	-0.1	1.00		0.0	-0.7	1.00		0.0	-0.3	1.00		0.0	0.1
Density (100 persons/sq. km.)	1.03		0.0	1.6	1.02		0.0	1.1	1.01		0.0	0.6	1.01		0.0	0.6
Recent pipeline accident	1.12		0.3	0.5	1.18		0.3	0.7	1.11		0.3	0.5	1.00		0.2	0.0
Constant	4.04	***	1.3	4.5	2.54	**	1.0	2.5	1.48		0.7	0.9	1.01		0.5	0.0
Summary Statistics																
Number of observations	85				85				85				85			
LR statistic	11.12				13.85				26.63				33.34			
Pseudo R2	0.03				0.04				0.08				0.10			

*p<0.1; ** p<0.05; *** p<0.01

The measurement of the land-use plan variable could also be improved. Previous research has looked at the quality of land use plans for a specific hazard or policy goal. Rodríguez and Godschalk (2004, 4), in an analysis of land use plans in North Carolina, found high variability in plan quality and in the amount of time since the most recent revision. Nonetheless, my exploratory analysis concluded that it was highly unlikely that any plan would have specific references to transmission pipelines. Given this variability identified by Rodríguez and Godschalk, a future study could include a measure of general plan quality even if the plan did not address the specific issue.

Given these two variable measurement concerns, there is potential for both type I and type II errors. Type I errors are those made when incorrectly rejecting a null hypotheses. Type II errors are made when a hypothesis is not rejected, but should be rejected (Shadish et al. 2002, 513). Addition of other variables might improve the model and reduce the potential for these types of errors. Additional variables that could be investigated include political pressures and size of hazard area. The inclusion of other variables or the use of alternative measurement of variables included in the model could affect log likelihood and pseudo r^2 values.

Second, the results of this study are not generalizable to all areas with pipeline hazards. A state such as Texas or Louisiana that has a large petrochemical industry may have better local knowledge about pipeline hazards as well as a constituency that is prepared to consider the risks of pipeline hazards. In addition, the majority of the communities within the study area were medium size communities. Due to the lack of multiple large urban areas in North Carolina, the comparisons made here may be limited to communities with similar population sizes. A future study could address if there are factors in large urban areas that are different than the communities considered in this study.

The categories used in this study to categorize tool use could be reorganized according to a different metric. I organized the tools into regulatory, information, and incentive tools. However, in several instances a tool could be categorized based on the outcome of the tool. For example, a regulatory requirement to conduct an environmental impact statement would produce information. Changing the categorization might yield different results.

Finally, while this study examined the tools most commonly used to address pipeline hazards, it did not calculate the utility of each tool. Some tools may be more effective than others for addressing pipeline hazards. Additionally, one tool may be more feasible to implement than another. This study did not evaluate the political or community support for tool implementation. A future study could address both effectiveness and feasibility of individual tools.

4.3 Conclusions

The findings from the research in this chapter are twofold. First, the study determined the tools most likely to be used by local governments to mitigate pipeline hazards. Second, it identified the factors that predict adoption of these tools. Communities in North Carolina use few tools to mitigate pipeline hazards. The most frequently used tools require effort from developers or pipeline operators rather than planning agencies. The large number of localities that use no tools to mitigate pipelines hazards highlights an area where homeland security partnerships for protection of pipeline infrastructure are minimal and indicate the scant emphasis critical infrastructure protection has received at the local level. These results suggest that pipeline hazards are of little substantive interest to planning agencies and generally rank extremely low on the planning agenda.

Given the limited interest in pipeline hazards at the local level, the results of the regression analyses provide tangible evidence for improving mitigation of these and other issues that receive little attention. The statistically significant association of perception of risk with use of mitigation tools by environmental groups, pipeline operator groups, and individuals highlights the importance of advocates for addressing development management outcomes for low-priority issues. The engagement of the environmental community specifically could prompt discussion of hazard mitigation near transmission pipelines in order to motivate tool adoption generally and regulatory tools especially. Pipeline operators were more active once a pipeline rupture had occurred. Given that the most frequently used tool was identification of pipelines on a subdivision plat, pipeline operators should be encouraged attend development-review processes in rapidly expanding urban areas.

Generating commitment to mitigation can payoff in adoption of tools. Commitment to mitigation had a statistically significant relationship with the number of total tools used to mitigate pipeline hazards. Fostering a climate where mitigation of any hazard is considered valuable may improve mitigation of hazards that receive less interest. However, the results also indicate that commitment may be most effective for information tools. Implementation of regulatory tools may require more than commitment to mitigation.

Capacity for planning was associated with adoption of pipeline mitigation tools. This result suggests that building capacity for planning generally can facilitate engagement with issues that may be lower on the agenda. For pipeline hazards specifically, improvements to the local knowledge base about transmission pipeline locations and the appropriate means to address nearby development may help local planning agencies choose appropriate tools. Likewise, while many communities know the location of the pipelines in their community, a large portion did not. Remedying this deficit would provide a positive benefit for the community.

The association of the percent lower-income residents in a jurisdiction with lower total tool usage suggests that continued research on exposure of marginalized groups to hazards remains necessary. Land use scholars have identified the potential differentials in exposure to other hazards and planners should continue to reflect on these potential disparities during land-use planning. Likewise, state-level and national-level resources could be provided to improve the planning disparities between affluent and underprivileged communities. Planning research has indicated that both pre-disaster planning implementation (Berke et al. 1996; Brody et al. 2006) and post-disaster recovery (Dash et al. 2001) have been tied to community-level prosperity.

While this research provided insight into an area that has received little attention, it also identified the difficulty of researching policies with little traction at the local level. Future research should focus on improving insight into the importance of individual land-use planning techniques to manage pipeline hazards, evaluating the most effective methods of transmitting information about pipelines hazards, and developing understanding of potential equity issues related to pipeline hazards.

5 Building capacity through collaboration between planners and emergency managers

Full stakeholder participation can improve long-term planning outcomes by generating consensus about contentious issues (Innes 2004). Nevertheless, some suggest that there are specific types of planning problems, such as growth management in hazardous areas, where there is little interest by a large and diverse group of stakeholders (May 1991a, 1991b). In these cases, technical collaboration among specific groups of stakeholders may jumpstart the planning process. Godschalk and colleagues (1998) view this technical collaboration as a precursor to processes that include broader groups of stakeholders.

The findings from Chapter 4 illustrate the effect that interest in transmission pipelines can have on mitigation of pipeline hazards. This interest can be viewed in the role that perception of risk by environmental groups, pipeline industry groups, and individuals have on use of mitigation tools (Tables 4.6-4.8). However, there may also be other groups whose influence is important to improving mitigation practices such as neighboring planning or emergency management agencies.

Planners are not the only actors within the community that deal with pipeline hazards. Andrews (1987, 5) highlighted the role that coordination between planners and emergency managers can play for reducing community risk for hazardous materials risks. Emergency managers have unique skills and perspectives to offer the planning process, yet their expertise can be overlooked, leading to a less integrated hazard management program (Petak 1985). In addition to emergency managers, a regional perspective offered from nearby planning departments has the potential to fill knowledge gaps and promote horizontal coordination that can reduce trans-jurisdictional hazards.

The findings from Chapter 4 also illustrate the need for additional exploration of the connections between information and commitment. Planning literature suggests the link between commitment to and capacity for mitigation can be improved through collaborative practices (e.g., Burby & May 1997; May & Burby 1996). Capacity, measured through access to information, was positively associated with use of tools to mitigate pipeline hazards in Chapter 4 even though planning agencies had a very low frequency of access of information tools about pipeline hazards (see Table 4.3). Improving capacity by address knowledge gaps using collaborative partnerships may have an effect on hazard mitigation practices.

Within this chapter I address collaborations between planners and emergency managers. I first describe the types of partnerships I observed. Based on the literature on collaborative partnerships, I analyze how the collaborations improve capacity, build knowledge, and develop the mitigation agenda. I propose the following hypotheses:

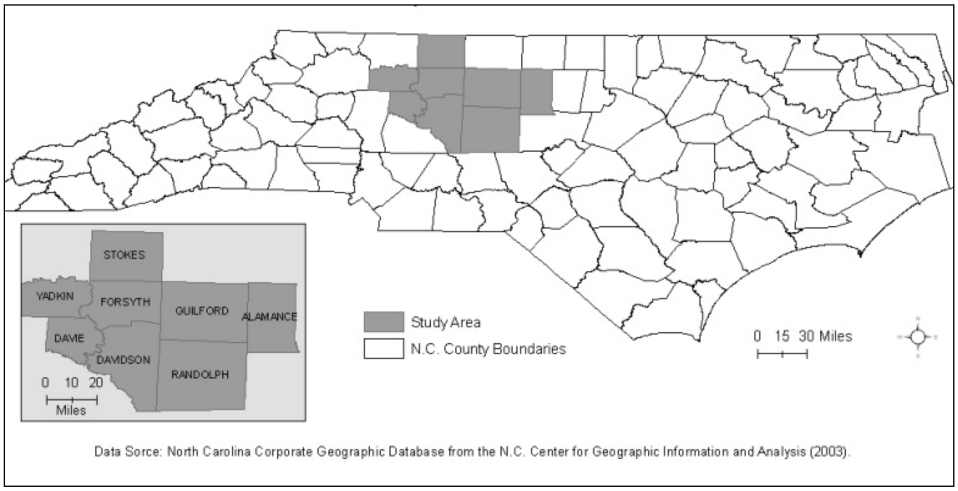
> H1. Collaborations between planners and emergency managers will improve knowledge about transmission pipeline hazards
> H2. Collaboration between emergency managers and planners will improve regional networks for agencies to draw on when addressing transmission pipeline hazards in their community
> H3. Collaboration between planners and emergency managers will help place pipeline hazards on the local agenda

Using interviews of planners and emergency managers in the Greensboro-Winston-Salem metropolitan areas, I find a range of types of collaborations that build capacity for addressing transmission pipeline hazards. In this chapter I detail three specific types of collaborations that planners and emergency managers used. I classified these collaborations as loose alliances, full partnerships, and hierarchically-cooperative groups. I find that each type of collaboration had implications for addressing pipeline hazards within a mitigation agenda, for generating long-term capacity to mitigate pipeline hazards, and for improving knowledge about pipelines.

5.1 Methods

5.1.1 Study Area

The Greensboro-Winston-Salem (GWS) metropolitan area is located in central North Carolina (Figure 5.1). This area contains both liquid and natural gas transmission pipelines that run between the two largest cities in the region, Greensboro and Winston-Salem. The study area included 23 planning jurisdictions and 22 emergency management jurisdictions.[15] While much of the area surrounding the transmission pipelines is rural, future growth patterns suggest urban growth in these areas is likely. Expected growth for the larger jurisdictions and smaller rapidly growing jurisdictions centers on the space currently occupied by pipelines.



Data Sorce: North Carolina Corporate Geographic Database from the N.C. Center for Geographic Information and Analysis (2003).

Figure 5.1, Location of Greensboro-Winston-Salem Metropolitan Statistical Area within North Carolina

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[15] In four communities, the emergency management and planning jurisdictions did not correspond precisely

Within the GWS metropolitan area there are over 780 miles of transmission pipelines. This includes approximately 392 miles of natural gas and 389 miles of liquid transmission pipelines (Hall 2005). Many communities have both types of pipeline within their community boundaries. The GWS metropolitan area has more natural gas transmission pipelines than any other metropolitan area in North Carolina. Guilford County has the highest total number of miles of transmission pipelines of any county in North Carolina with over 307 total miles of transmission pipelines.

5.1.2 Population characteristics

The communities in the study area were generally comparable to the state of North Carolina. While the percent black, white, Latino/Hispanic were similar to overall population characteristics for North Carolina, the median household income and percent owner-occupied housing units were higher for the study area (Table 5.1). Given that the Greensboro-Winston Salem metropolitan area is home to several large employers and less rural than many area of the state, these differences were not unexpected.

Table 5.1, Comparison of population characteristics of case study communities to North Carolina

	Case study communities	North Carolina
Percent Black only	21%	22%
Percent White only	74%	72%
Percent Hispanic/Latino	5%	5%
Percent owner occupied units	75%	69%
Percent renter occupied units	25%	31%
Median household income	$45,680	$39,184

Source: U.S. Bureau of the Census (2000) Summary File 3

Planners and emergency managers worked in jurisdictions of varying sizes. The mean population size of communities in the study was 50,700 with a range from 3,000 to 260,000 (U.S. Bureau of the Census 2000). Fifteen jurisdictions were smaller rural or suburban communities connected to the major urban areas of Winston-Salem, Greensboro, and High Point. I purposefully included many rural or suburban areas since these areas appeared to be rapidly expanding into areas with transmission pipelines. Communities with fewer than 50 thousand inhabitants added population at almost double the rate between 1990 and 2000 as communities with more than 50 thousand inhabitants (average rate of 30% versus 16%).

5.1.3 Data collection and analysis

I used a purposeful sampling design to identify cases (Miles & Huberman 1994, 27-28). Forty-five semi-structured interviews were conducted with planning directors and emergency managers in the Greensboro-Winston-Salem metropolitan area during August 2005 through January 2006. With three exceptions, all interviews were conducted one-on-one. In the exceptions the contacted interviewee brought a member of the local government whom he or she felt could provide an important viewpoint. These additions either were specialists or had been employees in the planning or emergency management department for many years and the primary director was new to the job. Since in these cases there was one individual who led the conversation, these pairs were treated as a single case. In areas without emergency managers, interviews were conducted with fire chiefs. Interviewees were identified through the community's website. If the website provided unclear information regarding planning and emergency management leaders, the town hall (or county seat) was called for clarification.

An interview protocol was created prior to beginning the case study (Yin 2003, 73-76). Two planning experts, a former town planner, and a pipeline safety expert from the U.S. Office of Pipeline Safety reviewed questions included in the protocol. The University of

North Carolina Behavioral Institutional Review Board approved the interview process and materials. The interview questions provided a prompt for guiding discussion, but each interview was semi-structured and informal follow-up questions proceeded the formal questions. Interviews lasted between 20 and 90 minutes, with the majority of interviews completed within 40 minutes.

I attempt to present an unbiased portrayal of the interview responses. Interviews were coded both by hand and using Atlas.ti 5.0 (Muhr 2007). The coding scale was developed after completion and transcription of the interviews. I conducted first-level coding which was then refined through several iterations to look for patterns prior to recoding (Miles & Huberman 1994, 69). I used field notes and post-coding memos (Miles & Huberman 1994, 72) to assist reflection on interview interpretation. The results are organized around several key areas identified in the analysis. I use extracts from interviews to illustrate the link between data and analysis; quotes exemplify connections links or exceptions to specific themes identified in the analysis.

5.2 Findings

I find three types of collaborations within the study area: loose alliances, full partnerships, and hierarchically-cooperative groups. Each type of partnership had distinct ramifications for building community capacity. Collaborations that involved full partnerships were most likely to result in improved capacity through knowledge sharing. Loose alliances and hierarchal relationships provided communities with access to planning or emergency management experts, but required both departments to be proactive in their mitigation efforts for pipeline addressing accidents. Departments with little interest in pipeline hazards were the least likely to leverage their loose alliances or hierarchal relationships to the benefit of mitigation. Lack of interest led to only minor knowledge sharing between these two types of partnerships, reducing the capacity-building effects of the collaborations. Below I describe the three types of partnerships I identified in the study area and discuss the ramifications for building capacity.

5.2.1 Types of collaborations

In the Greensboro-Winston-Salem area I find a range of types of collaborations. I categorize the collaborations into three types: loose alliances, full partnerships, and hierarchically-cooperative groups. I define the loose alliances as a partnership between two agencies where collaboration is ad hoc, but both parties are cognizant of resources available through the other. I define the full partnerships as a pairing between two agencies where collaboration is ongoing and active. Partners are interconnected with shared resources (knowledge, physical or both types of resources). The hierarchically-cooperative groups are partnerships formed between two unequal agencies. One agency is typically larger and has access to additional resources. The partnership is either contracted for a period of time or for an ongoing period. In Table 5.2 I illustrate some of the characteristics of these three collaborative groups. The collaborations involved planner-emergency management parings or within-discipline groups (either emergency manager-emergency management or planner-planner). I discuss the three types of partnerships in detail then evaluate how these partnerships influence capacity to address pipeline hazard mitigation.

Table 5.2, Description of collaborative partnerships for transmission pipeline hazards

	(+)	(-)
Loose alliance	• Familiar with counterparts • Feeling of self-sufficiency • Able to find expertise when needed	• Segregated expertise • Ad-hoc meetings, no joint leadership • Lack political support for joint ventures (e.g., long-range mitigation)
Full partnerships	• Jointly staffed boards • Formal agreements • Partners bring familiarity with multiple aspects of issue to table • Someone familiar with problem even if many are not • Developed collaborative relationship • More likely to incorporate mitigation	• Consensus building can be difficult • Potentially slower progress • Needs leadership (often outside contractor)
Hierarchically-cooperative groups	*Smaller government* • Able to leverage outside resources at low cost • Many needs met with outside expertise *Larger government* • Strong knowledge base • Staff w/specialized education • Large staff • Uses complex planning tools or has specialized emergency management equipment	*Smaller government* • Reliant on partner agency • Small staff (1-2) • Staff w/limited specialized education/certification/tenure • Less interest in mitigation due to other concerns *Larger Government* • Busy with own needs • Not anticipating regional planning concerns of smaller locality

5.2.1.1 Loose alliance

Many of the collaborations between planners and emergency managers could be identified as loose alliances. In these collaborations, both parties identified their counterpart and discussed interactions with that organization. The relationships between planners and emergency managers were largely voluntary and informal. One planner in a small county agency noted, “We cooperate very well when necessary. Planning and emergency management are under the same umbrella of services in the county. It’s a day-to-day thing—everyone knows each other and shares a secretary” (P4). An emergency manager working in a moderate-sized jurisdiction described the collaboration with the planning department as the following, “We have good contact…If they have a question they just pick up the phone. We know one another by name. It’s not a day-to-day thing, but it’s close” (EM16). In the loose alliance collaborations there appeared to be a respectful distance between organizations but a willingness to lend assistance if needed.

Interviewees mentioned a variety of reasons for lack of more formal joint planner-emergency management efforts. These reasons included limited support for joint efforts that specifically involved transmission pipelines or lack of interest by one or both parties. One director of a larger county emergency management agency noted that the two agencies “coordinate well, but we don’t focus on every application and plan. But if they [planning] need assistance, the emergency department is happy to help review plans” (EM2). A few interviewees suggested that joint-meetings were not necessary. Others noted the lack of political support for joint efforts. The lack of support from various corners follows Gray’s (1985, 928) assessment that without a perception of dependence stakeholders in interorganizational collaborations are unlikely to formalize relationships.

Planners also had loose alliances with other planning departments. These groupings were frequent among agencies in jurisdictions of similar population size. Small planning agencies had informal ties with nearby and similarly small agencies. These smaller agencies were likely to have the same types of issues with developers and have developed a relationship with other planners.

5.2.1.2 Full partnerships

Agencies actively involved with previous regional planning efforts, such as creation of a regional hazard mitigation plan, were most likely to discuss the role of collaboration among planners and emergency managers concerning transmission pipeline hazards. An emergency manager of a smaller county that had jointly managed the county hazard mitigation plan with the planning department described their cooperation as "great." In describing his agency's role he stated, "Generally when the site plan comes in, the emergency management department gives input on design, utilities, etc. in the plan. . . We have a good working relationship…We call the pipeline company when we are looking at a site plat that has a pipeline" (EM5). This last comment illustrated how the emergency management department's relationship with the pipeline industry was incorporated into hazard planning to the benefit of both planning and emergency management. A planner of a smaller municipality described the how the subdivision review process brought together a collection of local departments. He stated, "Subdivision construction has a plan review—it looks at all things and tries to catch them up-front before construction happens. The fire chief, planning, utility engineer meet about once a month and look for problems" (P10). Similar to the emergency manager quoted above, this planner indicated relevance and influence of joint meetings for hazard mitigation. In their discussion of the power of networks in collaborative planning, Booher and Innes (2002) highlighted the role of shared discussions for framing communication and generating common understanding of the problem. The planners and emergency managers in these full partnerships have discovered the advantages and power of this shared dialogue.

Emergency managers were likely to have full partnerships with other emergency mangers. Almost all emergency managers interviewed mentioned formalized cooperative agreements and regional partners. Several emergency managers detailed how the emergency chain of command would function with a pipeline rupture. Most emergency managers were connected into a network that incorporated contact with pipeline industry officials. Several emergency managers spoke of joint trainings with the pipeline industry to address a pipeline rupture. The contact with other emergency management departments and pipeline industry officials led several emergency managers to conclude that their jurisdiction was very prepared to address pipeline hazards.

Planners and emergency managers discussed the role of a recent effort to create a hazard mitigation plan in developing their relationship with their counterpart. One county's collaborative effort to create the hazard mitigation plan led the planner (P1) to develop relationships with not only his counterpart at the emergency management department, but also with small planning departments and fire marshals across the county. Innes (2004, 13) claims the power built through collaborative practices is one of the "most potent incentives" to generate long-term commitment to working together.

Many interviewees mentioned that the hazard mitigation plan followed state requirements to focus on natural hazards and did not include information specifically on transmission pipelines. However, the relationships created during the collaboration for research and writing the plan had an impact on building connections, relationships, and in knowledge sharing. Innes and Booher (1999a, 414) observed that the consensus building process, such as the one for the hazard mitigation plans in North Carolina, can result in offshoots such as new or continuing partnerships. The existence of these offshoots would follow Putnam's (2001) claim to the beneficial effects of building social capital. In only one case did interviewees suggest that the hazard mitigation plan creation effort was counterproductive to building collaborative partnerships. In this particular case the emergency management department had a previously generated hazard plan that was not fully incorporated into the overall county-wide plan.

5.2.1.3 Hierarchically-cooperative groups

Hierarchically cooperative groups allow small agencies to benefit from the resources available in a large agency. Planning agencies for smaller, suburban areas discussed their interconnectedness with their closest larger city or county agency. A planner for a smaller municipality described his department's role in conducting hazard mitigation as only doing "small stuff." He stated, "As a municipality we don't deal with large events. We defer it to the county. The hazard mitigation plan was put in place at the county-level and we are a partner with the county" (P23).

While most of the hierarchically cooperative groups were among planners only or emergency managers only, a few exceptions existed. One planner in a small municipal area noted, "[Community name] has a contract with the county to address hazards—all new subdivision plats are sent to emergency management to review" [P15].

Hierarchical cooperation had many strengths for smaller areas. Few planners at these smaller jurisdictions had AICP certification even though many were certified by the state as zoning officers. Others had limited tenure as a planner. In contrast, the planners contracted from the larger communities were AICP certified and experienced. The relationships with larger planning departments gave smaller towns access to personnel with experience and education. These intangible resources provided smaller towns with several types of information that a paper manual on transmission pipelines would not supply. Larger communities also had access to additional resources such as GIS mapping that the smaller jurisdictions lacked. Innes (1998, 58-59), in a review of the influences of information on policy, observed that many types of information help create an environment for authentic dialogue. For the hierarchical partnerships, the information resources gained through the partnerships were both tangible and intangible.

However, the interviewees also revealed weaknesses in the hierarchical relationships. While discussing one of the downsides of the relationship, an emergency manager noted that in the town he was a part of there was a "Planning board for the [small town name]. But [county name] does the planning…This fire department has little contact with planners. Sometimes they send development plans out, but not always. Some things get caught, but not always" (EM24). The county-level planning staff was not as connected to the municipal-level emergency managers. The separation led to less on-the-ground knowledge about new development by the emergency management. An emergency manager that had territory that included town and county areas noted,

> "There are definitely different responsibilities with the town than the county, but we have to answer to the county, not the town. . . we are involved in the planning process because the town is associated with our district. . . there is less direct cooperation because we are not under the town government here" (EM15).

The disconnect between different levels of government happened between both the lower-to-higher and higher-to-lower levels. Those at a higher level that provided contract services to a smaller government had less local information. A county-level planner who worked under a contract to provide planning for one small town noted there was a "county-wide mitigation plan. Through the countywide plan the [small town] assumes that countywide emergency services would come from the county. I haven't read the final draft of the plan; however, I think that [small town] approved the plan" (P15). The contracted county-level planner knew some about available resources, but was unsure about the municipal government's knowledge or if it had adopted the protocols.

The possibility for information transmission breakdowns within the hierarchical cooperative partnerships highlights a potential information diffusion problem. Innes (1998) described several types of information that planners use in collaborative practices and the value of collaborative practices for transmitting information. She suggests that planning research needs to identify how information is embedded into planning practice. The hierarchical cooperative partnerships relied on several sources of information, but have potential for barriers of information transmission problems within this type of partnership.

5.2.2 Using collaboration to build capacity

In the evaluation of factors contributing to mitigation of transmission pipeline hazards, I found local capacity to address transmission pipeline hazards had a positive statistical association with use of land use planning tools to mitigate pipeline hazards (see Table 4.6). Pearce (2003, 226) argued that local governments need to leverage both community planning and disaster management specialists to move towards sustainable hazard mitigation. These case studies confirm that some types of partnerships between emergency managers and planners can improve capacity for addressing mitigation hazards. Chaskin (2001, 295) defines community capacity as the interaction of human, social, and organizational resources that a community can leverage to solve problems and maintain well-being. Some partnerships between planners and emergency managers serve to improve connections between these agencies in order to leverage human and organizational resources. The regional networks created by multiple partnerships can develop social connections that communities draw upon to improve mitigation. However, the three types of partnerships provide different types of connections. Table 5.3 expands on capacity differences between the three partnerships.

Table 5.3, Comparison of capacity aspects of partnerships for transmission pipeline hazards

	Type of collaboration		
	Loose alliance	Full partnership	Hierarchically-cooperative group
Information flow	Bi-directional flow Requires interest from one or both parties	Bi-directional flow Circular building of shared knowledge	One-direction (top down)
Organizational resources	Shared as needed	Fully shared	Unequal. Larger agency provides more resources
Continuity	Disjointed	Interconnected	Interconnected, but potential for fragmentation with personnel changes
Leadership requirements	Requires individual(s) to follow through. One person or one agency may take the lead.	Leadership from both partners. Group can jointly contract outside leader to organize	Smaller government contracts services, including leadership, from larger government
Staff size	Various	Various	Usually one small agency, one larger agency
Staff education & training	Various	Various	One agency with more education/training than other agency

The collaborative partnerships build on the findings in Chapter 4 in several ways, but also have implications for other areas. First, I discuss the connections of the three type of partnerships to the findings from the previous chapter. Next, I discuss the implications of the three types of collaboration for creation of regional networks and access to information and experience.

The differences in how knowledge flows among partners in different collaborative relationships relates to findings from Chapter 4. Access to information about transmission pipelines was on average quite low for all communities in the survey (Table 4.3). Multivariate analysis (Table 4.6-4.8) revealed that access to information was positively associated with the number of tools used to address mitigation of pipeline hazards. The collaborative partnerships I identified above are unequal with regards to information transmission. However, the quality of information sharing among partners has implications for preparedness to address pipeline hazards. The circular knowledge sharing of a full partnership has benefits for both partners. The organizational qualities of the hierarchical relationships and loose alliances mean that communities that participate in these types of collaborations may miss opportunities for knowledge sharing.

The findings from Chapter 4 also illustrate the importance of advocates for mitigation. In Chapter 4, the role of advocates was considered through examination of outside groups such as environmental or pipeline operator groups. A perception of risk and thus input into the planning process by either type of group had positive influences on local mitigation tools used to address pipeline hazards. Innes and Booher (1999b, 153) identified that leadership can structure policy goals through facilitation of collaborative practices. Innes and Booher’s conclusions have two implications in light of the role played by environmental and pipeline operatory groups in Chapter 4. First, leadership by policymakers can help bring groups such as those identified in Chapter 4 into the planning process. Second, advocacy by planners can be used for agenda setting that places hazard mitigation on a list of items that require attention.

5.2.2.1 Regional networks

I identified a spillover effect of previous and recent collaborations for other types of hazard mitigation. Agencies that had collaborated with other regional agencies—emergency management or planners—on a state-required hazard mitigation plan were more likely to discuss knowledge sharing about transmission pipelines. This collaboration spillover suggested that building capacity for any type of planning effort might work its way into efforts that receive less attention, such as transmission pipelines. This finding builds on Boin and colleagues' (2003, 103) suggestion that knowledge sharing through networks can improve prevention learning. Likewise it follows Innes and Booher's (1999a, 414) finding that second-order collaborations on new topics can result from collaborative groups formed for other purposes.

The role of regional networks was the topic most frequently discussed by all respondents (Table 5.4) when discussing mitigation of pipeline hazards. The regional networks discussed ranged from local emergency planning committees, regional councils of governments, emergency management cooperative agreements, county groups created in response to a requirement for creation of a countywide natural hazard mitigation plan, and other less formal groups. However, while 50% of all respondents mentioned this topic, just over 20% of planners did so. Within the different types of partnerships, planners I identified as participating in full-partnerships with emergency managers were likely to mention this topic. Given that planners did not address pipeline company interactions when discussing mitigation of pipeline hazards and over 50% of emergency managers did mention interactions with pipeline company personnel, these partnerships could be a great source of knowledge sharing. The information-sharing potential from these partnerships could generate lasting improvements to public security (Comfort 2002) and widen the network strength of those concerned (Booher & Innes 2002).

Planners were more likely to mention growth management tools and the role of a hazard mitigation plan than emergency managers. Planner in all types of partnerships mentioned these topics suggesting that in any type of partnership with emergency managers they were likely to contribute this information to the partnership. The different priorities of each group also indicates the importance of involving perspectives from multiple disciplines to facilitate comprehensive hazard management (Fischhoff, Slovic, & Lichtenstein 2000, 135).

Table 5.4, Pipeline topics frequently mentioned by planners and emergency managers for improving mitigation of pipeline hazards

	% Mentioning topic		
	All Respondents (n=45)	Planners (n=23)	Emergency Managers (n=22)
Role of regional agreements/partnerships	58	22	95
Training for pipeline hazards	36	9	64
Growth management tools used for mitigation	31	43	18
Pipeline company interactions	29	0	59
No knowledge about transmission pipelines	29	43	14
Lack of growth management tools in use	22	30	14
Role of hazard mitigation plan	9	17	0

Boin et al. (2003, 103) suggest learning from organizations and networks within the same region is important to increasing hazard resiliency. The interviews revealed that planners and emergency managers have distinct skills for mitigating pipeline hazards to contribute to partnerships with other organizations. Using these diverse skills jointly can reshape policy agendas and ways of thinking (Healey 1998, 1537) even with a limited number of stakeholders.

The hierarchical alliances built relationships that small communities could access for dealing with pipeline hazards. A few larger agencies had much more information about pipelines. One particular county-level emergency management department was mentioned by almost all smaller emergency management agencies as having regional expertise on pipelines and chemical hazards. Chapter 4 illustrates the limited access to information of most planning departments with pipeline hazards across North Carolina (Table 4.3). The hierarchical relationships appear to have potential for improving this knowledge deficiency. However, the interviews also highlighted the uneven use of the social capital built through these networks. Hierarchical relationships were more likely to have fragmented continuity if personnel changes occurred than full partnerships (Table 5.3). Margerum (1999) in an analysis of watershed partnerships in the United States and Australia found similarly haphazard effectiveness of stakeholder groups for implementing the products of their collaborations.

5.2.2.2 Access to information and expertise

The three types of collaborations had different effects on building capacity in the form of access to information about how to mitigate transmission pipeline hazards. Full partnerships were likely to lead to better awareness of hazards and leverage multiple skills. The continuity of the full relationships meant availability of complementary skills at all times and likelihood of frequent contact about mitigation issues. Margerum (2002a, 245) identifies access to resources as one of the barriers to collaborative practices. Full partnerships had two committed partners, making resource availability and access more likely.

Loose alliances and hierarchal relationships provided accessibility to expertise, but required the departments to have foresight about the potential for pipeline accidents. In these alliances proactive departments had experts available to them to help create a mitigation program, but those lacking the initiative to launch a hazard mitigation program did not access these human resources. This finding follows Burton and others (1993, 160) observation that an organization with an interest in hazard mitigation can do much to enhance the adoption of hazard mitigation practices. Likewise, the differences in leadership among the different types of collaborations follows Ansell and Gash's (2008, 554-555) observations that leadership is crucial to creating successful outcomes in any type of collaborative partnership.

Networks that smaller communities accessed through hierarchical relationships allowed new communities and staff with modest tenure experience to gain insight from contacts in established agencies. When pipeline issues arose, having access to agencies with experience can make a difference for decision-makers with limited knowledge. Chapter 4 revealed that planning departments across the state have accessed few sources for information about transmission pipelines (Table 4.3). In addition to information sources, human resources can influence capacity. Staff size is associated with adoption of growth management practices (Berke, Backhurst et al. 2006; Burby & May 1997), thus this extra support may provide important assistance for improving growth management. However, one planner at a larger agency described the smaller agency this way, "As a new town, the [planning] board changes frequently. Sure, they're interested, but they are still learning how to be a town" (P15). Given that the hierarchical relationships tended to have knowledge inquiries flowing from small to big, frequent changes in leadership in the smaller towns might leave the knowledge networks with limited longevity. These potential changes at the smallest level of government may suggest that within the hierarchical relationships there is a role for building administrative interest and capacity in hazard mitigation. Given that several researchers have found organizational capacity to be linked with hazard mitigation practices (Brody et al. 2010; Gerber et al. 2005), consideration of distribution methods for hazard mitigation information from the larger to smaller level of government might lead to regional progress in mitigation of pipeline hazards.

Emergency managers in the larger jurisdictions were especially sensitive to transmission pipeline information concerning the public. Both planners and emergency managers shared reservations about the location of transmission pipelines near sensitive environmental areas and near water supply reservoirs. They indicated concern over the reaction of the public if something unfortunate was to happen. Given Lindell and Perry's (1992, 30) conclusion that both citizens and officials of the community need to be aware of the hazard for local governments to effectively implement a response to environmental hazards, the shared reservations of the planners and emergency managers provide a good first step for initiating community preparedness. These interviewees brought up the need for more formal collaboration among planners and emergency managers within a larger regional framework given the potential environmental and public health damage should a pipeline rupture impact a water supply reservoir. Since governments can initiate large scale hazard adjustments that individual households would not be capable of accomplishing (Lindell & Perry 2004, 120), fostering these types of partnerships can lead to better community preparedness.

5.2.3 Pipeline hazards low on agenda

Even as interviewees discussed collaboration with other agencies and organizations, many commented on how other pressing issues would supersede pipeline issues. One emergency manager noted, “We are always concerned about highway disasters; nuclear fuel goes down it. We’re more concerned about the highway than the pipelines. There is a lot of traffic up and down it and many tankers that go to and from the tank farm. Also it’s one of America’s most deadly highways” (EM14). Another stated, “The gas companies come once per year and discuss where the main and back-up pipelines are. This class is especially helpful. It helps in knowing where things are, what’s going on. The companies seem safety-minded. I’m more worried about the train track” (EM11). Given the focus on the highway and train, the underground transmission pipeline were not high priorities for either government. Comments such as these illustrated the difficulty of addressing less common or visible hazards. The comments also highlighted the opportunity presented by collaborative practices to jointly articulate the problem and work to find a solution (Innes 1996). Moreover, Burby and French’s (1981) land use management paradox, that suggests that land use planning tools are often not used until after a problem becomes entrenched, but that mitigation tools are preventative rather than responsive to well-established problems, appears to hold relevance for transmission pipeline problems.

The comments by emergency managers also indicated the limited local commitment to hazard mitigation and a comparatively low perception of pipeline risk. Dalton and Burby (1994) demonstrated that planning agency commitment increased the number of hazard mitigation techniques adopted by a locality. Given the influence of different types of collaboration, the lackluster interest in addressing the pipeline by the emergency mangers may contribute to how well planners mitigate the hazard. Likewise, the comments by emergency managers indicated a comparatively low-perception of risk for transmission pipelines as compared to the rail or highways. The low-perception of risk may feed back into Lindell and Perry's (1992, 30) observation that risk perception by officials is a necessary ingredient for addressing mitigation. The generally low commitment also follows findings from Chapter 4 of no statistical association between commitment and number of regulatory tools in use by a community. Once the informational data was acceptable, other activities may be of less interest to communities.

Planners also discussed lack of interest in mitigating potential hazards. One comment summarized the feelings of many planners stating, "we haven't done anything and we haven't had any problems" (P5). Given the low visibility of buried transmission pipelines, several planners indicated that no effort and no rupture equaled successful practices. This no-effort viewpoint would follow Birkland's (1998) claim that technological hazards require a focusing event such as large rupture to generate agenda-setting pro-change support. It would also support the idea that pipelines hazards fall into May's (1991b) category of a policy "without a public".

5.2.4 Case study limitations

There are several limitations to the data analysis for this chapter. First, in analyzing the data, my interpretation may be colored by my viewpoint as a planner. Due to my planning education, I may have been more sensitive to ambiguity posed by emergency managers, and more willing to infer meaning from a planning director's answers. Nevertheless, my planning background may also have pushed me to question any planning director's vagueness with addition questions due to knowledge about the planning environment.

Second, the data were gathered from one specific area in North Carolina. Additional case studies of other areas may enhance the conclusions. The communities in the study area were small to moderate in population size. The study did not include very large urban centers. Moreover, study of metropolitan areas with a large state-level petrochemical industry might provide contrasting results.

5.3 Conclusions

Scholars have called for interdisciplinary collaboration to improve hazard mitigation (Britton 2002, 44; Godschalk 2003, 142; Haimes 1999, 157). Drawing from the interview data presented above I identified three types of partnerships that address transmission pipeline hazards. I examined how these collaborative partnerships between emergency managers and planners enhance capacity. This chapter presents conclusions applicable to communities of a variety of sizes and for planning in areas surrounding transmission pipelines and other areas with low-profile technological hazards.

I found three types of collaboration. Loose alliances with other agencies allowed agencies to draw upon strengths of other departments, but hazard mitigation was driven more by individual leadership than through multiple agency direction. Full partnerships often grew from earlier collaborations such as for the creation of a hazard mitigation plan. Full partnerships had multiple agencies aware and interested in collaborating. Hierarchically cooperative groups gave smaller agencies access to resources at larger agencies. However, in hierarchical partnerships leadership changes could alter knowledge networks and lack of interest by one party placed limits on knowledge sharing. The differences in these three partnerships illustrated that not all technical collaborations yield similar collaborations.

Transmission pipeline partnerships provided a range of opportunities for collaboration and leveraging knowledge from other agencies. Part of these opportunities stemmed from how each partner drew on different skills. These distinctive expertieses provide for creative management options that can bridge both areas to create better mitigation options. Nonetheless, few collaborations focused solely on transmission pipelines; interactions were more likely to be extensions of earlier interactions. Additionally, the information transmission was not consistent among partnerships; differences in leadership, staff, and continuity of the collaboration affected how the collaborations functioned.

Interviewees frequently ranked pipeline hazard mitigation lower than other local issues, suggesting that leadership may play a role in keeping this issue on the table. Unlike some planning topics that have recognized communities of practice (Goldstein & Butler 2010; Schweitzer et al. 2008), for transmission pipelines the collaborative efforts were largely informal and low-profile. The loose alliance partnerships lacked the cohesiveness found Goldstein and Butler (2010) in their study of fire learning networks, whereas the hierarchically-cooperative groups lacked the continuity. These two types of collaborations are less likely to keep pipeline hazards on a local agenda. In fact, the informal groups were often part of other mitigation efforts. Nonetheless, given the idea that multi-hazard mitigation provides a more efficient means of addressing hazard mitigation than stand-alone plans (Alexander 2005, 162), the inclusion of hazard mitigation efforts for transmission pipeline within a larger mitigation framework appears sensible. Likewise, there may be productive outcomes from these relationships that can build future support for both collaboration and growth management (Innes & Booher 1999a). Regional leadership to build more formalized communities of practice might improve area-wide efforts to reduce accidents and the potential effects of disasters through improving agenda-setting power. This could be especially important in communities with heavy growth pressures in hazardous areas.

6 Characteristics of populations surrounding transmission pipelines

Natural gas and hazardous liquid transmission pipelines expose nearby residents to both chronic and acute risks. Given the potential hazards from these large-scale pipelines, understanding the community that surrounds them can provide planners, policymakers, and communities with information on those most vulnerable to pipeline ruptures. The pipeline industry suggested that pipelines were originally located within rural communities. Accident reports have insinuated that newer development poses considerable danger to transmission pipelines due to the large number of construction and third-party accidents. Communities of color and lower-income communities have historically had heightened vulnerability to technological and chemical hazards. Scholars have hypothesized that these vulnerabilities have accumulated for a variety of reasons including lack of power, racial or class discrimination, and limited access to decision-making positions. Nevertheless, given the largely invisible nature of transmission pipelines, land use practices in areas surrounding these pipelines might be different from those surrounding the average technological hazard.

This chapter describes the population surrounding transmission pipelines in North Carolina. I focus on improving understanding of the characteristics of those living near the transmission pipelines in North Carolina and whether vulnerable populations are disproportionately at risk from pipeline hazards. I propose the following hypothesis:

- H1. Block groups closer to transmission pipelines (within 1/2 mile, within 2 miles) will display statistically significant differences than those at distances farther away (2-4 miles) from the pipeline
  - H1.1. Average construction age of residential housing will be newer in block-groups closer to transmission pipelines than those farther away

    - H1.2. Block-groups closer to transmission pipelines will have a higher percentage of renter occupied housing than block-groups farther away from the pipeline
    - H1.3. Based on the reports that pipelines were originally placed in rural areas, block-groups closer to transmission pipelines will have lower density than block-groups located farther away from the pipeline
    - H1.4. Block-groups closer to transmission pipelines will have a higher percentage of African-Americans than block-groups located farther away from the pipeline

- H2. Comparison of large urban areas will indicate statistically significant differences in the distribution of the percent African-Americans at distances close to (2 miles or less) and farther away (2-4 miles) from the transmission pipelines. I specifically focus on African-Americans and large urban areas due to the historic practices that set urban African-Americans at a disadvantage compared to other groups or compared to African-Americans in less urban settings (Thomas & Ritzdorf 1997a, 7-8).

- H3. Population characteristics near transmission pipelines will exhibit statistically significant spatial autocorrelation at a global level. After correcting for this effect, I expect to find an association between distance to a transmission pipeline and vulnerable groups (percent African-American, percent lower-income, percent with a high school diploma or lower, and areas with higher density).

- H4. There will be statistically significant clusters of vulnerable groups near transmission pipelines (percent African-American, percent renters, percent lower-income, and higher density areas)

Using a variety of statistical techniques, I found statistically significant differences between the populations at a close distance to transmission pipelines as compared to farther away. The results indicated that development closer to pipelines is newer, but did not show support for equity differences. At a statewide level, populations living at a farther distance from transmission pipelines had higher percentages of lower-income and minority populations. Within the five largest cities, I found no differences in distributions of African-American populations at various distances from the transmission pipelines. However, I found statistically significant clusters in many urban areas with higher than the mean percent of lower-income, African-American, renters, or higher-density populations. I detected global spatial autocorrelation after accounting for the inclusions of several independent variables, but did not find large-scale disparities for vulnerable populations.

6.1 Methods

6.1.1 Study area

The study area included municipalities and counties in North Carolina with transmission pipeline hazards identified from the data provided by the Office of Pipeline Safety's National Pipeline Mapping System (U.S. Department of Transportation 1999). Figure 6.1 illustrates the areas with available data and transmission pipeline hazards.[16]

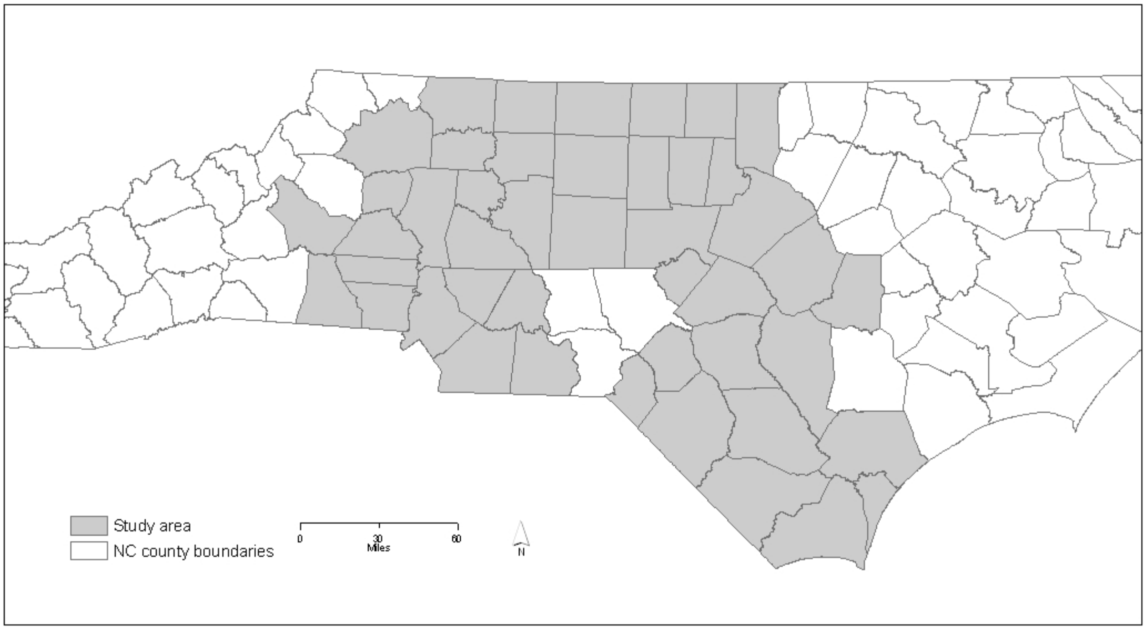

Figure 6.1, Counties included within analysis of population characteristics near transmission pipelines

6.1.2 Data

Data on locations of transmission pipelines in North Carolina were obtained from the U.S. Office of Pipeline Safety (U.S. Department of Transportation 1999). The Census block-group was chosen as the sampling unit since it is the smallest Census unit that contains data on race, ethnicity, and economic status. Socioeconomic and demographic features were

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[16] Due to security restrictions agreed to for the use of the transmission pipeline data set, the actual locations of the transmission pipelines are omitted in Figure 6.1

calculated using 2000 Census data. I used data from the North Carolina Corporate Geographic Database (2003) to identify municipal and county boundaries.

6.1.3 Analysis

I conducted several types of analyses to evaluate population characteristics near transmission pipelines. First, I conducted t-test between block-groups at different distances from transmission pipelines in order to examine large-scale differences in population characteristics. Second, I compared the distributions of percent African-Americans within close proximity to pipelines to the distribution at farther distances for the five largest metropolitan areas. Third, I evaluated local indicators of spatial autocorrelation for four population characteristics for all areas with pipelines and for the five largest cities. Fourth, I generated ordinary least square regression models and maximum likelihood regression with a spatial lag to predict factors associated with proximity to a transmission pipeline. I discuss each of these areas in more detail below.

In order to address the general characteristics of people living near transmission pipelines, I conducted t-tests to examine differences in population characteristics at ≤0.5 miles, >0.5-2 miles, and >2-4 miles. I also assessed differences at ≤2 miles and >2-4 miles. I chose these comparison distances based on the potential hazard zone near transmission pipelines. Rusin and Savvides-Gellerson (1987, 50) find 62.7% of deaths, 76.7% of injuries, and 67.8% of property damage occurred within 150 feet of the pipeline, 91.6% of deaths, 100% of injuries, and 94.1% of property damage occurred within one-half mile of the pipeline rupture, and all deaths, injuries and property damage are accounted for within 2 miles. Due to the accuracy limitations of the data (U.S. Department of Transportation 1999) analysis at 150 feet was not feasible. I evaluated differences in race (percent African-

American), ethnicity (percent Hispanic/Latino), wealth (percent under the poverty level, median household income), education (percent with a bachelor's degree, percent with a high school diploma or less), age (percent under age 5, percent over age 65), percent renters, median residential home age, and road density. I use a 0.05 statistical significance level to assess statistical associations between variables. A statistical significance of 0.05 is an arbitrary choice and implies a 5% chance that the confidence interval is incorrect (Rea & Parker 2005, 144).

For the five largest cities in North Carolina, I compared the African-American population within close proximity to the pipeline and the population at a farther distance. I considered race specifically due to the potential for inequalities in traditionally African-American areas in the South (Bullard 2000). For the five largest cities, Charlotte, Durham, Greensboro, Raleigh, and Winston-Salem, I created histograms and cumulative distribution functions (CDF) with the total number of block-groups and of the ratio of minority to total population. I compared block-groups within two miles of the pipeline to block-groups 2-4 miles away from the pipeline. I conducted a two-sample Kolmogorov-Smirnov test for equality of distribution to test for differences in the CDFs. For the three counties with combined city-county planning areas that had cities considered among the five largest in the state (Charlotte-Mecklenburg County, Durham City-County, and Winston-Salem-Forsyth County), I also conducted these analyses at the county-level. I used city and county boundaries identified by the North Carolina Corporate Geographic Database (NCCGIA 2003). I use an arbitrary 0.05 statistical significance level (Rea & Parker 2005, 144) to assess the statistical associations between variables. Given the size of the data set, using a standard 0.05 statistical significance level is appropriate.

Third, I evaluated local indicators of spatial association (LISA) (Anselin 1995) to identify clusters of vulnerable areas near transmission pipelines. Anselin (1995, 94) suggested a LISA will illustrate two criteria that a larger-scale analysis would overlook: (1) assessment of statistically significant local clustering around specific locations; and (2) indications of pockets of spatial outliers. I used a queen's contiguity weight matrix with row-standardization to identify neighbors. I addressed the following four areas: (1) percent low-income; (2) percent African-American; (3) percent renter occupied housing units; and (4) mean road density. The first three indicators addressed questions of the relationship of vulnerable populations to pipeline hazards. Mean road density was chosen since higher density areas would place larger numbers of people at risk should an accident occur. I compared these values for both the entire study area and for the five largest cities as well. A local Moran's *I* value (Anselin 1995) was used to evaluate significance of the clusters of vulnerability, using a 0.05 statistical significance-level to identify local clustering. A 0.05 statistical significance level is the least restrictive of the pre-defined significance levels in GeoDa (Anselin 2005). Given the quality of the data, more restrictive statistical significance levels were not appropriate. Statistically significant clusters were then combined with a Moran's scatterplot that identified clusters of block-groups displaying similar higher than the mean values or lower than the mean values. The Moran's scatterplot also identified outlier block-groups that had either higher or lower values than the surrounding block-groups.

Fourth, I estimated regression models to identify factors associated with distance from the transmission pipeline. The purpose of this analysis was to shed light on whether vulnerable populations were associated with distance from a transmission pipeline. The dependent variable for these models was measured as the log of the distance from the block-group centroid to the nearest transmission pipeline. Explanatory variables were chosen based on the environmental equity literature and on previous studies evaluating risk from technological hazards. I used 2000 Census block-group data to measure socioeconomic status, percent renters, percent Africa-American residents, education level, percent older adults, and average age of residential housing (U.S. Bureau of the Census 2000). I included the percent below the poverty level and percent renter-occupied housing units. Poverty is a common measure of socioeconomic vulnerability (Cutter & Solecki 1996) as is the percentage of renter (or owner) occupied housing units (Landry & Chakraborty 2009). I included the percent older adults (percent age 65 and older) given that older adults may be more vulnerable to hazards (Morrow 1999). I calculated education-level as percent with a high school education or lower. I used the median age of residential housing as a means of calculating the recentness of development in the area given that accident reports suggest pipeline encroachment is prone to accidents from third party and construction damage (Simonoff et al. 2008). I included road density as a measure of access to the area and as a measure of the general density of the area. I calculated mean road density for each block-group using detailed street data for North Carolina (ESRI 2004) by computing the average number of road segments per ¼ mile and taking the mean of all ¼ mile squares within or partially within each block-group. I applied a square root transformation for percent black and percent renters. I used the natural log of the road density and percent in poverty.

The models were evaluated using ordinary least squares regression. Tolerance and variance inflation factors were used to evaluate multicollinearity within the OLS models. I conduct Breusch-Pagan, Koenker-Bassett, and White tests for heteroskedasticity. Regression residuals were tested using the Moran's *I* statistic to evaluate global spatial autocorrelation.

Models were tested for appropriateness using R-square and F-tests to look at model strength and appropriateness. T-scores were used to evaluate statistically significant variables. I used a 0.05 statistical significance level cut off for the significance tests.

Since a statistically significant Moran's *I* score in the OLS residuals indicated global spatial autocorrelation, a maximum likelihood spatial regression model was created that included a variable to account for the spatial autocorrelation. Lagrange multiplier tests indicated that a spatial lag variable was more appropriate than a spatial error variable, so a spatial lag model was used. Pseudo R-square and log-likelihood tests were used to assess model appropriateness. I used log-likelihood tests and Akaike information criterion (AIC) to compare the goodness of fit between the spatial lag maximum likelihood model and the OLS models.

Several limitations apply to the study of the population surrounding transmission pipelines. These limitations include measurement error, endogeneity, and temporal precedence of pipelines and the development that surrounds them. This study seeks to evaluate the characteristics of people living in areas surrounding transmission pipelines. However, it does not make causal inferences regarding the relationships of the characteristics. This is due to the threats to validity that would render causal inferences inappropriate.

Measurement error due to problems with variable specification can lead errors in the outcome (Shadish et al. 2002, 402). While this study attempts to measure the variables appropriately, there is the possibility of both type I and type II errors. Type I errors occur when a null hypothesis is incorrectly rejected. A type II errors occurs when a hypothesis is accepted, but should be rejected (Shadish et al. 2002, 513). Errors can also be a result of endogenous variables (Shadish et al. 2002, 394), or variables that receive input from other variables in the model. In order to address these problems, model specification can be improved through addition of other variables, testing of robustness of outliers, cross validating the results with other types of analyses (Shadish et al. 2002, 401-403).

The temporal precedence of population centers and transmission pipelines is unclear. The available data does not contain information on year of pipeline installation (U.S. Department of Transportation 1999). Due to this deficiency, the study cannot make conclusive claims regarding the why specific groups live in areas with transmission pipeline hazards.

Finally, the analyses are limited by the availability of the locations of the data. While the dataset covers the largest urban areas within North Carolina, many of the rural areas are outside of the bounds of the dataset. Likewise, northeastern North Carolina, an areas of the state with the highest proportion of African-American residents (State Center for Health Statistics & Office of Minority Health and Health Disparities 2005) is omitted from the dataset.

6.2 Findings

6.2.1 General characteristics of people living near transmission pipelines

According to the U.S. Bureau of the Census (2000) block-group data, the average block-group within 0.5 miles of a transmission pipeline contained a population that was 23% African-American and 5% Hispanic/Latino (Table 6.1 and Appendix B, Table B2). The block-group median household income was just over $45,000 while 10% of the block-group lived under the poverty level. Renter-occupied housing units comprised 31% of all occupied housing units.

Table 6.1, Characteristics of populations near transmission pipelines in NC

	Distance from pipeline (miles)				
	<0.5	>0.5-2		>2-4	
Variable	mean	mean	t^a	mean	t^b
% African-American	23	24	-1.09	27	-2.31*
% Hispanic	5	6	-2.47*	5	0.87
% children under age 5	7	7	1.01	7	0.06
% persons over age 65	11	12	-3.44***	12	-0.17
% high school diploma or less	47	50	1.88	50	0.07
% Bachelor's degree or higher	25	23	1.00	24	-0.76
% under poverty-level	10	12	-3.39***	14	-2.97**
Medium household income	$45,138	$43,294	1.62	$41,730	1.62
Percent renters	31	34	-2.21*	37	-2.37*
Road density	8	10	-5.70***	11	-3.78***
Median year built, res. housing	1978	1973	6.58***	1970	4.68***
N	396	1086		899	

*p<.05, **p<.01, ***p<.001

[a] t-test compares ≤0.5 and >0.5-2 miles

[b] t-test compares >0.5-2 and >2-4 miles

At a distance of greater than 0.5 to 2 miles and a distance of over 2 to 4 miles from the transmission pipelines the population characteristics changed incrementally. For many variables this change was statistically insignificant, but the t-tests identified a statistically significant difference for several variables. The percent African-American residents did not display a statistically significant difference at a half-mile or less compared to 0.5-2 miles, but was statistically dissimilar (increase of 3%) at >0.5-2 miles compared to >2-4 miles. The percent Hispanic/Latino residents was higher (1%) at over one-half a mile compared to >2-4 miles from the pipeline, but not at the lower-interval. The percent of the population living under the poverty level had a statistically significant increase (to 12%) at over one-half mile and to 14% at more than 2 miles from the pipeline. The percent of renters had a statistically significant increase at one-half mile (to 34%) and again at over 2 miles (to 37%). The density of road segments also displayed a statistically significant increase with additional distance from the transmission pipeline. While all blocks-groups had some residential hosing built from before 1939 to 1999 the median age of the housing had a statistically significant decline with each increase in distance. At a closer distance to the transmission pipelines the median year built for homes was eight years newer than at >2-4 miles from the pipeline. There was no statistically significant difference in education levels, children under age 5, or median household income at the three distances from the pipeline.

Comparison of population characteristics of block-groups at less than 2 miles or at >2-4 miles distance from transmission pipelines showed similar differences. The percent African-Americans, percent under the poverty level, and percent renters showed a statistically significant increase at 2-4 miles from the pipeline (Table 6.2). The median household income was lower at a farther distance. The median residential home age showed statistically significant differences closer to the pipeline than farther away; closer homes were more recently built. Road density was higher at a greater distance.

Table 6.2, Characteristics of populations at less than 2 miles and at 2-4 miles from transmission pipelines in NC

	Distance from pipeline (miles)		
	<2	>2-4	
Variable	mean	mean	t
% African-American	24	27	-2.87**
% Hispanic	5	5	0.04
% children under age 5	7	7	0.42
% persons over age 65	12	12	-1.44
% Bachelor's degree or higher	24	24	-0.46
% high school diploma or less	49	50	-0.61
% under poverty-level	12	14	-4.43***
Medium household income	$43,787	$41,730	2.45*
% renters	34	37	-3.33***
Road density	10	11	-6.13***
Median year built, res. housing	1974	1970	7.38***
N	1482	899	

*p<.05, **p<.01, ***p<.001

Understanding the context of development near greenspaces and contaminated areas sheds light into the t-test findings. Kaufman and Cloutier (2006) discovered that brownfield sites have a measurable negative effect on property values whereas greenspaces such as parks have a statistically significant and positive effect on property values. Since transmission pipelines tend to be located underground, the difference in price for areas that have not experienced a pipeline rupture may be minimal. In fact, the visual greenspace presented by transmission pipeline right-of-ways may be considered an amenity by uninformed new homebuyers. Given that only 15% of survey respondents in Chapter 4 reported that their jurisdiction used deed restrictions and less than 17% required transmission pipeline disclosure in real estate transaction, new homebuyers may lack the necessary information to make an informed decision about purchasing a home near a transmission pipeline (see Table 4.3). Likewise, Hamilton and Schwann (1995) found that electronic high-voltage transmission lines to have statistically significant, but slight effect on home values. However, the authors established that the visual effect of the transmission lines generated the difference in home price (Hamilton & Schwann 1995, 442). Since transmission pipelines are generally not visible like high-voltage electric transmission lines, there may be no statistically significant negative impact of the pipeline on home prices in the absence of an accident.

The t-tests indicated that home age in close proximity to transmission pipelines was newer, occupied by fewer persons living under the poverty level, and fewer renters than areas farther away from pipelines. I speculate that, in the absense of a pipeline rupture, transmission pipelines might be considered an amenity by potential residents. Future research could address the potential greenspace influence by evaluating differences in population characteristics in areas surrounding transmission pipeline accidents.

However, in the aftermath of a pipeline rupture, differences in home values may affect the population living and purchasing homes near transmission pipelines. Simons and colleagues (2001) established that a transmission pipeline rupture had a negative effect on home sales in areas close to a pipeline rupture in Maryland. Likewise, Simons (1999) indicated that residential properties with transmission pipeline easements suffered a statistically significant decline in sales price if located within the same county as a pipeline rupture. Given that the real estate findings were at the parcel level, the results of the t-tests in this study may indicate that the scale of the analysis (block-groups) was too large to see the nuances identified by Simons (1999) and Simons and colleagues (2001). Future studies could take into account both geographic size of the study area and focus specifically on areas that had experienced accidents.

Finally, in the absence of data illustrating the data of transmission pipeline installation, conclusions about temporal precedence of pipelines and population are not conclusive. Ability to reconcile the construction date for the built environment with the data of pipeline installation would resolve this question.

6.2.2 Large urban areas near transmission pipelines in North Carolina

The five largest municipalities near transmission pipelines all grew at or faster than the state growth rate between 1990 and 2000 (Table 6.3). Urban areas in North Carolina are home to much of the state’s population and thus destinations for much of the pipeline products used within North Carolina. In order to assess if there were disproportionate differences for African-American populations within the urban areas, I looked at differences in population distributions for the five largest cities, Charlotte, Durham, Greensboro, Raleigh, and Winston-Salem. Three of these cities, Charlotte, Durham, and Winston-Salem have joint city-county planning districts. I assessed differences for the county related to each dual planning area, Mecklenburg, Durham, and Forsyth. Table 6.4 illustrates the total population within 2 miles and within 2-4 miles of a transmission pipeline in each of these areas.

Table 6.3, Growth rate of five largest municipalities in North Carolina and three related city-county joint planning areas

	1990	2000	Growth rate (%)
North Carolina	6,628,637	8,049,313	18
Largest Municipal Areas			
Charlotte	395,934	542,131	27
Durham (city only)	136,611	187,183	27
Greensboro	183,521	223,299	18
Raleigh	207,951	276,579	25
Winston-Salem	143,485	185,480	23
City-County Planning Areas			
Mecklenburg County (Charlotte)	511,433	695,454	26
Durham County	181,835	223,314	19
Forsyth County (Winston-Salem)	265,878	306,067	13

Table 6.4, Population of 5 largest cities near transmission pipelines and of three corresponding city-county planning areas

	Total Population	Distance to Transmission Pipeline	
		<2 miles	2-4 miles
Municipal Area			
Charlotte	542,131	293,506	133,173
Durham	187,183	63,410	61,625
Greensboro	223,299	83,068	119,342
Raleigh	276,579	61,473	68,680
Winston-Salem	185,480	62,404	102,785
City-County Planning Area			
Mecklenburg County (Charlotte)	695,454	377,196	169,207
Durham County	223,314	77,359	62,817
Forsyth County (Winston-Salem)	306,067	115,620	129,533

Using histograms (Figures 6.2-6.9) and two-sample Kolmogorov-Smirnov tests (Table 6.5) to assess the equality of the distributions, I find no statistical differences in the percent African-American population between areas in close proximity (≤2 miles) to pipelines and those at a farther distance (2-4 miles). The histograms illustrate the total number of 2000 Census block-groups within each distance overlaid with the cumulative distribution. Comparison of distributions at 0.5 miles and >0.5-2 miles produced similarly non-statistically significant results.

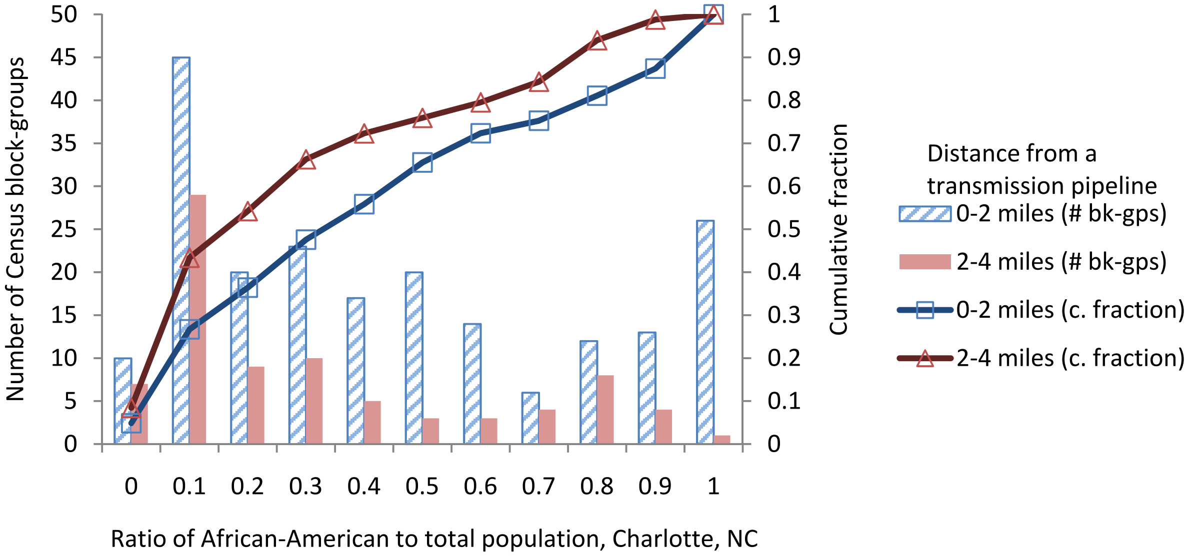

Figure 6.2, Histogram and cumulative distribution of minority-to-total ratios within 4 miles of a transmission pipeline for Charlotte, NC

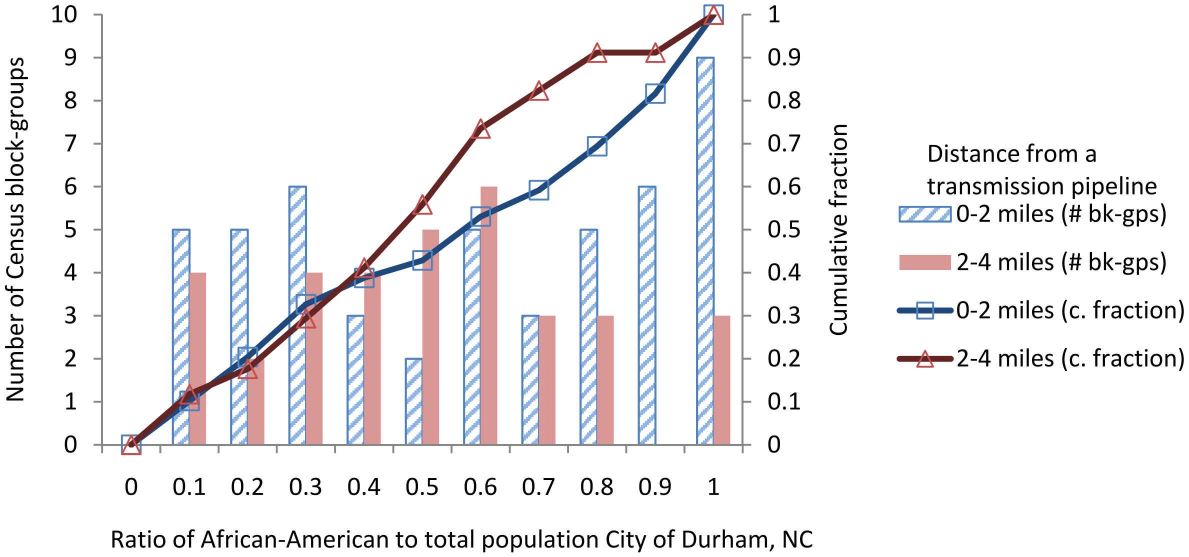

Figure 6.3, Histogram and cumulative distribution of minority-to-total ratios within 4 miles of a transmission pipeline for the City of Durham, NC

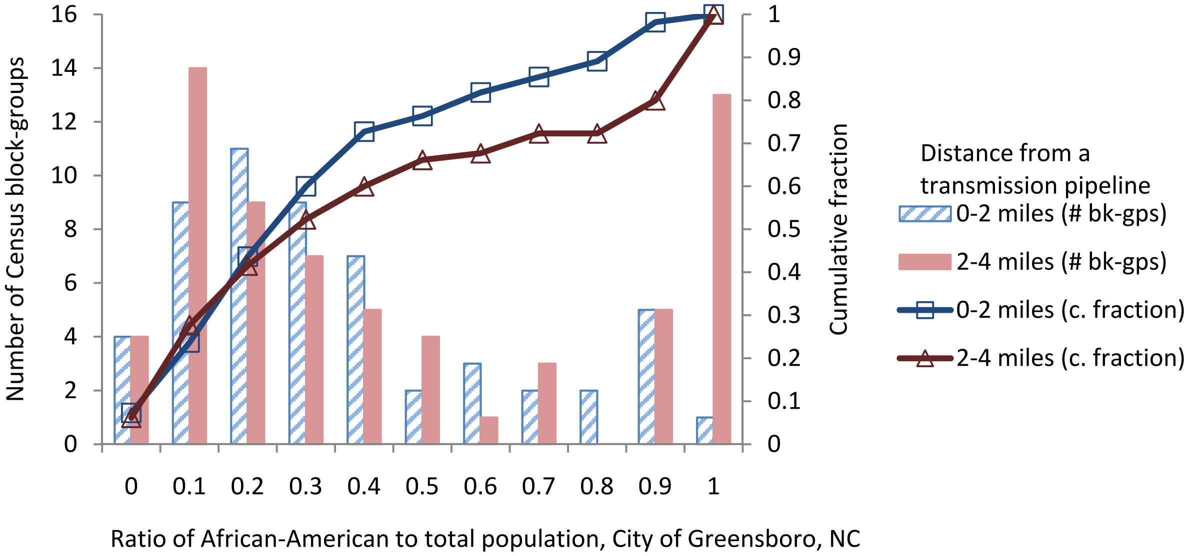

Figure 6.4, Histogram and cumulative distribution of minority-to-total ratios within 4 miles of a transmission pipeline for the City of Greensboro, NC

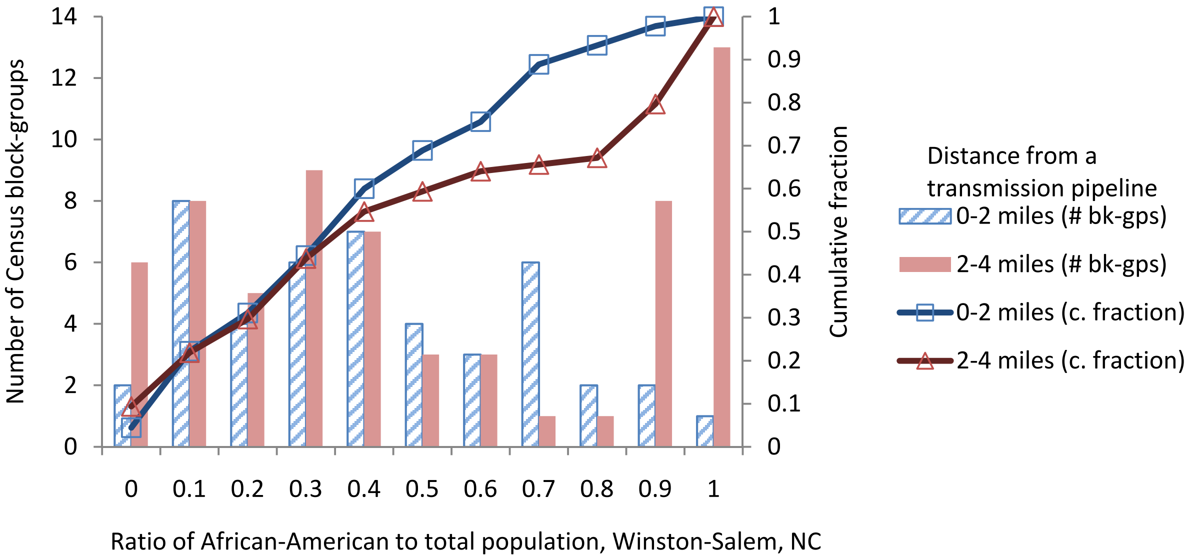

Figure 6.5, Histogram and cumulative distribution of minority-to-total ratios within 4 miles of a transmission pipeline for Winston-Salem, NC

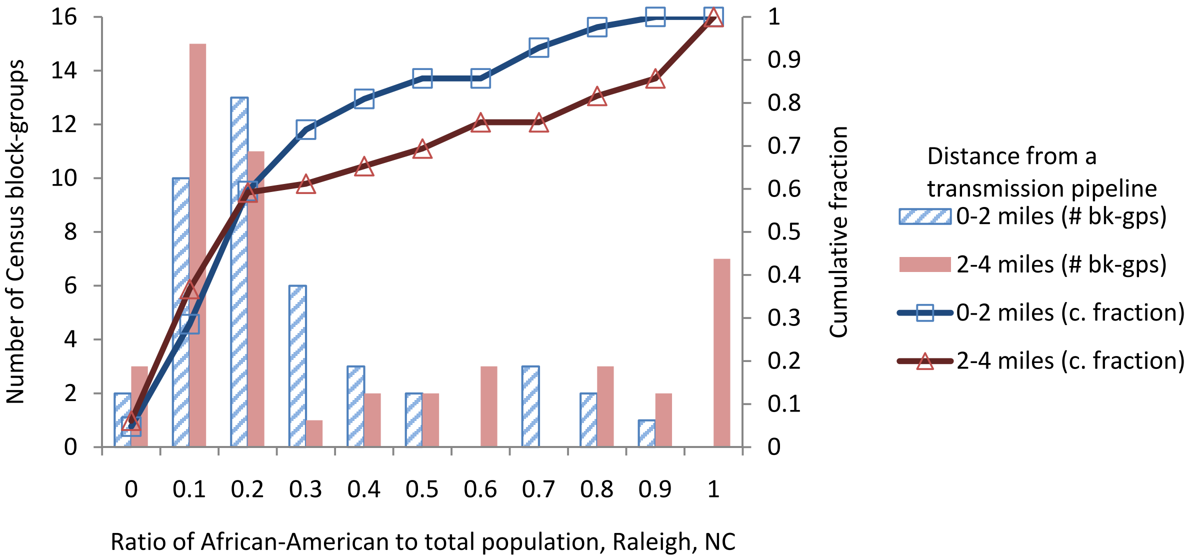

Figure 6.6, Histogram and cumulative distribution of minority-to-total ratios within 4 miles of a transmission pipeline for Raleigh, NC

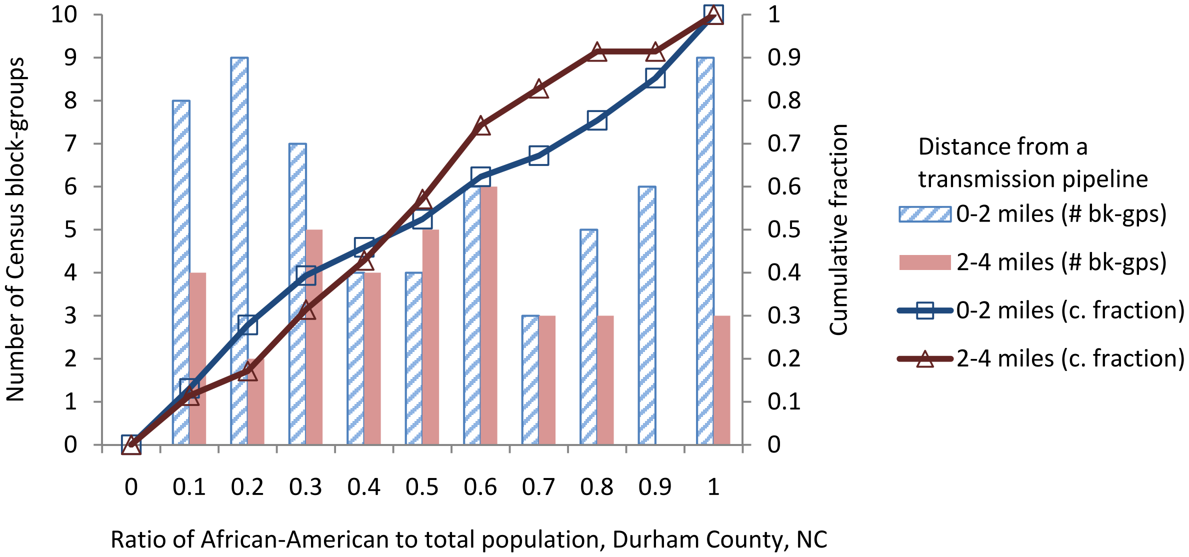

Figure 6.7, Histogram and cumulative distribution of minority-to-total ratios within 4 miles of a transmission pipeline for Durham County, NC

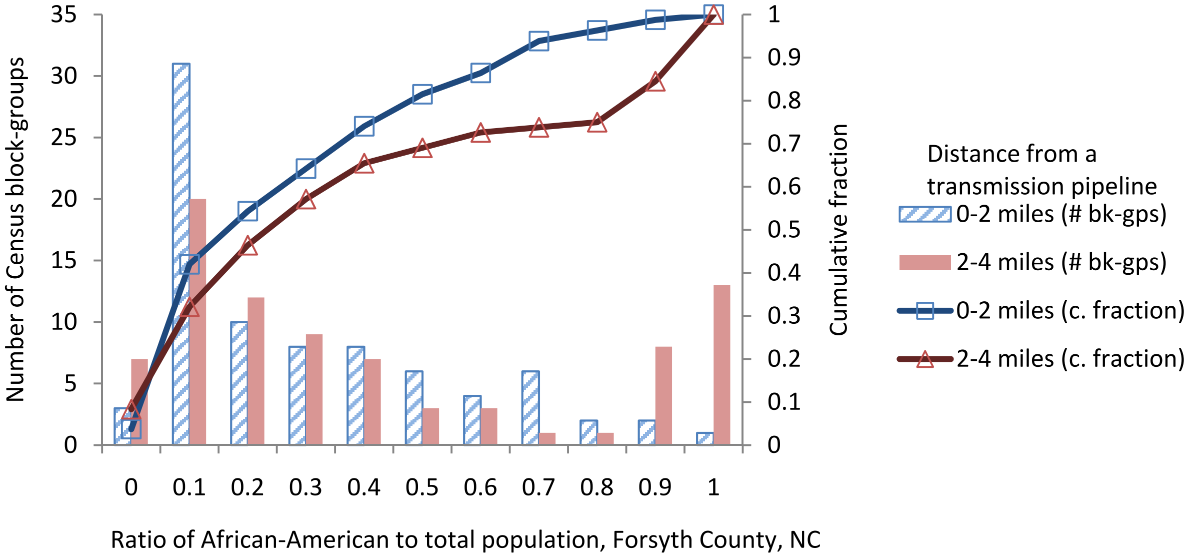

Figure 6.8, Histogram and cumulative distribution of minority-to-total ratios within 4 miles of a transmission pipeline for Forsyth County, NC

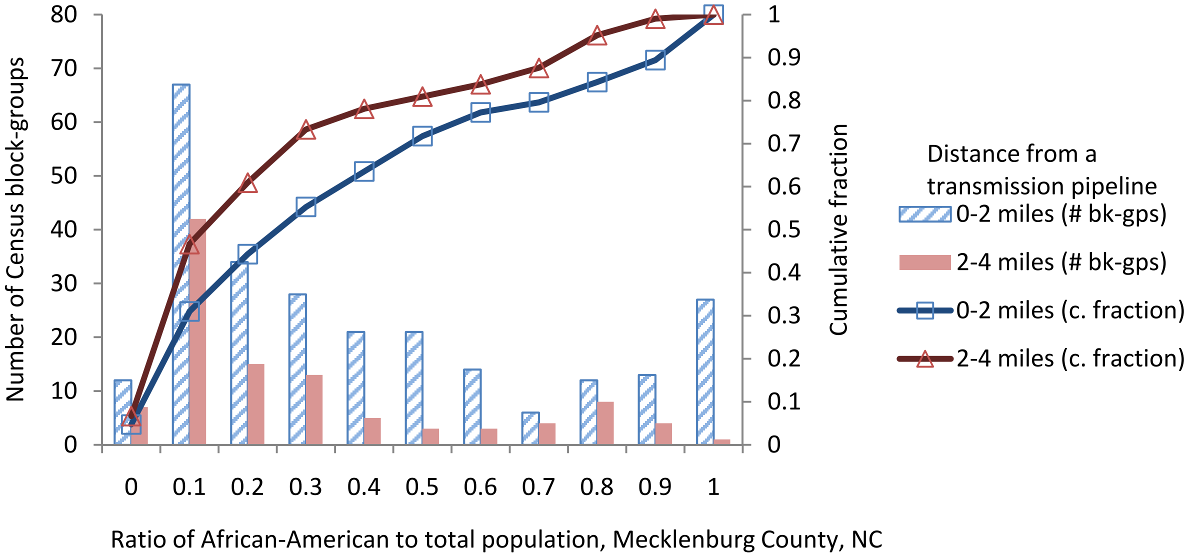

Figure 6.9, Histogram and cumulative distribution of minority-to-total ratios within 4 miles of a transmission pipeline for Mecklenburg County, NC

Table 6.5, Two-sample Kolmogorov-Smirnov test for equality of distribution functions comparing areas within 2 miles and 2-4 miles from transmission pipelines

Municipal Area	D	P-value	Exact
Charlotte	0.27	0.81	0.72
Durham (city only)	0.27	0.81	0.48
Greensboro	0.45	0.21	0.21
Raleigh	0.36	0.46	0.21
Winston-Salem	0.36	0.46	0.48
City-County Planning Area			
Mecklenburg County (Charlotte)	0.27	0.81	0.48
Durham County	0.18	0.99	0.83
Forsyth County (Winston-Salem)	0.36	0.46	0.21

The lack of statistical significance of the Kolmogorov-Smirnov tests indicated there were not statistical differences in the distributions of percent African-Americans near transmission pipelines within the five largest cities in North Carolina. The county-level analysis for the dual planning areas Mecklenburg County (Charlotte), Durham County, and Forsyth County (Winston-Salem) likewise showed no statistical differences.

The lack of statistical significance of the distributions for the five largest urban areas contrasts work by hazard researchers such as Mileti (1999, 119-120) who concluded that populations in urbanized areas are frequently more exposed to hazards than their rural counterparts. The results were also surprising given the historic impact of planning on the urban African-American community. Thomas and Ritzdorf (1997a, 8) described how urban renewal programs, many of which were related to transportation projects, redefined locations of the urban African-American community while failing to protect its' rights and interests. Moreover, given data limitations that did not provide the pipeline construction or installation date, additional analysis of these results may provide additional insights.

The lack of statistical significance of differences in distributions may indicate that additional exploration of vulnerabilities of smaller towns or towns is warranted. This finding would follow Comfort and colleagues (1999, 43) call for research that considers a place-based approach to vulnerability. Likewise, Dash and colleagues (2001) indicated that a community's socio-economic and ecological position within the region must be considered as part of understanding disproportionate impact from a disaster. From an equity point of view, Bullard (2000, 40) described how urban residents have better access to resources, organized groups, volunteers, and policy makers than rural residents. Bullard (2000) concluded that while rural residents can mobilize to address toxic hazards, they face difficulties due to the challenges associated with limited access.

6.2.3 Clusters of vulnerability

Using local indicators of spatial autocorrelation (LISA), I find limited clusters of vulnerable block-groups within two miles of transmission pipelines. Table 6.6 illustrates the number of total block-groups and percent of total block-groups with clusters or outliers for four vulnerable groups: percent renters, percent African-American, percent low-income residents, and mean road density. A LISA allows assessment of the relative value of different areas for four types of spatial association (Anselin 1995). Two indicators point out clusters of spatial association. The high-high category indicates a high value (higher than mean) for the block-group and neighboring block-groups with high values. The low-low category indicates a low value (lower than mean) for both the block-group and surrounding block-groups. Two indicators show spatial outliers, or block-groups that are different from their surrounding block-groups. The high-low category indicates a block-group with a high value surrounded by block-groups with low values. The low-high category indicates block groups with a low value surrounded by block-groups with high values.

Table 6.6, Characteristics of clusters of block-groups in counties with pipeline hazards

	Clusters		Outliers	
	High-high[a]	Low-low[a]	High-low[a]	Low-high[a]
Percent renter-occupied homes				
Within 1/2 mile	41 (4)	2 (<1)	6 (1)	14 (1)
Within 2 miles	190 (13)	5 (<1)	14 (1)	55 (4)
Percent African-American				
Within 1/2 mile	55 (5)	ns	ns	2 (<1)
Within 2 miles	203 (14)	ns	2 (<1)	10 (1)
Percent low-income				
Within 1/2 mile	28 (3)	ns	ns	14 (1)
Within 2 miles	133 (9)	1 (<1)	5 (<1)	58 (4)
Road density				
Within 1/2 mile	23 (2)	ns	ns	23 (2)
Within 2 miles	207 (14)	1 (<1)		118 (8)
*within 1/2 mile n= 392; within 2 miles n=1482				

[a] Number block-groups (% total block-groups)
All significant at p <.05

Within one-half mile of transmission pipelines, I found few clusters of block-groups with either high-high (fewer than 5% of the total block-groups for each characteristic tested) or low-low values (about 1% or less for each characteristic tested). Within 2 miles, I calculated a larger percent of vulnerable populations within block-groups with both high-values and neighbors with high values. However, all variables continued to have fewer than 15% of the total block groups within the high-high clusters. Overlaying the four areas (percent renters, percent African-American, percent below the poverty level, mean road density), I observed that each large city within the study area had at least one cluster of block-groups with two or more types of vulnerable characteristics in the area within 2 miles of a transmission pipeline. Table 6.7 illustrates the numbers of clusters and outliers associated with the five-largest cities (see Appendix B, Table B3 for related city-county areas).[17]

All five cities in the analysis had block-groups with vulnerable populations clustered within less than 0.5 miles of the pipeline. All the cities had several clusters of higher than the statewide percentage. However, the cities of Charlotte and Durham had especially higher percentages of their total block-groups with vulnerable populations compared to the analysis of all areas with pipeline hazards. For Charlotte about a third of all block-groups had a higher percent African-Americans or percent renter-occupied homes clustered near other block groups with similarly high percentages within 2 miles of a transmission pipeline as compared to the statewide percentage. Within Durham, this number was even higher. In Durham, 50% of the block groups with higher than the mean percentage of African-Americans were clustered near other similar block groups within one-half mile of a transmission pipeline. Within 2 miles the percentage was even higher. The variables for percentage of renters and lower-income residents displayed similarly higher percentages of clusters as compared to the statewide average. Like Durham and Charlotte, the City of Winston-Salem had a sizeable

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[17] Maps of the cluster locations are not shown due to security restrictions agreed to for the use of the transmission pipeline data set.

percentage of block groups with clusters of both higher than average percentages of African-Americans and neighboring block-groups with high levels that were in close proximity to transmission pipelines.

However, the analysis did not illustrate consistently high-high clusters for all four areas examined. In Charlotte only two blocks-groups had statistically significant high-high values for all four types calculated. While an area of southeast Durham had a group of block-groups with two or more high-high vulnerability characteristics, no block-groups had significant high-high indicators for all four characteristics calculated. Greensboro, located in the county with the highest numbers of natural gas transmission pipelines in North Carolina (Hall 2005), also did not have any block-groups where all four high-high characteristics overlapped. Raleigh and Winston-Salem likewise did not display any block-groups with high-high indicators for all areas.

Table 6.7, Characteristics of clusters of block-groups in areas with pipeline hazards for the five largest NC cities

	Clusters				Outliers			
	High-high[a]		Low-low[a]		High-low[a]		Low-high[a]	
Charlotte*								
Percent renter-occupied homes								
Within 1/2 mile	19	(31)	ns		1	(2)	4	(7)
Within 2 miles	67	(33)	5	(2)	2	(1)	8	(4)
Percent African-American								
Within 1/2 mile	24	(39)	ns		ns		ns	
Within 2 miles	75	(36)	ns		ns		ns	
Percent low-income								
Within 1/2 mile	6	(10)	1	(<1)	ns		ns	
Within 2 miles	33	(16)	12	(6)	ns		1	(<1)
Road density								
Within 1/2 mile	7	(11)	ns		ns		ns	
Within 2 miles	44	(21)	ns		ns		ns	

*within ½ mile n=60; within 2 miles n=206

Durham, City*								
Percent renter-occupied homes								
Within 1/2 mile	2	(17)	ns		ns		ns	
Within 2 miles	17	(35)	ns		ns		ns	
Percent African-American								
Within 1/2 mile	6	(50)	ns		ns		ns	
Within 2 miles	27	(55)	ns		ns		ns	
Percent low-income								
Within 1/2 mile	2	(17)	ns		ns		ns	
Within 2 miles	15	(31)	1	(2)	ns		1	(2)
Road density								
Within 1/2 mile	3	(25)	ns		ns		ns	
Within 2 miles	20	(41)	ns		ns		ns	

*within ½ mile n=12; within 2 miles n=49

Greensboro*								
Percent renter-occupied homes								
Within 1/2 mile	2	(14)	ns		ns		ns	
Within 2 miles	11	(20)	ns		ns		ns	
Percent African-American								
Within 1/2 mile	3	(21)	ns		ns		ns	
Within 2 miles	12	(22)	ns		ns		ns	
Percent low-income								
Within 1/2 mile	ns		ns		ns		ns	
Within 2 miles	2	(4)	2	(4)	ns		ns	
Road density								
Within 1/2 mile	2	(14)	ns		ns		ns	
Within 2 miles	14	(25)	ns		ns		ns	

*within ½ mile n=14; within 2 miles n=55

Raleigh*								
Percent renter-occupied homes								
Within 1/2 mile	2	(22)	ns		ns		ns	
Within 2 miles	5	(12)	1	(2)	ns		ns	
Percent African-American								
Within 1/2 mile	1	(11)	ns		ns		ns	
Within 2 miles	6	(14)	1	(2)	ns		ns	
Percent low-income								
Within 1/2 mile	ns		ns		ns		ns	
Within 2 miles	ns		4	(10)	ns		ns	
Road density								

Within 1/2 mile	1	(11)	ns		ns		ns	
Within 2 miles	2	(5)	ns		ns		ns	
*within ½ mile n=9; within 2 miles n=42								
Winston-Salem*								
Percent renter-occupied homes								
Within 1/2 mile	2	(18)	ns		ns		1	(9)
Within 2 miles	6	(13)	3	(7)	ns		1	(2)
Percent African-American								
Within 1/2 mile	4	(36)	ns		ns		ns	
Within 2 miles	14	(31)	ns		1	(2)	ns	
Percent low-income								
Within 1/2 mile	1	(9)	ns		ns		ns	
Within 2 miles	5	(11)	5	(11)	ns		ns	
Road density								
Within 1/2 mile	1	(9)	ns		ns		ns	
Within 2 miles	8	(18)	ns		ns		ns	
*within ½ miles n= 11; within 2 miles n=45								

[a] Number block-groups (% total block-groups)
All significant at p <.05 or lower

Based on the results of the LISAs for the entire study area and for the five largest cities in North Carolina, there appeared to be little overlap between areas where these four vulnerability indicators were statistically significant and the locations of transmission pipelines. Few areas illustrate outliers and limited areas of clusters exist.

Nonetheless, the LISA analyses indicated that localized vulnerability to transmission pipelines should be considered by planners. Decisions made by planners have produced discriminatory land uses (Ritzdorf 1997, 56). The LISA results combined with the findings in Chapter 4 (See Tables 4.6 and 4.8) that a community's percentage of lower-income residents was statistically significant and negatively associated with use of mitigation tools point to the need for consideration of vulnerable populations with new developments, since clusters of specific categories of vulnerable populations do exist in some areas.

Moreover, since the results indicate that vulnerable populations live in close proximity to transmission pipelines, planners should consider how to address exposure in their community. Burby (2003) found that planners can improve the plan-making process by reaching out to involve appropriate stakeholders. Likewise Stevens and colleagues (2010) discovered that a planners' decisions made a difference in participation and in hazard mitigation outcomes. Research by Innes (1996) suggests that including a diverse group of stakeholders in the planning process can improve planning outcomes. Given the power that an individual planner can have on planning outcomes, it would be irresponsible not to invite participation from exposed groups, communicate the potential hazards to community leaders, and address exposure of vulnerable groups in community-based plans, or make other efforts to work with vulnerable communities living in close proximity to pipelines.

There are several weaknesses to the LISA analysis that might unduly influence the results. First, the block-group is a large area to take into consideration. Planning scholars have used wide definitions of local, such as Census tracts (Talen & Anselin 1998) or neighborhoods (Lathey et al. 2009), when conducting a LISA analysis of disparities. However, aggregation of Census type data leaves questions of actual spatial allocation for characteristics measured (Hewko et al. 2002). Second, additional vulnerability measures could be calculated to evaluate if other characteristics present statistically significant clusters and how those areas correspond with the areas evaluated here. Addressing other types of vulnerabilities might illustrate different results. Third, a different type of contiguity matrix (e.g., distance based) might provide additional insight. Fourth, the data does not take into account the timing of pipeline installation or population location in the study area.

6.2.4 Global factors associated with distance to a transmission pipeline

This section addresses potential for global differences in characteristics of people in areas near transmission pipelines. Ordinary least squares (OLS) regression and maximum likelihood regression estimates are presented in Table 6.8. The model coefficients along with t-values are supplied for the bivariate and multivariate OLS regressions while z-scores are presented with the coefficient for the spatially corrected maximum likelihood regression.

Although the bivariate results of the OLS regression indicate that all variables were statistically significant, the multivariate OLS regression estimates indicated that percent African Americans, percent renters, and the percent with a high school education or lower did not display a statistically significant association with distance to a transmission pipeline. The remaining variables were all statistically significant. However, in the multivariate OLS regression the large Moran's *I* value indicated a strong spatial autocorrelation. The statistically significant Moran's *I* suggested that the OLS regression provided biased estimates and that a spatially corrected regression analysis would provide estimates that are more appropriate.

Lagrange multiplier tests indicated that a spatial lag variable would provide a better fit than the spatial error variable. Model comparison suggested that the maximum likelihood model with a spatial lag variable was a better fit than the OLS model. While the r-square and pseudo r-square variables from OLS and maximum likelihood regression models were not directly comparable, the log-likelihood and AIC values provide information that allows comparisons across models (Anselin 2005, 207). The increase in the log-likelihood value from -5,734 in the OLS regression to -4,097 in the maximum likelihood regression model suggested an improved fit of the maximum likelihood model over the OLS model. The AIC showed similar improvement with a decrease of from 11,484 in the OLS model to 8,211 in the maximum likelihood model.

The regression models showed that the housing age, percent older adults, percent of the population under the poverty level, and road density displayed statistically significant association with distance from the transmission pipeline. The regression findings were largely consistent with the results from the t-tests, Kolmogorov-Smirnov tests, and LISAs. The housing age variable was positively associated with distance. This finding was consistent with the t-tests (Table 6.1 and 6.2) that showed the median home age was newer within block-groups with a closer distance (≤0.5 or ≤2 miles) as compared to block-groups located in areas farther away. In addition, consistent with the t-tests in Tables 6.1 and 6.2, the percent of the population under the poverty level was positively associated with distance from the pipeline. Likewise, I found no indication that the percent African-American residents was a statistically significant variable, similar to results in the t-tests and presented in the histograms of the largest cities (Figures 6.2- 6.9).

Table 6.8, Ordinary least squares and spatial regression of natural log of distance to pipeline

	OLS (bivariate)			OLS (multivariate)			Maximum likelihood			
	Coeff.		t-value	Coeff.		t-value	Coeff.		z-value	Exp. Coeff.
% African-American (sqrt)	-0.03	***	-3.00	-0.01		0.43	-0.004		-0.64	0.996
% Renters (sqrt)	-0.06	***	-5.56	-0.02		0.16	-0.007		-0.82	0.993
% High school education or lower	0.01	***	11.40	0.00		0.58	0.000		-0.12	1.000
% Poverty-level or lower (ln)	0.13	***	7.69	0.14	***	0.00	0.027	*	2.15	1.027
Road density (ln)	-0.46	***	-15.13	-0.60	***	0.00	-0.094	***	-3.56	0.911
Median year built, residential housing	-0.46	*	-1.97	0.02	***	0.00	0.004	**	2.99	1.004
Percent age 65 or older	0.00	***	8.00	0.03	***	0.00	0.004	*	1.96	1.004
Spatial lag							0.854	***	85.42	2.348
Constant				10.61	***	0.00				
n	3561			3561			3561			
F-statistic				71.93						
R2				0.12						
Pseudo R2							0.71			
Adjusted R2				0.12						
Robust Legrange Multiplier (error)				6.46	*					
Robust Legrange Multiplier (lag)				241.22	***					
Log likelihood				-5734			-4097			
AIC				11484			8211			
Moran's I				0.63	***		-0.05			
*p<.05, **p<.01, ***p<.001										

Two variables, mean road density and percent older adults, presented contrasting outcomes to the t-tests. Based on the results of the maximum likelihood regression, road density was negatively associated with distance to a transmission pipeline. These results were contrary to the results from the t-tests. Given that the maximum likelihood regression results contained all block-groups in counties with transmission pipelines as opposed to the t-tests that looked only at areas within a limited distance to transmission pipelines, I speculate that the rural nature of many of the counties may explain this result. Although the transmission pipelines were generally located in relatively low-density areas, they do lead toward the urban areas that generate demand for the products carried by pipelines. The outskirts of these urban areas may have higher road density compared to the other areas in the rural counties. For the variable for percent persons over age 65, the t-tests indicated no statistically significant relationship at different distances. The maximum likelihood regression results indicated a statistically significant and positive relationship associated with distance from a transmission pipeline.

The results of the spatial regression analysis suggested distance to transmission pipelines was not associated with higher percentages of vulnerable populations. However, since the study used cross-sectional rather than longitudinal data, the above analysis may have missed findings that case studies or longitudinal analysis might uncover. Several researchers have noted the challenges of addressing equity issues using Census data alone. In attempting to address the challenges that using aggregated Census of Population data to understand the social disparities in areas with hazards, many researchers have concluded that historical case studies (Downey 1998, 775; Pulido 1996), historic risk-based approaches (Graham et al. 1999, 184), or reconciliation of several decades of Census data to create longitudinal data (Been & Gupta 1997; Pastor et al. 2001) remain a necessary ingredient for understanding distribution of different social groups in hazardous areas. Given that the pipeline data that did not provide pipeline construction or installation date, additional case study research could provide useful insights.

The results indicated that pipelines were statistically associated with rural areas. Although I did not have access to information on when the pipelines were sited, the pipeline industry claims that pipelines were originally located in areas with limited population (Transportation Research Board 1988, 8). Accident data has suggested that new development encroaching on transmission pipelines is one of the top causes of pipeline ruptures in the form of construction or third-party accidents (Simonoff et al. 2008). The regression analysis provided large-scale support for this claim.

6.3 Conclusions

Lack of appropriate local land-use planning has placed people at risk from a variety of toxic hazards (Bullard 2000; Maantay 2002b). Given that transmission pipelines carry over 35 types of hazardous chemicals (PHMSA Pipeline Safety Program 2005d), there are many potential dangers for those living close by. This analysis focused on determining who lives near transmission pipelines and if vulnerable populations showed statistically significant association with closer distances to transmission pipelines.

The results of the study illustrate that across North Carolina the average block-group was lower-density, slightly higher in income, with a lower percentage of the population living under the poverty level than at a farther distance from the pipeline. The homes closer to pipelines were on average newer than those homes at a farther distance. Within the five largest cities in North Carolina African-Americans were statistically less likely to live closer to transmission pipelines than to live in areas slightly farther away. These results are consistent with claims that pipelines were originally placed in areas with limited population (Transportation Research Board 1988, 8) and that ruptures occur closer to newer development (Transportation Research Board 2004, 1).

The results of the regression analysis suggested that variables for vulnerable populations were not statistically significant predictors of distance to a transmission pipeline. The spatially corrected regression results indicated that road density and the age of residential housing were statistically associated with distance. The percent under the poverty level was statistically significant and positively associated with distance from the pipeline, indicating that the incomes of those closer to transmission pipelines was higher than in areas farther away. Finally, the spatial regression results revealed that distance from the pipeline was statistically significant and positively associated with the percent older adults, showing that as distance increases the number of older adults also increased. However, the LISAs suggested that pockets exist with clusters of vulnerable populations near transmission pipelines.

The analysis of population characteristics living near transmission pipelines examined block-groups in areas with general risk from pipeline hazards. However, with access to data with specialized criteria (e.g., pipeline pressure, types of liquids, location of tank farms, etc.) that was unavailable for this project, one might refine the analysis to include more specific hazard risks to nearby populations. Chakraborty and Armstrong (1997) found that changing the geographic hazard zone from a distance-based to a hazard plume-based area produced statistically significant differences in the characteristics of the potentially affected population. Although the data available for this study did not include the necessary indicators (e.g., psi, contents, etc.) to calculate the potential hazard plume or explosion areas (U.S. Department of Transportation 1999), inclusion of this type of data would improve analysis of the actual hazard area. Similarly, Baden and colleagues (2007) evaluated published environmental justice studies and found that findings varied depending on the scale (size of unit of analysis) and scope (geographic domain) the authors chose in their analysis. Cutter and colleagues (1996, 525) evaluated equity concerns in South Carolina at different scales and concluded the smaller scale (e.g., block-group) to produce more efficient outcomes in a state-wide analysis. Analysis at different scales (e.g., at the Census tract level or parcel level) might produce different results. Likewise, analysis of areas that have had recent accidents or a consistent history of accidents might draw attention to specific problem areas that were not uncovered with the analyses conducted for this project.

The implications from the spatially corrected maximum likelihood regression analysis and the LISAs suggest planners need to take transmission pipelines into consideration with new development. Likewise, the LISAs indicated existence of vulnerable populations within close distance to pipelines. Planners have the opportunity and responsibility to assist communities currently living in close proximity to understand and plan for pipeline hazards. Stevens and others (2010) found that the planners' choices were associated with participation levels. Moreover, work by Brody and others (2003) suggested that information choices made by planners can influence citizen involvement and the resulting types of hazard mitigation tools adopted.

The LISA results suggest that there are areas where planners need to continue to be aware of potential hazards for vulnerable groups. The LISA analyses conducted for this study looked at four areas, percent African-American, percent renters, percent lower-income, and high-density areas. However, additional analyses could be extended to include other vulnerable groups. Given conclusions by researchers that hazardous industries were more likely to expand in areas with higher number of lower-income or minority groups (Hamilton 1995; Maantay 2001, 2002a), new development in block-groups with clusters of high numbers of vulnerable populations that are located close to transmission pipelines should receive strong scrutiny. Likewise, since urban and highly dense areas are more likely to have serious repercussions from chemical hazards compared to less populated areas (Quarantelli 1991, 58), understanding potential exposure in the urban areas can help policymakers address vulnerabilities.

Additionally, potential for new transmission pipelines in North Carolina as a result of natural gas “fracking” initiatives may put previously unaffected people at risk from pipeline hazards. While the data included in this dissertation did not evaluate areas with potential for fracking or the areas where the new pipelines that would be put in place, the methods used to evaluate populations living near transmission pipelines could be modified to include the fracking and new pipeline areas. Fracking poses additional hazards to local populations than those that would occur from transmission pipelines alone (Kerr 2010; Manuel 2010).

The results also indicated the importance of implementing growth management near transmission pipelines. Both t-tests and the regression analysis indicated that newer development was associated with closer distance to transmission pipelines. Given the survey findings (Section 4, Table 4.6) that access to information about transmission pipelines was positively associated with use of land use planning tools to mitigate pipeline hazards, communities with pipeline hazards should make extra effort to obtain information about the types, locations, and hazards from the transmission pipelines in their community.

7 Conclusions

7.1 Summary

Transmission pipelines cover much of the United States and construction of new transmission pipelines will be necessary to address future energy needs. Pipeline accident reports suggest that damage to pipelines by construction or third-party damage is a leading cause of pipeline ruptures. Pipeline ruptures pose hazards to communities on several fronts—lasting environmental damage if a rupture occurs and potential health risks from both chronic and acute leaks.

Through study of transmission pipelines, this dissertation addressed use of land use planning to mitigate hazards generally. The study illustrated factors that influence local adoption of land use planning tools. It assessed how collaborative partnerships between planners and emergency managers can build capacity of local governments to address hazard mitigation. The study also evaluated environmental equity issues surrounding a hazard that has received only limited addition in the environmental justice and equity literature.

7.2 Study implications

The study classified the most commonly used tools for planning in areas with transmission pipeline hazards. I found that communities use few tools to address pipeline hazards. Many use no tools, highlighting deficits in homeland security partnerships to protect pipeline infrastructure and a limited local emphasis critical infrastructure protection. The tools most commonly used were those that provided information about hazard locations. Regulatory and incentive tools were less frequently used than information tools. While these findings echo concerns about local participation in homeland security planning (Reddick 2008), they also highlight a gap in research on how communities use different types of growth management tools for addressing hazard mitigation.

I found a statistically significant and positive association of perception of risk by environmental groups and pipeline operator groups with adoption of land use tools to mitigate pipeline hazards. This finding illustrates the importance of perception of hazard risk for addressing development management outcomes for low-priority issues. The role of environmental groups was statistically significant and associated with adoption of regulatory tools and not information tools, illustrating the interest of environmental groups in achieving land use management that goes beyond information to protect the environment. In contrast, pipeline operator groups displayed statistically significant association with adoption of information tools, not regulatory tools. For planning practitioners, these findings illustrate how involvement of stakeholders with a perception of risk from a hazard can have a positive impact on local adoption of mitigation tools to address that hazard. Moreover, the results highlight how risk perception by different groups can influence adoption of specific categories of policy tools. For planners concerned about pipeline issues, reaching out to these stakeholders could prove fruitful. Collaborations with emergency managers and other planning departments could provide new ways to identify groups with a regional-level interest in these issues that could become active within planning processes.

Planning scholars have indicated the importance of commitment to achieving local mitigation goals. However, the results of this research suggest that commitment is statistically associated with use of information tools, but not regulatory tools. Given these findings, practitioners should be aware that implementation of regulatory tools may require going beyond their agency's commitment to mitigation.

Capacity for addressing pipeline hazards was associated with use of mitigation tools. The role of access to information about pipelines was especially interesting. Given the limited sources of information about pipelines that survey respondents used, the study illustrates that mitigation can be improved by addressing this knowledge gap. This finding exposes an opportunity for policymakers, pipeline operators, and planners, all of whom could facilitate risk reduction by shrinking the knowledge gap. The interviews in Chapter 4 revealed that some types of collaborative partnerships may address these deficiencies better than others. The full partnerships illustrated comprehensive knowledge sharing while information transmission in the other two partnerships was less inclusive and complete.

The study suggests continued research on exposure of marginalized groups to hazards remains necessary. Findings from Chapter 4 illustrate a statistical association of the variable for percent lower-income residents with a decrease in total tool use in the regression analysis. Additionally, I found pockets across the state where lower-income groups were clustered near transmission pipelines (Chapter 6). Land use scholars have identified inequalities in exposure to other hazards and planners should continue to reflect on these potential disparities during land-use planning. Given that the study identified areas where vulnerable groups are exposed to pipeline hazards (Chapter 6), planners have a responsibility to take action to inform community members, introduce mitigation tools that address developed areas, and invite participation of affected community members in planning. The participation of these groups may help communities adopt community-wide hazard mitigation practices that can ameliorate potential effects of pipeline hazards. Nonetheless, given the findings in

Chapter 6 that the percentage of a block-group living under the poverty level dropped with distance from the pipeline, it may continue to be an issue of community capacity to address hazards rather than simply an issue of those living nearby. These contrasting findings are indicative of the nuances required to understand exposure to hazards and adequately address them.

Using interviews with planners and emergency managers, I assessed types of inter-agency collaboration and how these partnerships built capacity for pipeline hazard mitigation. The results echo earlier findings that collaborative partnerships among local agencies can improve homeland security (Caruson & MacManus 2006), but go further by identifying how different types of collaborative groups build capacity. Some have noted the difficulties in addressing homeland security among agencies with different missions (Light 2004). This study illustrated that distinct types of collaboration influence capacity in different ways, suggesting that some technical collaborations address these challenges better than others. Local governments can use this information to improve their partnerships so that the partnership meets mitigation goals. In the absence of interest or ability in improving the partnership, understanding a partnership's limitations can also be helpful.

7.3 Future research

There are several areas where this research can be broadened. Due to limitations in access to transmission pipeline data, the study area was limited to North Carolina. Although the study provides a fairly comprehensive picture of moderate sized cities, there are few large cities in North Carolina. As the interviews in Chapter 5 illustrate, larger communities have different opportunities than smaller ones. A comprehensive analysis of larger metropolitan areas across the United States would confirm if the findings found in this study consistently occur at a larger scale. Moreover, a nationwide study that takes into account additional areas of the country, regardless of population size would be able to reduce the bias against planning in North Carolina. The majority of the techniques within the survey in Chapter 4 are applicable to communities across the country; however, nuances in state-level planning and political climates may make some communities more likely to adopt or discard specific classes of policies. Additionally, the focus on North Carolina limited the applicability to states without a large pipeline industry. In states such as Texas or Louisiana community knowledge about dangers associated with natural gas and the hazardous liquids carried by pipelines might positively influence agency knowledge about transmission pipelines.

Although this study categorized the tools most commonly used to address pipeline hazards, it did not calculate the utility of each tool. Some tools may be more effective than others. Likewise, individual tools may require political or community support for implementation to be feasible. Assessment of the effectiveness of specific land use planning tools for mitigating transmission pipeline hazards would provide both policymakers and scholars with informative data on choosing the best tools. The results presented in Chapter 4 did not address if specific tools were more effective than others in addressing pipeline hazards. One tool may be more effective than a combination of several tools. A study evaluating the effectiveness of specific tools could employ opinions of planners, rely on quantitative analysis of tool effectiveness conducted in collaboration with environmental engineers, ecologists, and risk analysis experts, or assess quality of new development within pipeline hazard zones in the aftermath of tool adoption.

In addition to the areas where study could be expanded, focusing the efforts of new research present opportunities. The interviews in Chapter 5 produced insight into collaborations between emergency managers and planners. Additional interviews could concentrate on how consideration of equity issues could be better incorporated into pipeline hazard mitigation. These interviews could be conducted with both planning and emergency management practitioners and with community members. Community participation in emergency management can be an important aspect of building capacity for hazard response (Lindell 1995). Israel and colleagues (1998) illustrated that community-based participatory research can produce insight that traditional research might miss. The insights gained from community-based participatory techniques can be particularly important for marginalized communities (Arcury et al. 2001). Another method would be to follow Comfort and colleagues' (1999, 43) suggestion for information exchange systems and informed local action.

Lack of access to data on specific types of pipeline hazards, such as tank farms or areas where pipelines branch into distribution points limited the conclusions this research can make about areas with specific pipeline hazards. Since areas with connections to storage tanks or distribution centers might have heightened risk factors (Reddic & Cuykendall 1995), a focus on the people living near these areas could yield insight into community characteristics in areas with higher risk from pipeline hazards.

Moreover, study of areas with potential for major environmental consequences might prove interesting. Pipeline hazard zones surrounding drinking water reservoirs or pristine natural areas are examples of such areas. The interviews in Chapter 5 revealed that several communities in North Carolina have transmission pipelines running under water supply reservoirs. According to the interviewees, the transmission pipelines were constructed prior to the water reservoir. Study of areas identified as having high environmental quality might yield important information for encouraging participation of environmental groups. Given the links found in Chapter four to adoption of regulatory growth management techniques by communities where environmental groups have a higher perception of risk from transmission pipelines, the study of pipelines in these areas could be fruitful for improving land use management near pipelines.

7.4 Planners and management of transmission pipeline hazards

This dissertation illustrated that planners can and do address mitigation of transmission pipeline hazards, yet it also demonstrated that there are several areas of concern that warrant additional attention. Planners play a critical role in addressing land use in areas surrounding transmission pipelines. Land use planning tools offer a clear opportunity to keep people away from pipeline hazards. In this study I found many planners that collaborated, to varying degrees, with emergency managers and other planners to ensure that the best possible mitigation occurred. The study uncovered how knowledge deficits reduce potential for planning that addresses development encroachment near transmission pipelines. The study found several clusters where vulnerable populations were at higher risk from transmission pipelines, yet did not reveal a large-scale indication of disproportionate disparities for vulnerable populations. Even so, the analyses conducted in this study identified that development closer to pipelines was newer than areas farther away, illustrating the failure of land-use planning to reduce development encroachment. As a result of this research, I uncovered several areas where additional research is needed to reduce development encroachment on pipeline hazard areas. Taken together, the results of this study highlight the potential of land-use planning reduce encroachment on pipeline hazards and protect people and the environment when pipeline ruptures occur. Nonetheless, while this study indicated that land use planning practices address pipeline hazards in many areas, it also identified that modifications to local planning practices can do much for reduction of risks to human health, homeland security, and the environment from transmission pipeline hazards.

Appendix A, Survey

Planning Agencies & Transmission Pipelines in North Carolina

A Survey of North Carolina Local Governments

Conducted by

University of North Carolina at Chapel Hill

Supported by

U.S. Environmental Protection Agency

Instructions

Transmission pipelines are large diameter pipes (2 to 42 inches in diameter) that transport natural gas and hazardous liquids over long distances. The goal of this study is to gain a better understanding of local government knowledge about transmission pipelines, the experience of planning agencies with new development near transmission pipelines, and polices and management of development near transmission pipelines.

Experts disagree about the risk of hazardous liquid and natural gas transmission pipelines. Some believe the risk is high, while others may view it as negligible. We are interested in your judgments even though we know that you may not have thought about or researched this topic before. Please answer all of the questions as accurately as possible. If there are questions you can not answer, please feel free to consult with others who may be able to provide the answer.

First we ask questions about your agency's experience with and knowledge about transmission pipelines

1. How much do you feel your planning agency knows about land-use and development management as it relates to hazardous liquid and natural gas transmission pipelines?

Check one

☐ A lot
☐ Some
☐ A little
☐ Nothing

2. Please check each of the following your planning agency has used as a source of information about hazardous liquid or natural gas transmission pipelines?

Check all used

☐ U.S. Office of Pipeline Safety website
☐ Oil industry trade associations websites
☐ Natural gas industry trade associations websites
☐ Environmental Protection Agency website: www.epa.gov
☐ NC Utilities Safety Commission website: www.ncuc.commerce.state.nc.us
☐ NC One-Call website: www.ncocc.org
☐ Other internet source
☐ Classes at a college/university
☐ Word of mouth
☐ Professional conference
☐ Magazine
☐ Local departmental meetings
☐ "Call Before You Dig" video
☐ Contact with pipeline operator
☐ Information from previous job
☐ Local emergency management/Local Emergency Planning Committee (LEPC) personnel
☐ Transportation Research Board Report 281: Transmission Pipelines and Land Use, A Risk Informed Approach
☐ Sign located near a pipeline
☐ Other source(s): *(list)*

3. How much do you feel your planning agency knows about the North Carolina One-Call system (also known as ULOCO or Underground Utilities Location Request)?

Check one

☐ A lot
☐ Some
☐ A little
☐ Nothing

4. Is your planning agency aware of any hazardous liquid or natural gas transmission pipelines in this jurisdiction?

☐ Yes
☐ No

5. Has this jurisdiction experienced a pipeline-related accidental release of hazardous liquids or natural gas (either due to pipeline rupture in this jurisdiction or effects from a pipeline rupture in a nearby jurisdiction)?

☐ Yes → When?:__________________________________
☐ No

Next we ask some questions about the approaches communities can take to limit the exposure of people and property to pipeline hazards

6. The following land use management measures have been suggested as possible ways of limiting the exposure of people and property to the hazards posed by transmission pipelines. Please tell us if the measure is used in your jurisdiction and, if so, how useful it is for limiting development near transmission pipelines. If the measure is not in use, please let us know how feasible the adoption of the measure (*i.e.*, technically, politically, etc.) would be should your agency wish to make use of it.

CIRCLE used/not used and usefulness/ feasibility of each tool

A) Transmission pipeline zoning overlay district with standards for pipeline rights-of-way
Used **Not Used** → **Low Feasibility 1 2 3 4 5 High Feasibility**
→ **Not Useful 1 2 3 4 5 Very Useful**

B) Low density zoning surrounding pipelines
Used **Not Used** → **Low Feasibility 1 2 3 4 5 High Feasibility**
→ **Not Useful 1 2 3 4 5 Very Useful**

C) Maps of transmission pipeline locations
Used **Not Used/ Not Available** → **Low Feasibility 1 2 3 4 5 High Feasibility**
→ **Not Useful 1 2 3 4 5 Very Useful**

D) Environmental impact statements for new developments near transmission pipelines

Used **Not Used** → **Low Feasibility 1 2 3 4 5 High Feasibility**

└→ **Not Useful 1 2 3 4 5 Very Useful**

E) Illustration of transmission pipeline easements on subdivision plats

Used **Not Used** → **Low Feasibility 1 2 3 4 5 High Feasibility**

└→ **Not Useful 1 2 3 4 5 Very Useful**

F) Mandatory open space dedication requirements of developers to provide buffers between transmission pipelines and development

Used **Not Used** → **Low Feasibility 1 2 3 4 5 High Feasibility**

└→ **Not Useful 1 2 3 4 5 Very Useful**

G) Special transmission pipeline hazard ordinance

Used **Not Used** → **Low Feasibility 1 2 3 4 5 High Feasibility**

└→ **Not Useful 1 2 3 4 5 Very Useful**

H) Berms and containment ponds adjacent to hazardous liquid pipelines that traverse subdivisions in order to contain spills and prevent damage to buildings

Used **Not Used** → **Low Feasibility 1 2 3 4 5 High Feasibility**

└→ **Not Useful 1 2 3 4 5 Very Useful**

I) Minimum building setback requirements for buildings adjacent to transmission pipelines

Used **Not Used** → **Low Feasibility 1 2 3 4 5 High Feasibility**

└→ **Not Useful 1 2 3 4 5 Very Useful**

J) Density bonuses or other incentives for developers that move development away from pipelines

Used **Not Used** → **Low Feasibility 1 2 3 4 5 High Feasibility**

└→ **Not Useful 1 2 3 4 5 Very Useful**

K) Restrictions on the location of critical facilities near transmission pipelines (*e.g.*, fire and police stations, public schools).

Used **Not Used** → **Low Feasibility 1 2 3 4 5 High Feasibility**

└→ **Not Useful 1 2 3 4 5 Very Useful**

L) Watershed protection ordinance with provisions to protect transmission pipelines from possible third-party damage

Used **Not Used** → **Low Feasibility 1 2 3 4 5 High Feasibility**

└→ **Not Useful 1 2 3 4 5 Very Useful**

M) Deed restrictions for property with pipeline easements

Used **Not Used** → **Low Feasibility 1 2 3 4 5 High Feasibility**

└→ **Not Useful 1 2 3 4 5 Very Useful**

N) Transfer of development rights from areas near transmission pipelines to less hazardous areas

Used **Not Used** → **Low Feasibility 1 2 3 4 5 High Feasibility**
└→ **Not Useful 1 2 3 4 5 Very Useful**

O) Transmission pipeline disclosure required in real estate transactions

Used **Not Used** → **Low Feasibility 1 2 3 4 5 High Feasibility**
└→ **Not Useful 1 2 3 4 5 Very Useful**

P) Fire resistance requirements as set by Section 7 of the North Carolina State Building Code

Used **Not Used** → **Low Feasibility 1 2 3 4 5 High Feasibility**
└→ **Not Useful 1 2 3 4 5 Very Useful**

Q) Areas subject to pipeline hazards identified with signs

Used **Not Used** → **Low Feasibility 1 2 3 4 5 High Feasibility**
└→ **Not Useful 1 2 3 4 5 Very Useful**

R) Excavators required to notify state one-call center (ULOCO) prior to beginning work

Used **Not Used** → **Low Feasibility 1 2 3 4 5 High Feasibility**
└→ **Not Useful 1 2 3 4 5 Very Useful**

S) Media campaign to alert people to the presence of pipelines

Used **Not Used** → **Low Feasibility 1 2 3 4 5 High Feasibility**
└→ **Not Useful 1 2 3 4 5 Very Useful**

T) Other tool(s) (List:________________________________):

Used **Not Used** → **Low Feasibility 1 2 3 4 5 High Feasibility**
└→ **Not Useful 1 2 3 4 5 Very Useful**

Next we ask some questions about local hazard reduction efforts for several types of hazards

7. Please rate the degree of effort your locality has devoted to reducing the potential adverse effects of the following natural and technological hazards on a scale from 1-5, (1= no effort, 5=high effort). If the hazard does not exist in your jurisdiction, circle N/A.

	No Effort		Some Effort		High Effort	
Floods	**1**	**2**	**3**	**4**	**5**	**N/A**
Winter storms	**1**	**2**	**3**	**4**	**5**	**N/A**
Tornadoes	**1**	**2**	**3**	**4**	**5**	**N/A**
Hurricanes	**1**	**2**	**3**	**4**	**5**	**N/A**
Wildfires	**1**	**2**	**3**	**4**	**5**	**N/A**
Hazmat releases from industry	**1**	**2**	**3**	**4**	**5**	**N/A**
Liquid transmission pipeline releases	**1**	**2**	**3**	**4**	**5**	**N/A**
Gas transmission pipeline releases	**1**	**2**	**3**	**4**	**5**	**N/A**
Highway hazmat releases	**1**	**2**	**3**	**4**	**5**	**N/A**
Rail hazmat releases	**1**	**2**	**3**	**4**	**5**	**N/A**

Next we ask some questions about perceptions of transmission pipeline risk in your community

8. In the last 5 years, have any individuals or members of the following groups expressed concerns about pipeline safety or requested action to deal with pipeline hazards in your community?

Check all that apply

	Requested Information	Attended Meetings	Asked for Action	No Request for Action
Business groups (*e.g.*, Chamber of Commerce)	☐	☐	☐	☐
Environmental groups (*e.g.*, Sierra Club)	☐	☐	☐	☐
Neighborhood groups	☐	☐	☐	☐
Petroleum industry representatives	☐	☐	☐	☐
Natural gas industry representatives	☐	☐	☐	☐
NC State Utilities Commission	☐	☐	☐	☐
Transmission pipeline company representatives	☐	☐	☐	☐
Individuals not associated with any particular organized group or interest	☐	☐	☐	☐

9. What proportion of each of the following groups within your jurisdiction do you think are very concerned with threats to property damage, injury to people, and environmental contamination from a natural gas or hazardous liquid transmission pipeline accident?

	None	**Very Few**	**Some**	**A Large Number**	**All**
Residents	☐	☐	☐	☐	☐
Elected officials	☐	☐	☐	☐	☐
Developers	☐	☐	☐	☐	☐
Persons responsible for planning and zoning	☐	☐	☐	☐	☐

Next, we ask some questions about developments near transmission pipelines in your community

10. Has your agency reviewed a development proposal within the last 5 years that included either a transmission pipeline or was within 200 yards of a transmission pipeline?

☐ **Yes** (continue below)
☐ **No** (Skip to question 11)

A) Name of development (if there are several, please identify the most recent one):
____

B) Year development was reviewed by your planning agency: __________

C) How did knowledge about the location of a transmission pipeline near the development arise?

Check all that apply

☐ Illustrated on a zoning map
☐ Illustrated on the subdivision plat
☐ During internal review of development proposal
☐ During the technical review process
☐ Due to public input
☐ Through an environmental impact study/ environmental assessment
☐ Other (list)

D) Did issues regarding pipeline safety arise during the review process?

☐ Yes → Who brought them up? **(Check all that apply)**
- ☐ This planning agency
- ☐ Land developer
- ☐ Local citizen (or citizen group)
- ☐ Discussion initiated by outside agency (*e.g.*, Fire Department)
- ☐ Transmission pipeline company representative
- ☐ Land owner
- ☐ Planning board/commission member
- ☐ Other (list)

☐ No

E) How were safety issues near the transmission pipeline dealt with?

Check all used

- ☐ Illustration of easement on subdivision plat
- ☐ Open space dedication
- ☐ Berms or containment ponds
- ☐ Building setbacks
- ☐ Density bonuses to move development away from pipeline
- ☐ Deed restrictions
- ☐ Transfer of development rights
- ☐ Signage identifying pipeline locations
- ☐ Required use of NC One-call (ULOCO)
- ☐ Other tool(s) (list):

F) Are there other comments on the development process for this development you would like to share? Please feel free to write them in the space below:

11. Please rate from 1 to 5 (1= poor, 5= excellent) the capacity of your planning agency to address transmission pipeline hazards. **(Circle one)**

	Poor				**Excellent**
Adequacy of agency budget	**1**	**2**	**3**	**4**	**5**
Agency technical expertise	**1**	**2**	**3**	**4**	**5**
Access to top management and elected officials	**1**	**2**	**3**	**4**	**5**
Authority for enforcing regulations related to pipeline hazards	**1**	**2**	**3**	**4**	**5**

12. If your agency needed additional information on transmission pipelines, who would your agency contact for additional information?

Check all that apply

☐ Fire department
☐ Engineering department
☐ Emergency management department
☐ Regional hazmat response team contact (RRT)
☐ The liquid pipeline company working in your jurisdiction (*e.g.,* Colonial Pipeline Company, Plantation Pipeline Company, Dixie Pipeline Company)
☐ The gas pipeline company working in your jurisdiction (*e.g.*, North Carolina Natural Gas Company, Public Service Company of NC)
☐ Pipeline Safety Section of the NC Utilities Commission
☐ Not Sure
☐ Other(s) (list):

13. Does your county or municipality have a land use or comprehensive plan?

☐ Yes
☐ No (Skip to question 19)

14. In what year was the plan developed or most recently updated? ___________

15. Was the plan prepared primarily by the planning agency staff or by a consultant to the staff or other party?

☐ Planning agency staff
☐ Private consultant/other party

16. Has the plan been officially adopted?

☐ Yes → Adoption year: ____
☐ No

17. Does the plan include information on transmission pipelines?

☐ Yes
☐ No (Skip to question 19)

18. How are transmission pipelines addressed within the plan?

Check all that apply

☐ Areas with pipelines are mapped
☐ Plan policies address pipelines
☐ Pipelines included within vulnerability analysis
☐ Not sure
☐ Other (explain)

19. Has your department participated in creation of a jurisdictional or multi-jurisdictional hazard mitigation plan, such as one prepared in response to the federal 2000 Disaster Mitigation Act?

☐ Yes
☐ No (Skip to question 23)
☐ Don't know (Skip to question 23)

20. What was the role of the planning agency in the creation of the hazard plan?

Check one

☐ Lead agency/department
☐ Supportive member
☐ Consultant to plan committee
☐ Not sure
☐ Other (explain)

21. Does the hazard plan include information on transmission pipelines?

☐ Yes
☐ No (Skip to question 23)

22. How are transmission pipelines addressed within the hazard plan?

Check all that apply

☐ Areas with pipelines are mapped
☐ Plan policies address pipelines
☐ Pipelines included within vulnerability analysis
☐ Not sure
☐ Other (explain)

23. How many staff members work in your planning department? (Please indicate the number of full-time equivalent positions):

Number Full-time Positions

_______	Number of planning positions
_______	Total staff

24. Of the planning agency staff, how many persons have received certification from a state agency or relevant professional organization or society?

Number of Staff

_______	Planning (*e.g.*, AICP)
_______	Engineering (*e.g.*, PE)
_______	Architecture (*e.g.*, Licensed Architect)
_______	Landscape Architecture (*e.g.*, ASLA)
_______	Other certification (List:________________________)

THANK YOU again for taking the time to complete this questionnaire. Your assistance is very much appreciated!

If there is anything else you would like to tell us about this survey, please do so in the space provided below.

PLEASE RETURN your completed questionnaire in the pre-stamped, pre addressed envelope provided.

In case you have misplaced the envelope, please return your completed questionnaire to the following address:

Anna Osland
The Center for Urban & Regional Studies
Campus Box 3410, Hickerson House
The University of North Carolina at Chapel Hill
Chapel Hill, NC 27599-3410

If you have questions about the survey or research study, please feel free to contact us:

Phone: 919-308-0546, ask for Anna Osland
Email: aosland@email.unc.edu

Appendix B, Supplementary tables associated with Chapters 4-6

Table B1, Bivariate negative binomial regression models predicting total number of pipeline mitigation tools in use

Independent Variables	Exp. Coef.	Std. Err.	z	
Risk Perception				
Environmental groups	1.33	0.3	1.4	
Pipeline industry groups	1.18	0.1	1.4	
Individuals	0.95	0.1	-0.4	
Commitment				
Commitment to mitigation	1.22	0.1	2.2	**
Capacity				
Land use plan	1.77	0.5	2.1	**
Access to information	1.11	0.0	2.7	***
Knowledge of pipeline location	1.20	0.2	1.0	
Community Context				
Low income households	0.98	0.0	-2.2	**
Population change 1990-2000	1.01	0.0	1.1	
Density (100 persons/sq. km.)	1.02	0.0	0.8	
Recent pipeline accident	1.26	0.3	0.9	

*p<0.1; ** p<0.05; *** p<0.01

Table B2, Detailed characteristics of block groups at three distances from transmission pipelines

Variable name	Mean	Std. Dev.	Min	Max
less 0.5 miles (n=396)				
Percent African-American	23	25	0	99
Percent Hispanic	5	7	0	50
Percent children under age 5	7	2	1	13
Percent persons over age 65	11	6	0	41
Percent high school diploma or less	47	20	1	90
Percent Bachelor's degree or higher	25	19	0	91
Percent under poverty-level	10	10	0	68
Medium household income	$45,138	$18,127	$6,232	$200,001
Percent renters	31	22	2	100
Road density (mean road seg./.25 mile)	8	4	2	20
Median year built, residential housing	1978	11	1939	1999
0.5- 2 miles (n=1086)				
Percent African-American	24	25	0	100

Percent Hispanic	6	8	0	68
Percent children under age 5	7	2	0	19
Percent persons over age 65	12	6	0	44
Percent high school diploma or less	50	21	0	94
Percent Bachelor's degree or higher	23	20	0	100
Percent under poverty-level	12	11	0	98
Medium household income	$43,294	$19,863	$4,520	$163,945
Percent renters	34	22	0	100
Road density (mean road seg./.25 mile)	10	6	1	30
Median year built, residential housing	1973	13	1939	1999
<u>2-4 miles (n=899)</u>				
Percent African-American	27	29	0	100
Percent Hispanic	5	8	0	87
Percent children under age 5	7	2	0	18
Percent persons over age 65	12	6	0	49
Percent high school diploma or less	50	21	0	97
Percent Bachelor's degree or higher	24	21	0	100
Percent under poverty-level	14	12	0	93
Medium household income	$41,730	$20,476	$4,545	$200,001
Percent renters	37	25	0	100
Road density (mean road seg./.25 mile)	11	6	2	29
Median year built, residential housing	1970	14	1939	1999

Table B3, Characteristics of clusters of block-groups in areas with pipeline hazards for the 3 counties with joint city-county planning areas

	Clusters				Outliers			
	High-high[a]		Low-low[a]		High-low[a]		Low-high[a]	
Mecklenburg County*								
Percent renter-occupied homes								
Within 1/2 mile	19	(24)	2	(3)	1	(1)	4	(5)
Within 2 miles	67	(26)	12	(5)	3	(1)	8	(3)
Percent African-American								
Within 1/2 mile	25	(32)	ns		ns		ns	
Within 2 miles	76	(30)	ns		ns		ns	
Percent low-income								
Within 1/2 mile	6	(8)	3	(4)	ns		ns	
Within 2 miles	33	(13)	20	(8)	ns		1	(<1)
Road density								
Within 1/2 mile	7	(9)	ns		ns		ns	
Within 2 miles	44	(17)	1	(<1)	ns		ns	

*within 1/2 miles n= 78; within 2 miles n=255

Durham County*								
Percent renter-occupied homes								
Within 1/2 mile	2	(13)	ns		ns		1	(6)
Within 2 miles	17	(28)	ns		ns		1	(2)
Percent African-American								
Within 1/2 mile	6	(38)	ns		ns		ns	
Within 2 miles	27	(44)	ns		ns		1	(2)
Percent low-income								
Within 1/2 mile	2	(13)	1	(6)	ns		ns	
Within 2 miles	15	(25)	2	(3)	ns		1	(2)
Road density								
Within 1/2 mile	3	(19)	ns		ns		ns	
Within 2 miles	20	(33)	2	(3)	ns		ns	
*within 1/2 miles n=16; within 2 miles n = 61								
Forsyth County*								
Percent renter-occupied homes								
Within 1/2 mile	2	(8)	ns		ns		1	(4)
Within 2 miles	7	(9)	7	(9)	ns		1	(1)
Percent African-American								
Within 1/2 mile	4	(17)	ns		ns		ns	
Within 2 miles	14	(17)	1	(1)	ns		ns	
Percent low-income								
Within 1/2 mile	ns		1	(4)	ns		ns	
Within 2 miles	4	(5)	7	(9)	ns		ns	
Road density								
Within 1/2 mile	1	(4)	ns		ns		ns	
Within 2 miles	8	(10)	ns		ns		ns	
*within 1/2 miles n= 24; within 2 miles n= 81								

[a] Number block-groups (% total block-groups)

All significant at p <.05 or less

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