

USING BROWNFIELD REDEVELOPMENT TO
MITIGATE TECHNOLOGICAL HAZARDS IN
SHREVEPORT, LOUISIANA

A Thesis

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Abstract

Brownfields are “abandoned, idled, or under-used industrial and commercial facilities where expansion or redevelopment is complicated by real or perceived environmental contamination” (USEPA 2003a). This thesis focuses on the practices of public and private institutions to redevelop brownfields in Shreveport, Louisiana, as a means of mitigating potential technological hazards.

The theoretical concept framing this analysis is hazards-of-place, a model of vulnerability that proposes interactions among physical vulnerability, social vulnerability, and mitigation efforts. In this model, vulnerability is a process that involves not only the likelihood of a hazardous incident but also the processes of hazard creation and mitigation that occur within social and geographical context. Hazards-of-place is an appropriate model for this analysis because of the roles of urban development processes and governmental authority in both creating and redeveloping brownfields.

The thesis describes how processes of brownfield creation and redevelopment correspond to components of the hazards-of-place theory. The review of environmental records, which documents the influence of the quantitative perception of risk prevalent among environmental service firms and regulators, demonstrates the influence of governmental authority. The thesis analyzes the connection between brownfield redevelopment and other urban development processes.

The analysis uses property values to compare investment at brownfields to investment in the surrounding properties. The two methods of analysis, statistical and cartographic, yield results with different degrees of success. The statistical analysis did not support the identification of any spatial patterns of investment relative to the subject

sites. Cartographic analysis, however, identified outliers that were excluded from statistical analysis but were nevertheless associated with brownfield redevelopment.

Supported by fieldwork, the cartographic analysis demonstrates that the new uses of redeveloped brownfields are part of industry-specific development in the surrounding area. The study areas surrounding both subject sites contained several properties that were the sites of significant levels of investment. The activities at these properties supported development of the same industries as at the new activities at the brownfields. These results indicate that, although it does not play a role in initiating new investment, brownfield redevelopment is closely associated with broader processes of urban development.

Chapter 1: Introduction to Hazards-of-Place

Brownfields are “abandoned, idled, or under-used industrial and commercial facilities where expansion or redevelopment is complicated by real or perceived environmental contamination” (USEPA 2003a). Based on this definition, this thesis will focus on the efforts and practices of various institutions, public and private, to redevelop brownfields and overcome the issues that complicate their redevelopment. The thesis considers redevelopment as a process of mitigating the technological hazards posed by brownfields.

The purpose of the thesis is to analyze and compare efforts to redevelop brownfields at two sites in Shreveport, Louisiana. Shreveport served as the subject city because it has engaged in an active brownfield redevelopment campaign. The redevelopment campaign was the setting for cooperation between private parties, city development officials, and environmental regulators, as illustrated by Shreveport’s participation in a U.S. Environmental Protection Agency (USEPA) brownfield redevelopment pilot program. Shreveport’s size (population approximately 370,000 in 2000; U.S. Census Bureau 2002) makes it the location of substantial industrial activity while still being more manageable than a major city.

Two brownfield sites serve as the basis for comparison of the redevelopment process. The two subject sites are a medical instrumentation research facility and a series of residential apartment buildings, fairground, and other entertainment venues located in downtown Shreveport near the Red River. These sites are significant because both have been the explicit focus of redevelopment efforts within the pilot program, and redevelopment of the sites is either complete or nearly complete.

The theoretical concept framing this analysis of brownfield redevelopment is the idea of hazards-of-place. Hazards-of-place is a model of vulnerability that proposes interactions among physical vulnerability, social vulnerability, and mitigation efforts associated with a range of hazards. This model is appropriate for both natural and technological hazards, since the method does not emphasize the distinction between the two (Cutter 1993, 1996). Recent studies have examined both natural and technological hazards using hazards-of-place. The strength of the model is its ability to integrate perspectives in hazards research including human ecology, hazards in context, and applications of social theory to vulnerability.

Hazards-of-place is suitable for analyzing brownfields because of its ability to integrate the diverse aspects of vulnerability. Brownfields are not necessarily hazards, but they are necessarily potential hazards. Even though changing economic and cultural geographies sites may make sites vulnerable to becoming brownfields, a particular site need not necessarily become a brownfield. Influences on vulnerability are the physical nature of environmental contamination, the role of institutions in implementing redevelopment projects, and the feedback effects of mitigation efforts. Efforts to mitigate brownfield hazards have consisted of incentives and assistance to private parties and public-private partnerships to promote redevelopment by reducing both environmental and legal risk.

Research Questions

The purpose of the thesis is to analyze strategies for mitigating environmental and financial risk by redeveloping brownfields. The research questions are concerned with

the redevelopment process and the outcome of particular redevelopment projects within the context of other development processes in the surrounding areas.

1. How do brownfield redevelopment strategies represent attempts to cope with interactions between biophysical and social vulnerability and the feedback effects that mitigation efforts for pre-existing hazards exert on the brownfield hazard? In other words, what elements of the hazards-of-place model are reflected by brownfield redevelopment strategies?
2. Is there an association between economic investment for the purpose of redevelopment at two particular brownfield sites in Shreveport, Louisiana, and economic investment at neighboring, possibly disinvested but not necessarily contaminated, sites?

The basis of these research questions is the hypothesis that redevelopment of brownfields is an investment that will both increase value at the site itself and spill over to prompt investment and increase value at surrounding sites.

Towards a Theory of Hazards

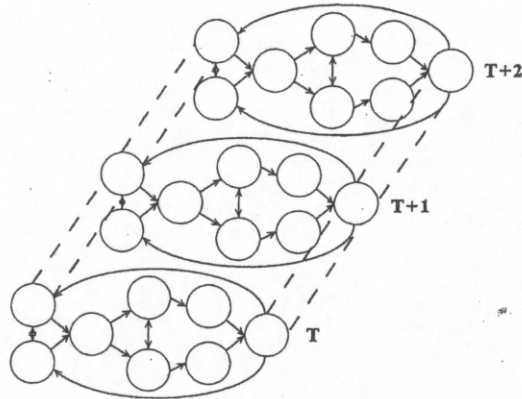
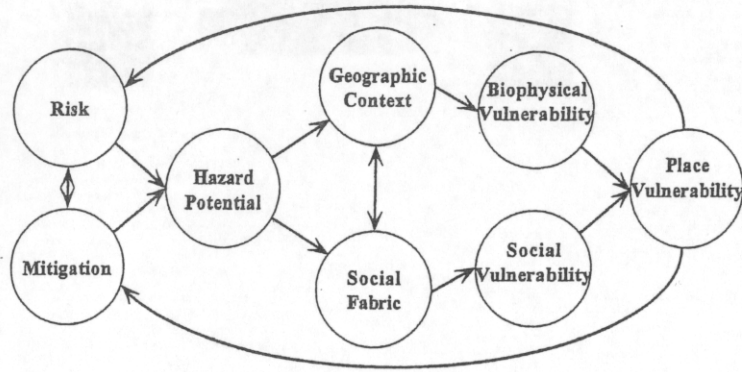
Theories of hazards research have elaborated on the original study of hazard geography as human ecology by introducing two themes. These two themes are the social construction of hazards and the distinction between risk and hazard (Cutter 2001).

Recognition of the social construction of hazards emerged from criticism of the natural disasters perspective of human ecology. The focus of these human ecology studies was the identification of areas at risk from a natural hazard, such as the location of physical features like floodplains, and the mapping of population within these risk areas (Cutter 1993, 2001). Although human ecology does includes studies of human

responses to hazards, the criticism of this perspective charges that it assigns too much importance to technical aspects of both the hazard and the response without adequately examining the social aspects of the response (e.g., Hewitt 1983). Mindful of this criticism, the hazards-in-context perspective analyzes the response to hazards in terms of social and political-economic context. The context of specific places, including cultural preferences for types of landscape that may affect losses and the access to political influence of affected populations, can contribute to the institutional response to the hazard (Mitchell et al. 1989).

By emphasizing the impact of social and political-economic context on hazardousness, these and other geographical studies of hazards have diminished the importance of the distinction between natural and technological hazards (Cutter 1993, 1996). Instead, “hazards are now viewed as a continuum of interactions among physical/environmental, social, and technological systems” (Montz et al. 2004, 480). Within this continuum is also a place for persistent, mundane hazards in addition to more dramatic natural or technological disasters (Montz et al. 2004).

The hazards-of-place approach is a model that incorporates ideas from these earlier hazard approaches (Cutter et al. 2003; Cutter et al. 2000; Lowry et al. 1995). This model seeks to integrate biophysical vulnerability (from human ecology) with social vulnerability (reflecting the social construction of hazards) to describe the vulnerability of a specific place. An important concept in this model is the interaction between biophysical vulnerability and human responses and mitigation efforts. Human responses occur within a feedback loop in which mitigation efforts can affect both the current hazard and new hazards (Figure 1; Cutter 1996).



The hazards of place model of vulnerability. The various elements that constitute vulnerability interact to produce the vulnerability of specific places and the people who live there (top). This vulnerability can change over time (bottom) based on changes in the risk, mitigation and contexts within which environmental hazards occur

Figure 1. Hazards-of-place schematic diagram
Diagram from Cutter (1996)

The theoretical approaches described above are concerned with hazard assessment, as opposed to risk assessment. Risk and hazards are distinct concepts, and the distinction is important enough to elaborate by defining these terms.

“Risk” is a measure of the likelihood of occurrence of the hazard.
“Hazard” is a much broader concept that incorporates the probability of the event happening, but also includes the impact or magnitude of the event on society and the environment, as well as the sociopolitical contexts within which these take place. (Cutter 1993, p.2)

Risk assessment techniques focus on estimating quantitative measures of risk within a particular degree of certainty. Hazard assessment, in contrast, often emphasizes the social processes that variously contribute to or attempt to mitigate hazards. The diminished importance of quantitative measures of risk makes hazard assessment more appropriate for brownfields, given the uncertain risk associated and the role of public and private institutions in redevelopment efforts. The hazards-of-place-based method that this thesis will employ more closely resembles a hazard assessment than a risk assessment.

Risks combine with mitigation... to create an overall hazard potential. Risks can be attenuated with good mitigation or they can be amplified by poor or nonexistent mitigation practices. The hazard potential is filtered through the social fabric of society... to determine the overall social vulnerability of the place. The hazard potential is also filtered through its geographical context... to determine biophysical/technological vulnerability. It is the intersection and interaction of both the social vulnerability and biophysical/technological vulnerability that create the vulnerability of places. The place vulnerability provides a feedback loop to both the risk and mitigation, which in turn further reduces or enhances both risk and mitigation. (Cutter 1996, p.536-7)

Because of its broad scope and its consideration of context, the hazards-of-place assessment in this thesis has limitations. The discretionary nature of the context chosen for analysis makes the hazard assessment less precise than a quantitative risk assessment. The presence of linkages and feedback mechanisms within the hazard assessment model

makes it difficult to isolate explicit causes. This difficulty limits the results of the assessment to an analysis of associations rather than correlations or causes. Despite these limitations, the hazard assessment has the advantage of considering social and geographical processes in addition to quantitative biophysical and environmental conditions.

The contents of the thesis reflect the components in the hazards-of-place model. Chapter 2 contains a literature review that establishes the hazard potential of brownfields. Firms that either abandon or redevelop industrial sites make business decisions within a social fabric that includes efforts to satisfy economic constraints and to avoid environmental and financial liability. These decisions interact with geographic processes, such as suburbanization, to create a place vulnerability that makes brownfields likely to occur in certain places. The risk of liability for environmental contamination aggravates the hazard by precluding mitigation or other revitalization of these places.

The research method presented in Chapter 3 provides details about the analysis in subsequent chapters. Chapter 4 contains an analysis of environmental records related to the two brownfield sites in Shreveport. These environmental records describe the quantitative risk assessments performed to satisfy regulatory requirements for redevelopment. The quantitative risk assessments describe the physical vulnerability to brownfield hazards in precise, detailed quantities based on the site's geology and hydrology, the chemical properties of the contaminants, the detectable concentrations of the contaminants, and the intended uses of the site. This quantitative method reflects the concept of risk and hazard held by redevelopers and environmental regulators.

The spatial and statistical analyses in Chapter 5 describe how mitigation efforts at brownfields can effect investment in surrounding properties. Using relative changes in property values as a measure of investment, the spatial analysis demonstrates that investment at brownfields is one part of broader strategies of investment that support dominant industries in the surrounding areas. The analysis also demonstrates the limitations of employing particular statistical methods. Investigating the effects of redevelopment on the surrounding areas gives an impression of how the efforts to mitigate the hazards of brownfields influence efforts of community revitalization.

Chapter 2: Review of Trends in Brownfield Creation and Redevelopment

The following literature review contains a discussion of the social fabric, geographic context, and risk and mitigation feedback loops that broadly influence brownfield hazards in North America. This review intends to discuss general trends in brownfields throughout North America, rather than Shreveport in particular.

Processes of urban development and shifts of industry constitute the geographic context of brownfield hazards. New forms of transportation and construction are a part of the geographic relocation of both residential population and industrial activity. This relocation has both an urban aspect (urban to suburban relocation) and a regional aspect (northern regions to southern region). As indicated in the hazards-of-place model, the social fabric and the geographical context interact with and influence each other.

The decision making process of industrial firms is an important component of the social fabric. Economic factors and an array of related federal policies strongly influence all institutional decisions of industrial firms. The combination of economic considerations and federal policies comprise the social fabric that often results in corporate decisions to abandon a particular industrial site or sector.

Environmental policies illustrate how mitigation efforts can influence risk. These environmental policies intend to mitigate the risk of a related hazard, such as abandoned sites with a known, very high level of pollution. The mitigation effort to this hazard, however, acts to amplify the risk of another hazard, the unknown levels of pollution associated with brownfields.

Other redevelopment issues also illustrate how mitigation of brownfields can either alleviate or aggravate the hazard potential. When the nature of the mitigation

process only addresses the interests of industrial or service firms, redevelopment may not address other community needs. These shortcomings may include redeveloped sites that lack public uses, such as residential or green spaces, or that were remediated improperly. Conversely, a mitigation process that includes input from community groups may address these needs.

The Hazard Potential of Brownfields

Brownfields pose the environmental hazards of pollution (potential or actual) and dereliction. Many brownfields pose a legitimate hazard to public health due to accumulated pollution. Where the presence of pollution is uncertain, the mere possibility of contamination and ensuing liability discourages redevelopment of brownfields (Sattler and Li 2001). Even if chemical contaminants are absent, brownfields contribute to dereliction. Dereliction is an environmental hazard, since it is associated with threats to health, such as crime and poor sanitation, and diminished enjoyment of urban spaces (Jakle and Wilson, 1992).

In addition to environmental hazards, these sites that were once economically profitable are now idle. Brownfields no longer house industries, and therefore cannot contribute to the city's economy with tax revenue and employment opportunities. The physical infrastructure, such as roads, water pipes, and power lines, that formerly served the site lie inactive, while redundant services often must be extended to outlying areas (Bartsch and Collaton 1997).

Economic Redevelopment as Hazard Mitigation

Both local agencies and the USEPA perceive an economic opportunity in brownfield mitigation, since land that could be used for profitable activity but is not

because of the possibility of pollution. The prospective industrial redevelopers are also active participants in the mitigation, and economic considerations influence their decisions. The purpose of the economically minded mitigation, therefore, is to attract new industries or other commercial activities to rehabilitate the abandoned sites (City of Shreveport 2002; USEPA 2003a).

The interests of private institutions are key factors in the entrepreneurial mode of urban development (Hall 2001). To promote redevelopment, therefore, governmental groups have attempted to remove barriers and reduce risks of redevelopment to firms. These incentives include modifications to environmental regulations, funding assistance for redevelopment, and administrative assistance.

The federal government has made modifications both to the application of environmental regulations and to the regulations themselves. In 1995, the USEPA exempted over 24,000 sites with low probabilities of contamination from CERCLA liability. The USEPA removed liability for the express purpose of encouraging redevelopment of these particular sites (Garcia and Colten 2001). Legislation passed in 2002 has exempted certain parties from CERCLA liability for actions at any site. These parties include prospective purchasers and lending institutions (USEPA 2003a).

Because of the uncertain condition of contamination, standards for environmental remediation are often not precise enough to ensure a compliant cleanup (McCarthy 2002). Therefore, USEPA introduced standard guidelines for drafting a covenant not to sue. A covenant not to sue is an agreement between regulators and redevelopers defining requirements that a remediation must satisfy to eliminate liability for contamination. To address environmental concerns, the covenant requires that environmental remediation

that will mitigate any contamination be completed, in progress, or planned, and that the final use of the site will not pose any health risk to the community. In addition to environmental concerns, the covenant also requires that any redevelopment will confer either a direct benefit to the regulatory agency or an indirect benefit to the community (Bartsch and Collaton 1997). Indirect benefits to the community could manifest in a number of different forms, including new industrial activities that would offer employment, new residences intended for downtown revitalization, commercial recreational activities, or public or green spaces.

The USEPA has established a brownfields pilot program that provides funds for environmental assessments and job training for environmental services employees. The assessment grants fund environmental assessments of sites to determine if they are actually contaminated. The job training grants help to provide a source of labor for environmental cleanup efforts (USEPA 2003a).

City and state governments coordinate efforts of private redevelopers with federal, state, or city incentives. State governments can be instrumental in clarifying ambiguous cleanup standards and helping private redevelopers negotiate complex regulatory arrangements (McCarthy 2002). In Shreveport, the city government identifies the locations potential brownfields and provides relevant information to redevelopers (City of Shreveport 2002).

The purpose of these governmental actions is to reduce the uncertainty (or risk) that could make brownfield redevelopment unprofitable. Government groups have attempted to make environmental regulations less strict, reduce the costs of redevelopment, and coordinate local projects with federal programs. These efforts are

aimed at mitigating the economic risks within the social fabric to brownfield redevelopment.

The consequences of brownfields, however, are unmistakably environmental. The issue of pollution often initiates the involvement of state environmental agencies. At worst, latent pollution poses a health threat (Litt and Burke 2002), and at best, the abandoned site diminishes the landscape (De Sousa 2003, 2002b; Jakle and Wilson 1992). Although potential contamination is either ruled out or cleaned up and the site maintained, which solves the environmental problem, both local agencies and the USEPA are seeking economic solutions to these environmental problems.

Efforts to mitigate brownfields must comply with a complex mixture of environmental and legal regulations enforced across different jurisdictions. Mitigation seeks to reduce two sources of risk. The environmental contamination itself is a source of biophysical risk. Environmental liability is the second source, of financial risk (De Sousa 2002a, 2000; McCarthy 2002). The subject of this thesis is the responses designed to reduce both environmental risk and financial risk through incentives for brownfield redevelopment.

The efforts of local agencies and the USEPA to revitalize brownfields are thus focused on attracting firms. These local agencies, federal agencies, and firms are institutions that pursue a variety of goals, both environmental and economic. Manion and Flowerdew (1982) describe “an institutional approach” to geography that “seeks for explanation[s] of events through a study of the institutions affecting them, with stress on the rules, procedures, and internal structure of these institutions.” Local and federal agencies, industrial firms, and other parties to redevelopment are institutions whose

actions have a substantial effect on the events contributing to the problems of brownfields.

Geographic and Social Context of Brownfield Hazards

Industrial firms contribute to brownfield hazards in two ways. One issue of brownfields is that they are sites that the original industries have abandoned, and another issue is that, for a variety of reasons, new industries are reluctant to redevelop. The actions of firms that contribute to these problems are the decisions of original firms to leave the sites and of new firms to decline the opportunity to develop the sites.

General processes of urban development form the broad context in which firms make decisions. Urban development refers to the processes in which the economic and residential activities in cities expand or contract in area and rearrange the spaces they occupy. Rearrangements in urban spaces have consequences for economic development and the importance of social and cultural landscapes. These shifts in demography and economics do not necessarily represent institutional decisions. Nevertheless, these processes figure prominently in institutional decisions made within industries themselves, and thus play a role in creating brownfield problems.

The exploitation of new technology and the exercise of governmental authority also affect the process of urban development. As governmental authority contributes to the shifts in economic activities, policies of the United States federal government influence the actions of industrial firms and contribute to brownfields. An industrial firm “operates in a complex institutional framework, created and regulated partly by government, central and local, and partly by... organizations..., which control or influence access to capital” (Manion and Flowerdew 1982). The body of literature

reviewed describes federal policies, both environmental and economic policies, that influence the industry actions.

Federal policies influence both kinds of industrial behavior that contribute to brownfields. Federal taxation policies influence industries' decisions to shift sectors or physically relocate, which may create brownfields. Federal environmental policies, especially those assigning liability for pollution cleanup, influence industries' decisions to select new sites to develop, which may result in industries avoiding brownfields.

Typical Urban Development

The processes of economic and residential shifts that influence brownfields are part of a sequence of urban development with its origins in the nineteenth-century United States. It is useful to organize this sequence of development in terms of innovations in transportation that facilitated the rearrangement of residential and economic activities. At the earliest stage in this sequence, a typical American city would consist of a tightly grouped cluster of residences and workplaces within walking distance of each other. Walking was the prevalent mode of transportation within the compact city. The introduction of the electric streetcar allowed for the expansion of both residential and economic activities. Residences expanded alongside the streetcar tracks in radial patterns from the older compact walking city. Specific types of economic activities, particularly retail stores, expanded with the streetcar suburbs, while expansion of industrial activities followed the later construction of heavy freight rail lines (Muller, P. 2004).

The next transportation innovation to significantly influence urban development was the automobile. The automobile provided a private means of transportation as an alternative to the streetcar. The private nature of automobiles meant that new residential

areas need not conform to the pattern of streetcar rails. New residences filled in the gaps between rail lines, smoothing the city's irregular, radial shape. The freeway was the next advance in transportation, which facilitated the dramatic expansion of both residences and businesses across large areas. Freeways combined with large increases in automobile ownership led to suburbs that were more populous and faster growing than the old urban center. The growth of economic activities in the suburbs also exceeded growth in the urban center as businesses followed their customers and workforces. Suburban areas with their own residential and economic capacities became more independent from the urban center (Muller, E. 1990; Muller, P. 2004).

Exercise of Governmental Authority

Although it is a useful mode for organizing urban development, transportation is not the sole organizing factor. Government groups also influence urban development in the process of exercising their authority. During the period of urban development described previously, government groups exercised authority according to a variety of ideologies. These ideologies emerged to cope with periodic economic crises, and therefore were directed at the recovery of the economy and civil society.

The measures implemented to achieve the recoveries influenced the landscapes occupied by businesses and their workforces as well. These policies tended to result in a pattern of alternating expansion and consolidation of urban areas (Earle 2003). The pattern of expansion and consolidation of cities under alternating political ideologies demonstrates the effect of governmental authority on urban development and elaborates on the pattern of urban development based on transportation innovations.

New Economic and Cultural Development

Adaptation and innovation in urban development does not apply solely to processes that expand the territory of cities. Urban development includes the implementation of new activities to replace those that vacated the central city for the suburbs. The large and spectacular facilities constructed for these new activities, which are both economic and cultural, intend to both provide space for conducting business and to lure shoppers and workers into downtown (Hall 2001).

This type of central city redevelopment has occurred throughout the period of urban development discussed earlier. Reuse of central cities includes the construction of ostentatious department stores during the late nineteenth century and the towering office skyscrapers of the 1910s-1920s. The extensive freeway construction of the mid-twentieth century combined with projects in “urban renewal” to link the city’s downtown to its suburbs (Muller, E. 1990).

Recent trends in redevelopment resemble these historic trends, attempting to link economic and recreational activities. Modern projects often involve spectacular flagship developments. These major projects, which are intended to attract other businesses as well as workers and shoppers, often combine service-sector employment with festival-style retailing. Although important for the economic activities they house, these new types of urban uses serve as cultural development because they symbolically demonstrate the significance of the city as a center of commerce, recreation, and consumption (Hall 2001).

Residential and Economic Effects

Of the typical processes of urban development, changes in residential and economic patterns that occurred after World War II have most recently affected the creation and sustaining of brownfields. Both economic and cultural practices contributed to residential shifts. These residential and demographic shifts, in turn, affected economic decisions of industrial firms that contribute to brownfields.

Residential home ownership increased, and residential areas became more dispersed outside of urban centers after World War II. Practical considerations, such as a scarcity of urban housing and favorable borrowing terms, were important to families and individuals seeking housing (Rome 2001). These economic considerations combined with distinctly American cultural traits to fuel much of the demand for new houses (Berry 1975). The subsequent section on spatial shifts will elaborate on changing residential patterns.

These demographic shifts had economic consequences because they effected the decisions made by industries. As population centers became more dispersed, industries' market and workforce became dispersed. Industries sought to organize their manufacturing and distribution networks along new transportation corridors, particularly highways, in order to adapt to the demographic shifts. This meant that existing, highly specialized urban manufacturing and transportation systems were no longer desirable (Sternlieb and Hughes 1975; Ullman 1988).

For example, many urban industrial sites were housed in multi-story loft structures and transported products within urban areas. New, dispersed residential patterns combined with changes in consumption patterns required a new economic

organization. Urban industrial lofts were abandoned in favor of large, single-story big-box-type buildings linked to a regional or national highway system (Sternlieb and Hughes 1975; Ullman 1988). The steps taken by industrial firms to adapt to the new residential patterns had spatial effects in addition to economic effects.

Spatial Shifts

Decisions by firms to abandon industrial sites have a spatial dimension, as industries that leave one place relocate to another place. Industries preferentially relocate in two ways, from urban centers to suburban edges and from Northern and Midwestern regions to Southern and Western regions. These urban and regional shifts of industry mirror similar demographic shifts.

Residential migration to suburbs had been occurring prior to World War II, but suburbanization increased after the war for a variety of reasons. A shortage of urban housing increased the demand for suburban housing. New mass-production methods of constructing houses lowered the cost of housing and opened the market to a new segment of the population, the middle class (Rome 2001). Federal loan and taxation policies encouraged middle class families and individuals to buy or build housing for lower costs than renting apartments. The construction of the Interstate highway system by the federal government created a transportation network that provided access to new suburban residential locations. Improvements in automobile manufacturing increased the reliability and decreased the cost of the vehicles on those highways (Gillham 2002).

Another reason for suburbanization was cultural traits (Berry 1975). One important trait was the association of personal success and fulfillment with the abandonment of the old and the adoption of the new. Another influential cultural trait

was the desire to return to nature. The move to the suburbs was seen as the solution that would embrace the new and nature, moving away from city centers, which were perceived as the old, decrepit antithesis of nature (Berry 1975; Jakle and Wilson 1992; Rome 2001).

As they shifted to suburbs, population concentrations also shifted to the Southern and Western regions of the United States (Howes and Markusen 1993; Sternlieb and Hughes 1975). Industries followed both of these shifts, to the suburbs and to the South and West. The new home ownership patterns, which included more middle class homeowners, meant that industrial workforces were now living in suburbs (Rome 2001). Suburbanization increased the importance of highways and interstates as transportation routes, and industries moved out of cities for better access to the highways (Sternlieb and Hughes 1975; Ullman 1988). Certain nuisance-causing industries left cities to avoid legal restraints on their operations (Colten 1990). For a variety of reasons, some political, military bases were established preferentially in the South and West (Ullman 1988). Therefore, the economic incentives that attracted industrial firms to military sectors had spatial consequences as some manufacturers relocated to the South to better supply military facilities (Howes and Markusen 1993).

Federal Fiscal Policies

Federal fiscal policies are a specific instance of the exercise of governmental authority that contribute to brownfields within the general context of urban development. These policies influence industries to make decisions about investment strategies and locations that contribute to plant closings and abandonment. Two kinds of federal policies that affect industries' decisions are foreign aid expenditures and tax policies.

Foreign aid policy encourages industries to invest in locations in foreign countries in preference to domestic locations. Jakle and Wilson (1992) state that portions of “annual foreign-aid bills require that money be spent with American corporations, if any, in the countries aided.” These provisions provide an incentive for industries, already considering foreign investment for its opportunities in new markets and lower production costs, to invest abroad. Industries will select foreign locations for investment in order to benefit from what amounts to a subsidy provided by U.S. foreign aid.

Federal tax policy has influenced industries’ decisions to abandon existing plants and relocate to new sites. Federal tax policy awards industries tax credits for starting up new plants. Federal tax policy also contains a provision known as accelerated depreciation, which awards additional tax credits on new industrial machinery over a period of several years after installation (Jakle and Wilson 1992). These practices provide incentives for relocating existing manufacturers to new plants.

Institutional decisions are made in industrial firms for the purpose of increasing profits (Manion and Flowerdew 1982). Although federal fiscal and tax policies may not have been intended to affect industrial investment strategy, firms have adopted investment strategies that take explicit advantage of available tax credits and subsidies. As a result, industrial investment strategies systematically disinvest from existing facilities and shift capital to new facilities (Jakle and Wilson 1992).

The purpose of tax credits for new plants is to encourage the growth of manufacturing, and the purpose of depreciation tax credits for new machinery is to offset the cost of maintenance on the new machinery. While in some cases, these tax credits may be having the intended effect for new firms, well-established firms are also using

these federal policies as tools to improve their financial performance. Jakle and Wilson (1992) provide an example of the effects of a deliberate industrial strategy of disinvestment. A conglomerate firm acquired several metal working facilities in Youngstown, Ohio in the 1970s. The conglomerate used the profits from the plants not to maintain and modernize the plants, but instead to provide capital used in acquiring facilities and assets in other sectors. It allowed the metal plants to deteriorate and abandoned them.

Industries formulate their investment strategies deliberately to both increase profits and to take advantage of tax laws. The result is a strategy of deliberate disinvestment in existing sites and investment and relocation to new facilities. The investment strategy creates brownfields, derelict and potentially polluted sites.

Federal Military Spending

Federal military spending policies have had a notable effect on manufacturing patterns. Supplying the military with products is attractive to industrial firms because of economic considerations. But emphasis on the military sector, especially at the expense of other sectors, is detrimental because it diverts investment from other sectors in both built facilities and technological expertise.

The peculiar economic nature of military spending makes it appealing to the manufacturing industry. Unlike many sectors of the manufacturing industry, which are subject to fluctuations in demand their products, the demand for military equipment for the federal government has been sustained (and often increasing) since the mid-twentieth century. This situation establishes the military sector as a comfortable “safety valve”

(Jakle and Wilson 1992) for industrial firms, and it encourages investment strategies that emphasize military products (DiFilippo 1986).

Because of these economic consequences, federal military spending promotes strategies of disinvestment similar to those promoted by federal fiscal policy. To alleviate economic pressures, industrial firms deliberately seek to invest in the military sectors so that they can benefit from the constant demand of the federal government. Reliance on investment in the military sector is often accompanied by deliberate disinvestment in civilian sectors (Jakle and Wilson 1992).

Environmental Policies

Federal environmental policies, another exercise of governmental authority, have unintended consequences on brownfield hazards due to their influence on the institutional industrial decision making process. While fiscal and military spending policies encourage industrial relocation and the creation of brownfields, federal environmental policies, along with analogous state policies, discourage reinvestment in abandoned urban sites, further exacerbating existing brownfield hazards. Environmental policies affect industrial decisions by imposing liability for past pollution and limitations on ongoing pollution.

Federal environmental policies present the potential to impose liability for past pollution on new industries considering developing brownfields. The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) imposes the liability to pay for cleanup of contaminated sites on past and current owners who contributed to pollution or failed to clean it up. CERCLA also imposes liability on any bank or lending institution that participates in the management of the site. The

Resource Conservation and Recovery Act (RCRA) establishes contamination monitoring standards and cleanup requirements for waste disposal facilities and underground storage tanks (Bartsch and Collaton 1997). The Toxic Substances Control Act (TSCA) places requirements on site owners to eliminate hazards posed by toxic substances such as lead paint and asbestos (Sattler and Li 2001).

Although these laws were enacted to ensure cleanup of past pollution, monitor ongoing waste generation, and manage health hazards, the threat of liability has acted as a powerful deterrent to redevelopment of brownfields. New industries are reluctant to develop brownfields, whose potential for contamination could subject them to liability under CERCLA. Banks are reluctant to fund industries developing brownfields, since their managerial role in the redevelopment exposes them to liability as well (Bartsch and Collaton 1997). Decontaminating underground storage tanks, which are vulnerable to leakage, governed under RCRA is particularly problematic. Brownfields, which are often older sites, often contain lead paint and asbestos that must be remediated during redevelopment (Sattler and Li 2001).

Industrial firms and developers often perceive the risks of liability in economic terms. Bartsch and Collaton (1997) provide several examples on how much decontamination adds to the cost of redevelopment. In terms of dollar value per square foot, the cost to redevelop these sites was nearly ten times greater than the market value of the site. In a case requiring removal of asbestos (which was not redeveloped), the redevelopment cost was estimated at nearly seventy times the property's market value (Bartsch and Collaton 1997).

Redevelopment Issues

Since private and governmental groups are the primary participants in brownfield redevelopment efforts, the projects tend to reflect the interests of those groups. These interests include generating profits for private groups from under-used land and generating employment and tax bases for governmental groups (McCarthy 2002). While emphasizing these interests, however, redevelopment efforts may neglect the interests of other community groups. These include the demand for housing and green spaces and ensuring that any contamination is actually reduced to safe levels.

Incentives may help remove the stigma of brownfields, but developers still consider the choice between new manufacturing, commercial service, or residential activities in terms of the profitability of the development (De Sousa 2002b). Regardless of the type of activity, however, developers place the most importance on the development's economic return (De Sousa 2000). Development projects will therefore address these interests, even though community groups may prefer residential, recreational, or public land uses (Greenberg and Lewis 2000).

In some cases, redevelopment efforts have addressed community interests. Although early redevelopment was directed toward manufacturing or commercial activities, there is now a growing interest both in Canada and the United States in residential activities (Bartsch 2002; De Sousa 2002a; Greenberg 2002). In Toronto, brownfield redevelopment has made a substantial addition to green spaces (De Sousa 2003).

Incentives may also promote redevelopment of brownfield sites without actually addressing the issue of contamination. This is an incomplete solution, however, since

liability for contamination is one of the initial issues that complicate redevelopment. The USEPA exempted, or “delisted,” many sites from CERCLA liability, but a study of Texas brownfield showed little correlation between delisted brownfields and redeveloped brownfields (Garcia and Colten 2001). Although it is an important issue for private developers, the study indicates that environmental liability is not the sole issue that complicates redevelopment. As private-public partnerships work through regulatory arrangements and incentive programs, it is important address to environmental contamination and public health in the redevelopment process (Greenberg 2002; Litt et al. 2002).

This review has discussed broad processes in which the social fabric interacts with the geographic context to create brownfield hazards. Industrial decisions to disinvest from or invest in a particular site, thereby creating or mitigating brownfields, occur within a social fabric of economic considerations and regulatory and fiscal policy. Spatial shifts in residential and economic activities contribute to the geographic context of these decisions. While this chapter broadly described these processes throughout North America, the next chapter outlines the method for investigating a selected aspect of these processes, redevelopment and mitigation, in a specific location, Shreveport, Louisiana.

Chapter 3: Research Method

Brownfield redevelopment is a form of hazard mitigation that takes place within the context of urban development. Contributing factors to urban development act as inputs to brownfield redevelopment projects. These factors, which are recurrent throughout general processes of urban development, include the exercise of governmental authority and the establishment of new economic and cultural activities.

The hazards-of-place model proposes both that social and geographic context influence hazard mitigation and that hazard mitigation influences social and geographic context. In terms of brownfield redevelopment, mitigation and urban development affect and reflect on each other under the influence of governmental authority and the establishment of new economic and cultural geographies. The research method in this chapter is designed to analyze these interactions between governmental authority, brownfield redevelopment, and the establishment of new economic and cultural geographies.

The subject of the thesis is redevelopment efforts at two brownfield sites in Shreveport, Louisiana, between 1992 and 2000. During this period, various parties undertook concerted redevelopment of brownfields. The parties include not only the private firms actually performing the redevelopment, but also city development officials and federal and state environmental officials. The role of federal environmental officials was to provide funds for redevelopment under USEPA's brownfield pilot program. The interval from 1992 to 2000 brackets the period of time that Shreveport participated in the federal pilot program.

Site Selection

The site selection procedure reflected the influence of governmental authority on brownfield redevelopment. City development officials maintained the inventory of brownfields in the study city, and it reflected their perspective and intentions. The method for defining the study area used procedures listed in the standard environmental assessment procedures designed by the American Society for Testing and Materials (ASTM) and mandated by environmental regulators.

The procedure for selecting the two brownfield sites consisted of two steps. The first step identified a city to investigate, and the second step selected the sites themselves.

Shreveport served as the subject city because it has engaged in an active brownfield redevelopment campaign. Shreveport has been a participant in the USEPA's brownfield redevelopment pilot program since 1996 (USEPA 2003), which indicates a degree of coordination between public and private organizations committed to redevelopment. City and state officials and private redevelopment parties have cooperated to complete several brownfield redevelopment projects (McMullen 2003), which makes it possible to study specific redevelopment projects through their entire span. Besides being a participant in the brownfield pilot program, the size of the Shreveport metropolitan area (population approximately 370,000 in 2000; U.S. Census Bureau 2002) makes it the location of substantial industrial activity while still being more manageable than a major city.

The two brownfield sites that are the subject of the thesis are a medical instrumentation research facility and a series of residential apartment buildings, fairground, and other entertainment venues located in downtown Shreveport near the Red

River. Discussions of these sites will refer to them as the “medical” or “downtown” site or facility.

The extent of the study area is a 1.0-mile-radius zone around each brownfield site, and two concentric buffers encircle each zone at one-half-mile intervals. This results in two buffers around each brownfield site, at radii of 0.5 and 1.0 mile, for a total of four buffers.

The ASTM environmental site assessment procedure (ASTM 2001) is the basis for this study area design. The assessment procedure specifies that environmental investigators are to search within either a 0.5- or 1.0-mile buffer around the site in question to determine the off-site impact of any contamination. The radius of the buffer depends on the type of contamination under consideration. Using the same search radii as the ASTM procedure establishes a common study area with the assessments performed for the subject sites and provides the opportunity to test the effectiveness of the procedure in measuring economic impact rather than environmental impact.

Certain portions of each study area fell outside edges. Edges are linear landscape features that are likely to serve as barriers to development decisions (Lynch 1984, 1960). The edges of the study areas include an Interstate right-of-way, the Red River, and Cross Bayou, a tributary of the Red River. Areas lying beyond these edges were excluded from my study zones.

These sites are suitable as subject brownfields because redevelopment was either complete or nearly complete and because the redeveloped sites are intended to support two contrasting types of activities. The medical facility will support research and

development of medical instrumentation (an industrial use), while the downtown site supports service and private residential activities.

The medical facility is a group of buildings that contain laboratory and office space. A portion of this space had been used for offices of various commercial or community organizations prior to redevelopment. The site's laboratory space was idle. The environmental regulatory agencies approved the site for redevelopment, but redevelopment is not yet complete (City of Shreveport 2002).

The downtown site includes two apartment buildings, a fairground, and several entertainment venues, such as restaurants and bars. Prior to redevelopment, the buildings housing the apartments and entertainment businesses were idle warehouses and offices, and the fairground site was an idle, empty lot. Redevelopment of these sites is complete, and they are all currently in use housing tenants or businesses and hosting public fairs (City of Shreveport 2002).

The city had designated these two sites as brownfields as part of its urban redevelopment initiative (City of Shreveport 2002). This thesis relied solely on the city-compiled list.

The reliance on the official list represents a limitation of the thesis, since potential sites are limited to those that the City wishes to redevelop. The limitation reflects the influence of city brownfield coordinators, and therefore represents a technique employed by local government organizations, and important party in redevelopment.

The city's list does present the advantage, however, of positively identifying specific brownfield sites. Unlike CERLCA sites, which meet standard specifications for inclusion on the National Priority List, brownfields are not subject to a standard legal

definition. As a result, and due to the uncertain environmental condition, it is difficult to identify which sites actually are brownfields.

The official city list overcomes this obstacle by explicitly identifying sites that will be the focus of redevelopment efforts. Further, the fact that the city has explicitly designated the sites as targets for redevelopment improves the likelihood that records exist that describe the results of environmental investigations at the sites.

Environmental Records

The environmental records that documented the brownfield redevelopment process documented the influence of governmental authority as well. Environmental regulators require the completion of remediation procedures and the records of completion. The standards for the remediation procedures, defined by ASTM, reflect a particular concept of risk. Therefore, that concept of risk determines both the execution of any remediation activity and its success.

Environmental site investigations serve both to report the types and quantities of contaminants and to mediate redevelopment efforts between developers and environmental regulators. The environmental site investigation (or assessment) procedure consists of several steps, and its extent depends on the site's current condition and past uses. Under certain circumstances, some investigations will be more extensive than others. Standard site investigation protocol and regulatory enforcement define the extent of the investigation.

The ASTM and the Louisiana Department of Environmental Quality (LDEQ or DEQ) specified the steps in the environmental site investigation procedure employed at the study sites. This discussion of environmental site assessments is a general account of

an extensive investigation. The specific results and findings for the assessment of each of the brownfields considered in this thesis will appear in the Records chapter, while this section will provide a typical overview of site assessments in general.

The site investigation procedure consists of a preliminary assessment, analytical testing, remediation and cleanup, application of remediation standards, and validation of results. The assessments are divided into two levels of detail, known as Phase I or Phase II Environmental Site Assessments (ESA).

The Phase I ESA involves a site inspection (or field trip), review of environmental databases, review of historical records, interviews with individuals familiar with the property, and preliminary analytical testing. The objective of Phase I is to identify the presence or possible presence of environmental contamination either within the site itself or within neighboring sites that have the potential to contaminate the site of interest. Evidence of contamination during the site inspection or the records review may necessitate either analytical testing or a more detailed Phase II assessment. The objective of a Phase II ESA is to obtain quantitative data describing the presence of contaminants in soil and/or groundwater that can be compared against remediation standards.

A commonly used set of standards is known as the Risk Evaluation / Correction Action Plan (RECAP). These standards represent maximum concentrations of specific contaminants that have been estimated to minimize risk. The RECAP standards are a representation of the quantitative concept of risk that is the basis for remediation and regulation by redevelopers and environmental agencies. The RECAP standards serve as the goal for remediation efforts at the site. The purpose of site remediation, for example, the excavation of contaminated soil, is to reduce the concentration of the specific

contaminants in the medium (soil, for example) below the RECAP specification.

Following remediation, additional analytical testing serves to validate that the remediation reduced contaminant concentrations to comply with RECAP specifications.

Data Collection

The method for collecting, manipulating, and analyzing data in the following sections is designed to interpret the effect of brownfield redevelopment on the surrounding economic and/or cultural geographies. Redevelopment represents investment in brownfields that influences and occurs in the context of investment in the surrounding area. The research method uses assessed property values as a proxy for investment. Measurement and mapping of property values serves as the basis for interpreting patterns of investment and subsequently brownfield redevelopment within the context of urban development.

The Caddo Parish Assessor's Office in Shreveport provided property value information for three assessment years: 1992, 1996, and 2000. This time period brackets the beginning of Shreveport's participation in the USEPA brownfield pilot program and the completion of most of the downtown site's redevelopment. Property value information is maintained in two forms: the assessed property values of each parcel and the base map showing the location of each parcel.

The Assessor's Office organizes property values based on township, range, and section. Each section is comprised of smaller units called subdivisions. Subdivisions contain individual parcels, and property values are recorded for each parcel. Often a subdivision is the size of a city block, although several subdivisions (such as industrial or warehouse sites) have different sizes.

Property value information at the subdivision level served as the basis for this analysis. By calculating the sum of the values of all parcels in a subdivision, an aggregate value was determined. Aggregating property values at the subdivision level represents one level of data generalization. One of the disadvantages of this generalization is that it fails to reflect street-level variations, or variations within a subdivision, in analysis or mapping. Since the generalization assumes that city blocks are homogeneous, variations of property value within each block are obscured. Despite these disadvantages, however, the subdivision proved most effective by (1) facilitating data collection and analysis with a manageable number of measurements and (2) making the maps easier to read with larger polygons. Therefore, statistical values and maps will represent subdivisions of properties, not individual properties themselves.

The numerical values recorded in the tax rolls are calculated from the market-value assessment of each property. The market value is the value that the assessors estimate a property will sell for on the open real estate market. The values assessed in the tax rolls are 10 percent of the market value for residential properties and 15 percent of the market value for commercial and industrial properties. The first \$75,000 of a residential property's value (\$7,500 of the assessed value) is exempt from taxation. In order to calculate an accurate value, this method added the exempt value to the non-exempt value (Weidner 2004).

Some properties are fully exempt from property taxes, and these include religious institutions and government facilities. Therefore, these properties do not appear on the non-exempt tax rolls, although they do appear on the exempt tax rolls. The property values recorded for the years 1992 and 2000 are obtained from the non-exempt tax rolls,

and they do not include religious, governmental, and other public properties. For the year 1996, however, only the exempt tax roll was available (Weidner 2004). Consequently, property values recorded for 1996 include several properties that are not present in either 1992 or 2000.

The exempt/non-exempt discrepancy has introduced several outliers into the dataset. Certain subdivisions containing exempt properties showed dramatically higher property values in 1996 than in 1992 and 2000. Without accounting for these outliers, the analysis would interpret these subdivisions as the sites of rapid investment followed by rapid disinvestment. This incorrect interpretation results from the use of tax-exempt property values for only one of the study years.

Removal of outliers from the dataset corrects this complication for the purposes of cartographic classification and statistical analysis. The outliers were omitted from these analyses to avoid the distortion they would introduce. The locations and attributes of these outliers remain in the dataset since they may represent real property, rather than measurement error. Field checking the sites confirmed the sources of the discrepancies.

The dataset includes only subdivisions that had values for all three years of the study period. Some subdivisions did not have values for all three years. The property value data for these subdivisions could possibly have been incomplete for several unknown reasons, including the further dividing of subdivisions, consolidation of multiple subdivisions, or the elimination of subdivisions that are surrendered for construction to railroad or Interstate right-of-ways. Therefore, because of the data integrity requirement, the dataset does not list some subdivisions, and some cartographic locations do not display property value information.

A spreadsheet contains the assessed property values from three years (1992, 1996, and 2000) at the subdivision level (calculated by summing values of individual parcels) and identifies each variable by a unique serial number containing township, range, section, and subdivision number.

The Assessor's Office owns city maps that show the location of each subdivision, including its serial number, within the township, range, and section survey. Photographs of the city maps corresponding to the study area have been converted to digital images and registered to the GIS application. Street intersections serve as the basis for registering the digital images, matching intersections visible on the photograph images with intersections contained in TIGER Line street files provided by the U.S. Census Bureau (2001).

The registration procedure produced a georeferenced image of the Assessor's township, range, and section maps showing the locations of subdivisions (Figure 2). A data layer in the GIS contains a digitized polygon for each subdivision, labeled with the subdivision's serial number. The serial number for each subdivision polygon served as the index number for joining the assessed property values contained in the spreadsheet to the polygons. The joining procedure produced a GIS data layer of polygons representing each subdivision and containing the subdivision's serial number and assessed property values for the three study years.

Data Calculation

Data calculation produces the variables that serve as the basis for analysis. Since the purpose of the analysis is to use property value as a proxy for investment and development, the calculated values consist of changes in property value over time. The

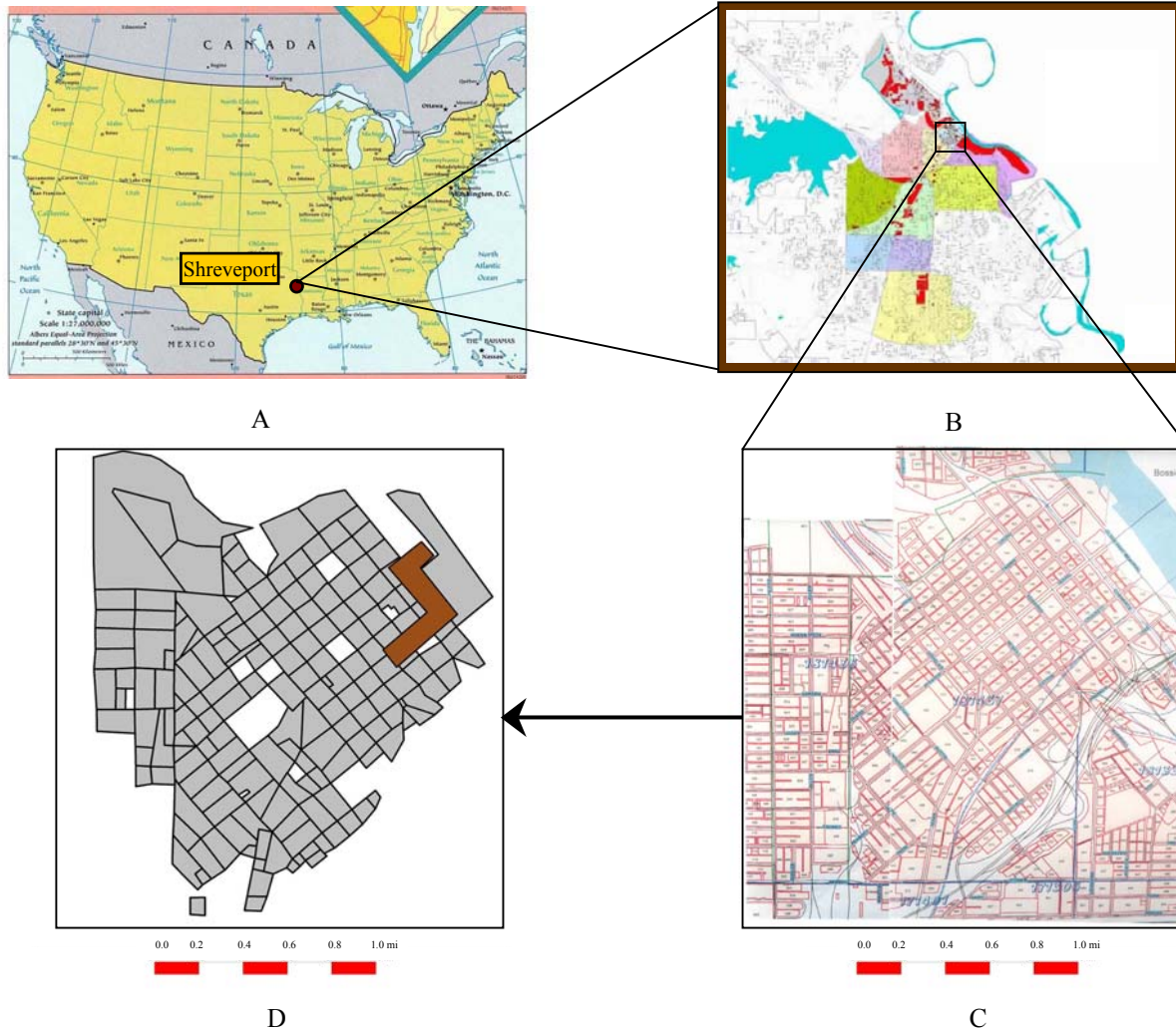


Figure 2. Digitizing subdivision data layers. Photographs from the Caddo Parish Office of the Assessor (C) serve as the template for digitizing the subdivisions basemap (D). Shreveport city map shows sites officially designated as potential brownfields (B).

Sources: (A) University of Texas Map Collection, <http://www.lib.utexas.edu/maps>. (B) City of Shreveport 2002.

incremental change in property value represents the level of investment (or disinvestment in the case of declining value) for a property.

The raw data from the Assessor's Office enabled the calculation of four additional variables for the analysis: absolute value change from 1992 to 1996, absolute value change from 1996 to 2000, percentage value change from 1992 to 1996, and percentage value change from 1996 to 2000. The absolute property value change is the simple difference of assessed values between each study year (at four-year intervals) for each subdivision. The absolute value change divided by the initial property value equals the proportional property value change. Multiplying the result by 100 produces the percentage property value change for each subdivision from 1992 to 1996 and from 1996 to 2000.

The rationale for calculating percentage change is to allow for comparisons between subdivisions with greatly different absolute property values and to enable cartographic representation with choropleth mapping. Using percentage value change provides a common basis for comparison and eliminates the effect that high-value properties will have of obscuring changes in value for lower value properties. The basis for comparison is the increase of a subdivision's property values relative to the previous assessment. Using a common basis for comparison also facilitates choropleth mapping, which requires normalized data (Dent 1999).

The disadvantage of relying on percentage change is that very small absolute changes in property values may distort analysis if their percentage is similar to large value changes. The significance of this disadvantage is that very low value investments in property may be assigned the same importance as large value investments in expensive

properties that have similar effects on the overall value of the property. This is a practical issue, because both the concrete cost of the investment (the absolute value change) and the expected return (the percentage value change) influence investment decisions.

Data Manipulation

The data manipulation step is necessary to prepare the dataset to meet the requirements of statistical analysis. The method describes the data manipulation not only to document the steps taken during analysis but also to identify the extent to which the dataset was changed. Datasets often require manipulation to satisfy the requirements of statistical tests. Those requirements, however, are based on assumptions about non-spatial data patterns and quality. These assumptions do not necessarily apply to geographic datasets in general or to this thesis's dataset in particular. The steps taken to satisfy these requirements will have consequences for interpretation later in this analysis.

Data manipulation enabled the identification of numerical outliers in the property value data. The two purposes for identifying outliers are to identify properties that have extremely high rates of change in property value (real changes or artificial changes) and to obtain a normal frequency distribution to meet the requirements of the statistical test (Devore and Peck 2001). The variables measured to identify outliers are the percentage value changes from both 1992 to 1996 and 1996 to 2000. Boxplots identify the outliers (Appendix 1).

Boxplots display frequency information and outlier locations. Boxplots group data into quartiles, which are intervals of unequal bounds containing equal numbers of measurements (25 percent of the dataset, in the case of quartiles). The boxplots show the

location of the quartile intervals, including the median value. Boxplots also identify two categories of outliers, based on the Interquartile Range. The Interquartile Range is the difference between the 3rd quartile boundary and the 1st quartile boundary. (This means that the Interquartile Range spans half of the measurements in the dataset.)

The boxplots identified normal outliers and extreme outliers. Normal outliers are measurements that exceed the 4th quartile bound by 1.5 times the Interquartile Range, while extreme outlier exceed the 4th quartile bound by 3 times the Interquartile Range (Devore and Peck 2001). For the purposes of the statistical analysis, extreme outliers were eliminated while normal outliers were retained.

Although the extreme outliers are absent from the statistical analysis dataset, a separate dataset preserves their information. These outliers still contain interesting and worthwhile information, and they are still legitimate subjects for investigation. The sole purpose of eliminating the outliers is to prevent them from distorting the results of the graphical and statistical analyses. Field checking of numerical outliers will identify the causes of their extreme values and identify any spatial patterns.

In addition to preventing analytical distortions, identifying outliers is necessary to obtain a normal data distribution to meet statistical requirements. Graphical and statistical evaluation of the manipulated datasets determined the success of the manipulation. Histograms and the Kolmogorov-Smirnov statistic for comparing two data distributions test the normality of the manipulated data.

Data Analysis

The data analysis consists of three types of analysis: graphical, statistical, and cartographic. Graphical analysis includes investigation of percentage property value

changes using histograms. Histograms allow for a quick and convenient, but qualitative, interpretation of the location, spread, and shape of a data distribution. The arithmetic mean is the measure of the average location of the variable, and the standard deviation is the measure of the spread. This analysis is interested in a specific shape, a normal distribution, since this shape is a requirement of the statistical tests. Additionally, histograms can display information about trends between zones over time.

Although graphical analysis is simple, it is imprecise. Statistical analysis is a way to precisely quantify and confirm the conclusions reached by graphical analysis. The statistical test ANOVA (Analysis of Variance) identifies differences in the means between the four buffers over the three study years. The ANOVA tests the variables of the 0.5-mile buffers for both sites over both time intervals.

Neither graphical nor statistical analyses account for outliers, which were excluded prior to analysis. Cartographic analysis allows for the physical identification of outliers. Mapping the percentage property value changes in choropleth maps indicates subdivisions that contain outliers. Field verification of the property indicates if the outlier is produced by measurement error or if the property actually is a special case that falls outside the data distribution.

Since the purpose of data manipulation is to satisfy requirements for non-spatial statistical tests, the results of those tests will not reflect some of the information eliminated during manipulation. The non-spatial statistical analysis includes histogram interpretation and ANOVA. Cartographic analysis, however, is useful for identifying properties that were eliminated, which are necessary for a complete interpretation of geographic patterns. These properties, which are defined as statistical outliers and

identified by field checking, are significant in the new economic and cultural geographies established during the process of urban development.

Chapter 4: Environmental Records

This chapter demonstrates brownfield redevelopment as a process of interaction between development groups and public/government agencies using official environmental records. Each section discusses the steps taken at various stages of the redevelopment process of each brownfields site to satisfy environmental regulations imposed by the Louisiana Department of Environmental Quality (LDEQ).

The records reviewed in this chapter demonstrate the methods that redevelopers use to meet LDEQ's requirements for returning a brownfield to active use. Both the requirements and the methods of compliance rely on and employ the terms of the quantitative concept of risk as a specific variable or set of variables to be estimated within a certain degree of certainty.

Remediation projects sometimes involve a covenant not to sue between the developers and governmental regulators. In these agreements, regulators specify that successful remediation includes not only sufficient removal or containment of biophysical risk but also some benefit for the community. Even when this is not the case, regulators often attempt to direct the redevelopment toward some benefit to the community or economy.

The exercise of governmental authority contributes to processes of urban development, which serve as the social and geographic context of brownfield mitigation. Governmental authority both establishes the dominance of quantitative risk assessment in brownfield remediation and directs the establishment of new economic and cultural geographies that are (in the estimation of the government) beneficial to the community.

These applications of authority are examples of how decisions made within the social fabric can influence the biophysical outcome of remediation activities.

Medical Facility

An environmental services firm performed a Phase I Environmental Site Assessment (ESA) to identify current and past uses for the facility, determine the possibility of contamination, and obtain preliminary analytical evidence of contamination. The environmental investigators discovered limited contamination, the developers performed remediation, and the site was approved for redevelopment by the government regulatory agency.

The site contained four one-story buildings, which were part of parish or municipal health units. The buildings' floor plans indicated that laboratories take up approximately three quarters of the area, with offices occupying the remainder. The historical records indicated that the former occupants were the Caddo-Shreveport Health Unit, the Louisiana State Department of Health, and the Caddo Parish Rabies Control Center and Mosquito/Rodent Control Center. Investigators confirmed the former activities of the site with interviews with former employees and occupants (LDEQ 1998a).

The investigators also examined environmental databases for existing environmental conditions either within the site of interest or within neighboring sites. The ASTM ESA procedure specifies the search radii that will define the extent of the review, based on the particular database being searched (ASTM 2001). The environmental review searched the Superfund National Priority List (NPL), CERCLIS, the RCRA database, and Underground Storage Tank and Leaking Underground Storage

Tank (UST and LUST, respectively) registries. The review identified no NPL, CERCLIS, RCRA, or UST facilities either within the site of interest or within the search radius. While the LUST registry did not list the site itself, the review did identify six leaking storage tanks within neighboring sites. The investigators, however, did not conclude that any of the leaking tanks would disperse contaminants into the site of interest (LDEQ 1998a).

The visual inspection of the site identified evidence that the activities of these former tenants may have resulted in possible contamination. The site contains several storage tanks for pesticides, including a dip tank, which would have been used for animal control activities. The inspection also revealed the possible presence of asbestos-containing material in the buildings (LDEQ 1998a).

A specialized environmental abatement firm to remove the asbestos-containing material (LDEQ 2001b), and the environmental services firm performed further sampling and analysis to determine the extent of pesticide contamination. The analysis procedure called for the collection of several soil borings plus sampling of two groundwater monitoring wells already present at the site. The analysis confirmed that pesticide contamination was present in the soil but not in the groundwater. The analysis also revealed that a combination of hydrocarbons and organic aromatic compounds, including benzene, toluene, ethyl benzene, and/or xylene, had contaminated the groundwater (LDEQ 1998a).

The environmental services firm submitted its report to DEQ. Because of the presence of pesticides, however, environmental regulation of this site was within the jurisdiction of the Louisiana Department of Agriculture and Forestry (LDEQ 1998b).

The Department of Agriculture and Forestry ordered a Human Health Risk Evaluation to identify risks associated with the pesticide and organic contaminants. The environmental services firm performed the evaluation.

Its report claimed that risk from either the pesticides or the organic contaminants could be limited if future site uses met certain requirements. Since pesticide contaminants in the soil had not infiltrated the groundwater, they posed little risk. Future activities at the site, however, must not allow pesticide infiltration. Therefore, earthmoving excavations that could expose groundwater to contaminated soil were prohibited. Although organic contaminants had infiltrated groundwater, they too posed little risk. Neither the site of interest nor any surrounding site draws from groundwater, but rather from city utility-supplied water (LDEQ 1998c).

The findings of the risk evaluation report, including restrictions on future activities at the site, satisfied the Department of Agriculture and Forestry, and it, along with DEQ, issued a notification of environmental compliance and approval for site redevelopment (LDEQ 1998c).

Downtown Site – Festival Plaza

At the time of the environmental investigation, the festival plaza site had already been partially remediated. An environmental services firm performed a site investigation and submitted it to DEQ along with a request to implement a Voluntary Cleanup Plan (VCP). The Department of Environmental Quality required additional remediation beyond that described in the VCP. After the environmental services firm performed the additional remediation, DEQ granted a covenant not to sue and approved redevelopment of the site.

Although the investigators did not perform a Phase I ESA according to ASTM procedure, they did perform a site investigation, which used similar methods toward a similar goal. The purpose of the site investigation was to quantify the extent of contamination that remained after the prior cleanup and to obtain regulatory approval for a VCP. The site investigation identified prior uses of the site with a review of historical archives, performed analysis to identify concentrations of contaminants, and proposed remediation activities (LDEQ 1999a).

Records of the previous remediation suggested that the brownfield was the former site of an abandoned industrial facility. Those records did not, however, specify details of the site's past industrial activities. The site no longer contained any buildings or above-ground structures. A large portion of the site consisted of a field of potentially contaminated soil that had been temporarily capped with asphalt to prevent exposure between remediation activities (LDEQ 1999b). The site contained several sumps or vaults, which contained liquid, and two underground storage tanks. During the site inspection, investigators determined that both underground tanks had leaked their contents into the soil and that contaminants had left black stains on soil surrounding the sumps (LDEQ 1999a).

The environmental services firm performed remediation as part of the VCP. The remediation consisted of excavation of a portion of the contaminated soil (along with the asphalt cap), draining and removal of the sumps, removal of the underground tanks, and excavation of the soil surrounding the sumps and underground tanks. The VCP also contained a provision for deed restrictions that would prohibit development of the site for residential uses (LDEQ 1999a).

Analysis of contaminants from the remediated materials revealed high levels of arsenic and formaldehyde. Analysis of soil remaining at the site also revealed high levels of arsenic even after the excavations. The analysis results indicate that the arsenic concentrations were high relative to RECAP standards (LDEQ 1999a).

The historical records review produced information that possibly explained the presence of arsenic and formaldehyde. The investigators reviewed Sanborn Maps for the site dating to 1885. Although they do not provide conclusive evidence of the precise activities for any particular property, Sanborn Maps can provide general impressions about the types of activities (LDEQ 2000c).

The investigators' review of the Sanborn Maps indicates that from 1885 to 1961 the site tenant was a warehouse used for storing cotton and hides. A tannery shared the site with the warehouse. The site also contained several gasoline tanks, which may have been the underground storage tanks. After 1961, the Sanborn Maps indicate the site served as a general warehouse, which was demolished in 1979. The site remained vacant until the end of the records review in 1990. The investigators suggested that activities at the tannery might have released the arsenic and formaldehyde contamination (LDEQ 2000c).

After the initial remediation, DEQ required additional remediation because of the high-level arsenic contamination. The purpose of the additional remediation was to confirm the presence of arsenic contaminant concentrations that exceeded RECAP standards. The environmental services firm performed further excavation and spoil analysis. The arsenic levels were within the RECAP specifications. In the absence of high arsenic concentrations, the investigators concluded that the high arsenic levels

detected following the initial excavation were the result of high naturally-occurring (background levels) of arsenic in the soil (LDEQ 2000d).

The final analytical results reported arsenic and other contaminant concentrations within the RECAP standards for acceptable risk, fulfilling the remediation requirements. The Department of Environmental Quality reported that no further remedial action was required, approving the site for redevelopment (LDEQ 2000d).

Downtown Site – Riverfront

These environmental documents describe a site adjacent to the study area. There were no documents available from DEQ for the segment of the study area next to the riverfront, but records are available for the riverfront itself. Because of its close proximity to the study area, a review of records for the riverfront gives an impression of the kind of efforts and obstacles to redevelopment encountered in the adjacent site. Since the riverfront site contributes to the concentration of downtown activities focused on entertainment, development of this site complements brownfield development.

Redevelopment of the riverfront site involved the most extensive and complex assessment and regulatory interaction of all of the selected brownfield sites. Environmental investigators performed both Phase I and Phase II assessments, as well as a Cultural Assessment. The environmental services firm submitted two remediation proposals in order to satisfy all requirements issued by DEQ. The Department of Environmental Quality approved the site for redevelopment after the implementation of the final remediation plan, which involved both active cleanup and regular monitoring.

Prior to redevelopment, a public park and memorial art garden occupied the riverfront site. The site also contained parking lots for nearby entertainment

establishments. The investigators performed a site inspection and reviews of environmental and historical archives to complete the Phase I ESA (LDEQ 1999c).

During the site inspection, investigators encountered no evidence of chemical contamination, underground storage tanks, or solid waste mounds or landfills. The age of the buildings on the site presented the possibility of asbestos-containing materials. The investigators concluded, however, that the asbestos would only be an issue if the buildings were to be demolished (LDEQ 1999c).

The investigators found records of few existing environmental conditions in adjacent properties during their review of environmental databases. There were neither any NPL nor RCRA sites adjacent to the site, within the 1.0-mile search radius. Although two CERLCIS site were located within the 0.5-mile search radius, a sewage outfall into the Red River and a landfill on the opposite bank of the Red River, USEPA had designated that these sites require no further action (NFRAP). The underground storage tank registry reported that all of the 17 underground tanks within the 0.5-mile radius (mostly gasoline tanks) had been removed. The LUST registry listed three leaking underground tanks, which had contained either gasoline or oil, but the investigators assessed that none of these would have an impact on the brownfield site (LDEQ 1999c).

Both the environmental and historical archive reviews (particularly Sanborn Maps) indicated, however, that for some period of time a landfill had occupied a portion of the site itself. Part of the site consisted of sediment deposited by the Red River. This deposited part of the site was not developed until approximately 1950, when development consisted of public buildings, gardens, and parks. The Sanborn Maps indicated that the portion of the brownfield used as the former Shreveport City Dump had been partially

developed since 1885, providing a possible date for the commencement of waste disposal (LDEQ 1999c).

The Cultural Assessment provided background information on the creation of the dump. During the Civil War, Shreveport served as a transshipment location for railroad and river traffic. Cargo traffickers used the site, which was close to both the river docks and the railroad depots, as a storage and staging area for transferring shipments. After the Civil War, river traffic decreased, and the transfer site declined in importance. The storage and staging activities ceased, and the site became a dump. The Cultural Assessment concluded, however, that despite the duration of activity at the site, the brownfield did not qualify for the National Register of Historic Places (LDEQ 2000b).

Although the site inspection did not report any evidence of contamination, the single fact of the presence of a former dump on the brownfield necessitated a Phase II Environmental Site Assessment. The investigators collected samples of soil and groundwater and analyzed them for petroleum hydrocarbons and other organic contaminants, pesticides, and a battery of metal contaminants known as Primary Pollutants. These analyses revealed high concentrations of petroleum hydrocarbons, organic aromatic compounds (such as benzene), and arsenic in both the soil and the groundwater. In the assessment, the investigators recommended further analysis to determine the extent of the contamination (LDEQ 2000a).

The environmental remediation firm performed further analysis and proposed a cleanup plan in their first RECAP draft. Further analysis confirmed the presence of high concentrations of organic contaminants and arsenic, as well as some other metals, in both soil and groundwater. The risk evaluation elaborates pathways of exposure to these

contaminants through both types of media, soil and groundwater, and describes the toxicological vulnerabilities of human organs and organ systems to each contaminant. The evaluation reports that risks from these contaminants are relatively low because the absolute mass of contaminated soil is small (despite the high concentrations) and the groundwater does not supply water for human uses. The corrective action portion of the RECAP proposed a limited remediation plan that would reduce contaminant concentrations below specific concentrations (LDEQ 2000e).

The Department of Environmental Quality did not approve the first cleanup proposal. The proposed cleanup included an application for a “variance,” or exception, to the standard concentration specification for arsenic. The DEQ, however, denied the variance and instructed the remediation plan to reduce arsenic either below the standard concentration or below the background concentration at that particular site. The Department of Environmental Quality also determined that the cleanup plan did not delineate the site boundaries of the area included in the cleanup precisely enough and that some of the analytical methods used to measure concentrations were inappropriate (LDEQ 2001a).

A second draft of the RECAP addressed the issues that had concerned DEQ. This draft included much of the same information as the first draft, but it also described in detail updated analytical methods and discrete site boundaries. Based on the site boundaries, the report stated that contamination from the former dumpsite posed a high risk of off-site impact. The report described how groundwater contamination could migrate off site either through natural features in the soil or through technological underground features such as pipes or electrical conduits (LDEQ 2001a).

The final proposed cleanup plan involved both active and passive remediation (LDEQ 2002c). Active remediation consisted of excavation of contaminated soil, followed by filling and capping of the excavation, with the capping to be partially accomplished by paving with sidewalks for recreational use. The plan called for passive remediation of groundwater contamination, which involved not the actual draining of groundwater but instead a procedure for routine sampling of monitoring wells positioned to detect migration of contaminants (LDEQ 2002b).

The environmental services firm reported to DEQ that the cleanup had reduced contaminant concentrations to levels complying with RECAP standards and monitoring wells and sampling schedule were in place to detect migration. This remediation action satisfied the conditions, and DEQ approved the site for development (LDEQ 2003, 2002a).

The purpose of this chapter is to demonstrate the importance that regulators and developers assign to quantitative risk assessment in communicating regulatory requirements and compliance. Risk assessments quantify risk on the basis of analytic chemistry methods and consider the potential for vulnerability on the anticipated uses of the site in question. The records reviewed in this chapter provide several instances of this perspective. In cases where, even though contamination was present after remediation, regulators approved the sites following implementation of measures to prevent exposure or proof that contaminated aquifers would not be used for drinking water. These environmental conditions are the result of a quantitative concept of risk employed by governmental authority.

Although the hazards-of-place theory that supports this thesis makes a distinction between quantitative and qualitative assessments of risk or hazard, these two perspectives are not entirely disconnected. An important factor in any quantitative study is the decision on where to define the scope of the study. These records give an indication about some of the decision-making processes in the definition of the project scope. These include standards for defining the physical boundaries of the site, standards requiring offsite investigations, historical research (including Sanborn Maps), and interviews with individuals with knowledge of the previous uses. One of the cases included a detailed cultural assessment to evaluate the historical importance of the site. Although these practices are specified within the ESA procedure, they demonstrate how a quantitative study attempts to identify aspects of the social and geographic context that may influence the results.

Chapter 5: Statistical and Cartographic Analysis

This chapter's three sections contain graphical, statistical, and cartographic analysis of percentage change of assessed value for properties surrounding the two study sites. Change in property value serves as a proxy for measuring investment or disinvestment in a property. Investment and disinvestment often occur during the process of urban development, which reconfigures economic and cultural geographies. These changing geographies are part of the context, proposed by the hazards-of-place model, in which brownfield redevelopment occurs.

The purpose of the graphical and statistical analyses, therefore, is to determine if investment at brownfields has a uniform or gradual effect on investment on the surrounding area. Investment at brownfields takes the form of redevelopment, while changing property values reflects investment at surrounding properties. These two analyses do not include extreme sites of investment or disinvestment, which are categorized as outliers. Cartographic analysis has the ability to identify these exceptional sites by allowing field checking.

Graphical analysis, the first step, provides general summaries about the data distributions by displaying location, spread, and shape. This analysis sometimes refers to these quantities as mean, standard deviation, and resemblance to a normal curve.

Statistical analysis adds precision to the general summaries from graphical analysis. Conclusions reached by graphical analysis are imprecise and lack validation or reproducibility, which is available through statistical analysis. This analysis includes the ANOVA test for differences in the means.

Cartographic analysis visualizes the dataset and provides the ability to investigate a dataset that was excluded from the graphical and statistical portions. These outliers are real properties whose extreme changes in value, either gaining or losing value, required they be excluded from the first two analyses to prevent data distortions. Mapping outliers allows for visual verification through fieldwork, which can indicate why a particular property measured as an outlier and how the property fits into redevelopment trends in the areas surrounding the brownfields.

Graphical Interpretation

Graphical interpretation is the first step in the data analysis, and the purpose is to perform a broad exploration of the dataset prior to detailed statistical and cartographic analysis. Histograms, the graphic sources for the first step of analysis, visually display information about the average location and spread of the variable. The variable is the percentage change in assessed value between assessment periods. The arithmetic mean is the measure of average location, and the standard deviation is the measure of spread.

The first series of histograms (Figures 3-6) displays the percentage change in property value for all of the properties within a 1.0-mile radius of both the medical facility and downtown entertainment area. The entire 1.0-mile radius area will also be referred to as the combined area or simply the area. These histograms reveal a consistent contrast between the two sites for standard deviation, but not for mean. The standard deviation for the downtown area (approx. 35 percent or 36 percent) is roughly double the standard deviation of the medical area (approx. 19 percent).

In addition to the contrasts between the sites, the downtown area exhibits shifts in mean between the first assessment interval (1992-1996) and the second interval (1996-

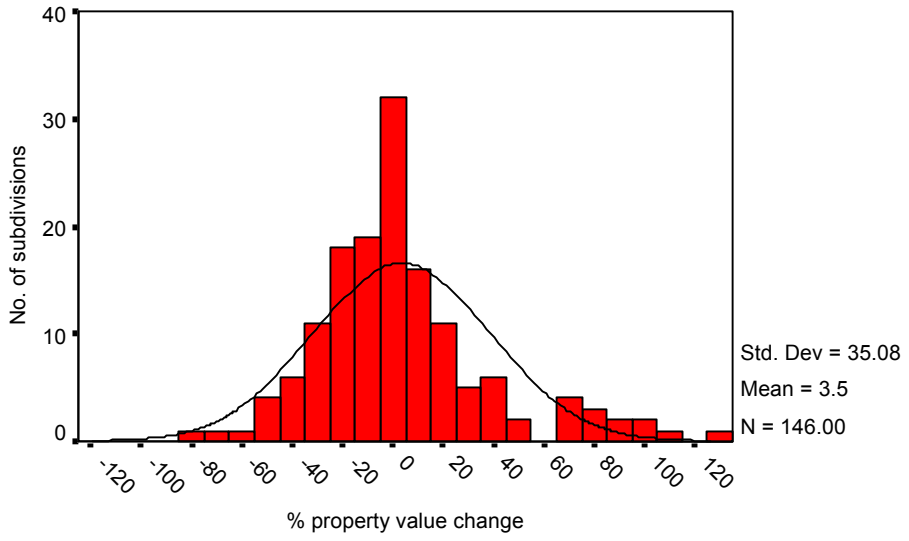


Figure 3. Downtown Site Subdivisions
1992-1996

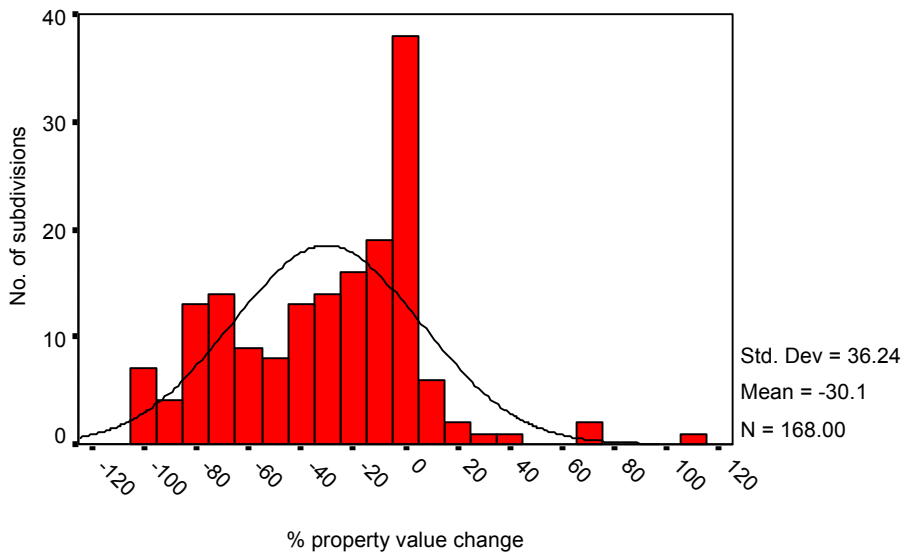


Figure 4. Downtown Site Subdivisions
1996-2000

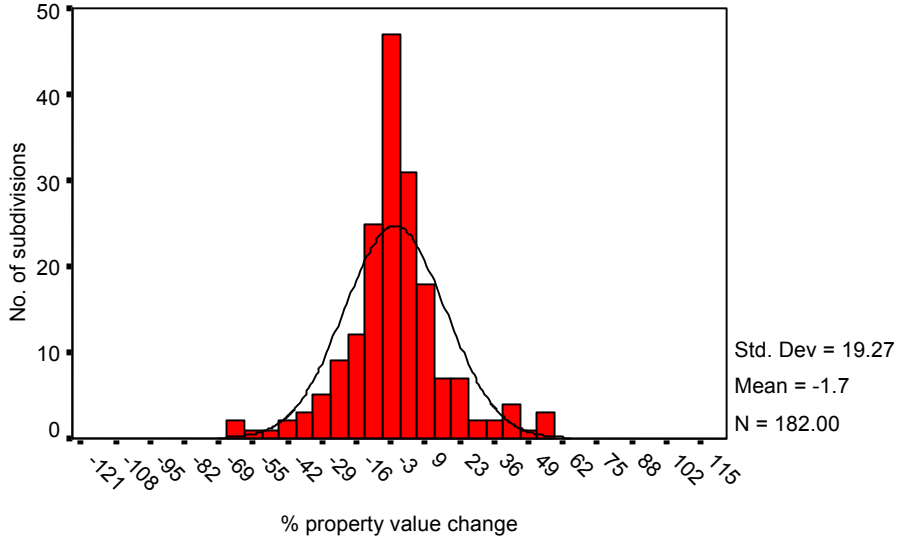


Figure 5. Medical Facility Site Subdivisions
1992-1996

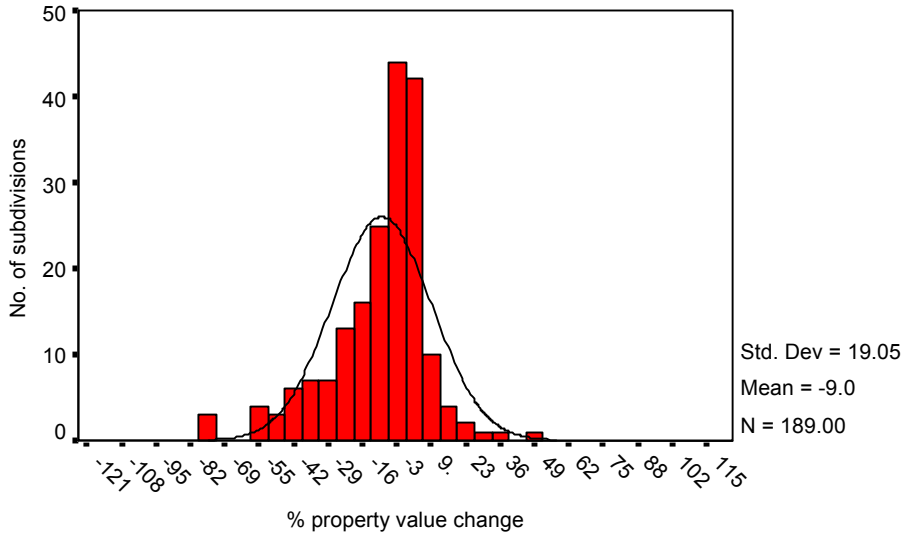


Figure 6. Medical Facility Site Subdivisions
1996-2000

2000). The mean percentage property value change decreases from nearly zero in the first assessment interval to negative thirty in the second interval, indicating a general shift over time towards decreasing property values. This shift in mean over time for the downtown area contrasts with the medical area, which has similar means for both the first and second intervals (-1.7 and -9.0, respectively).

The histograms (Figures 7-14) of percentage property value change for the 0.5- and 1.0-mile buffers reflect, in large part, the trends and contrast of the combined areas. Except for the second assessment interval (1996-2000), the distributions of the buffers roughly resemble the distributions of their respective areas in their means, standard deviations, and shapes. The buffers, therefore, exhibit similar trends and contrasts to the areas.

The major instance of contrast between buffers is for the period from 1996 to 2000 for both the 0.5- (Figure 8) and 1.0-mile (Figure 10) buffers for the downtown site. While the standard deviations of these distributions may be similar, the means do not appear to be similar. The shapes of the distributions are also different. Figure 8 exhibits a bimodal shape similar to the distribution of the combined area. In contrast, the shape of the distribution of Figure 10 resembles a block-like, uniform distribution, with roughly equal numbers of samples falling into the categories between 0 percent and -80 percent change in value. The differences, however, are the most notable contrasts, since all other buffers resemble their respective combined area.

Although the similar patterns between buffers and areas might seem appropriate, this kind of relationship does not contribute much new knowledge about brownfields. The buffers are the constituents that determine the characteristics of the areas, therefore it

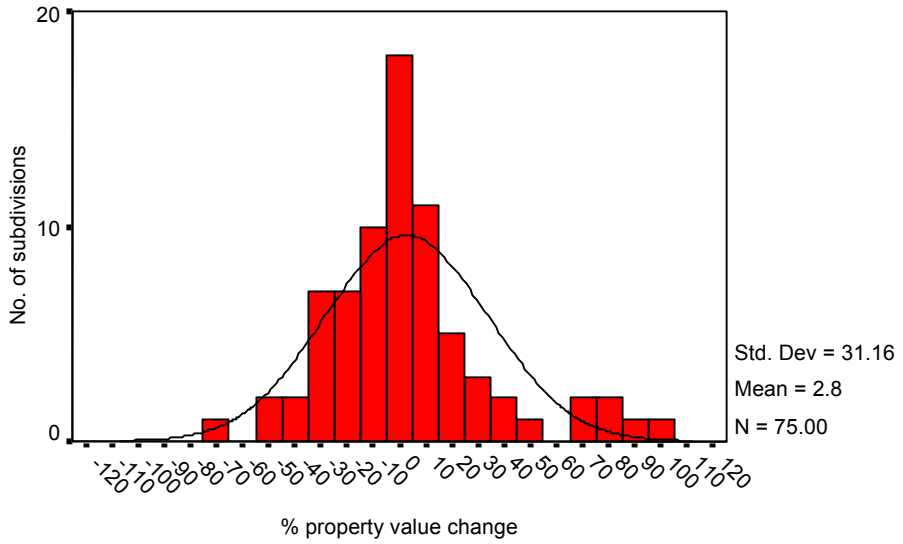


Figure 7. Downtown 0.5-Mile Buffer Subdivisions
1992-1996

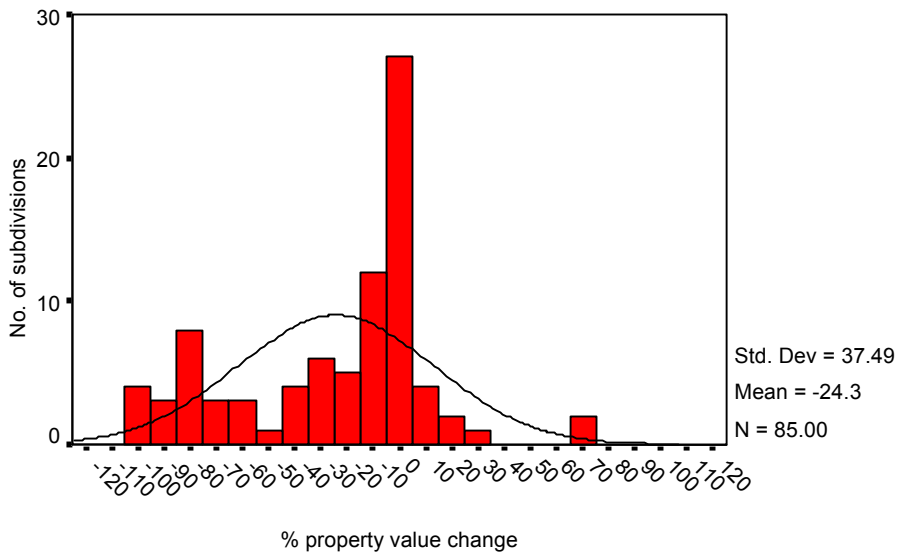


Figure 8. Downtown 0.5-Mile Buffer Subdivisions
1996-2000

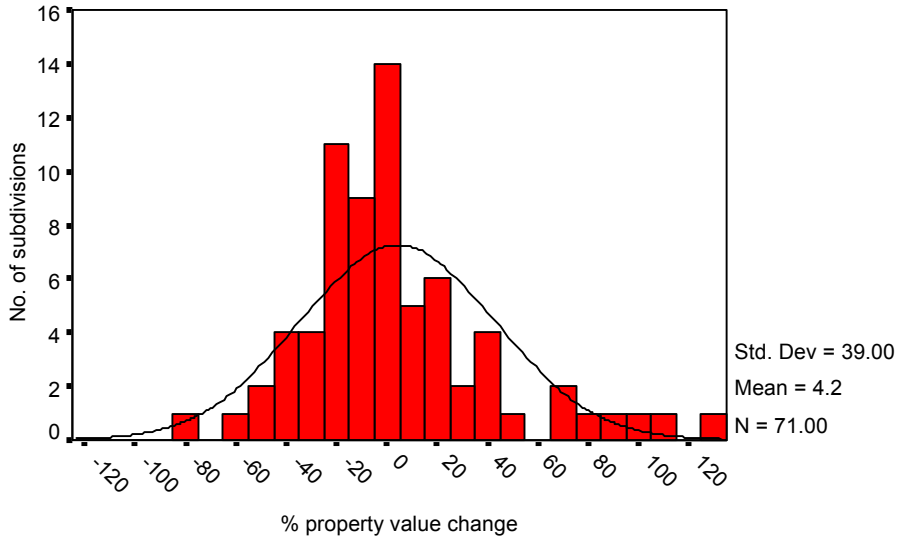


Figure 9. Downtown 1.0-Mile Buffer Subdivisions
1992-1996

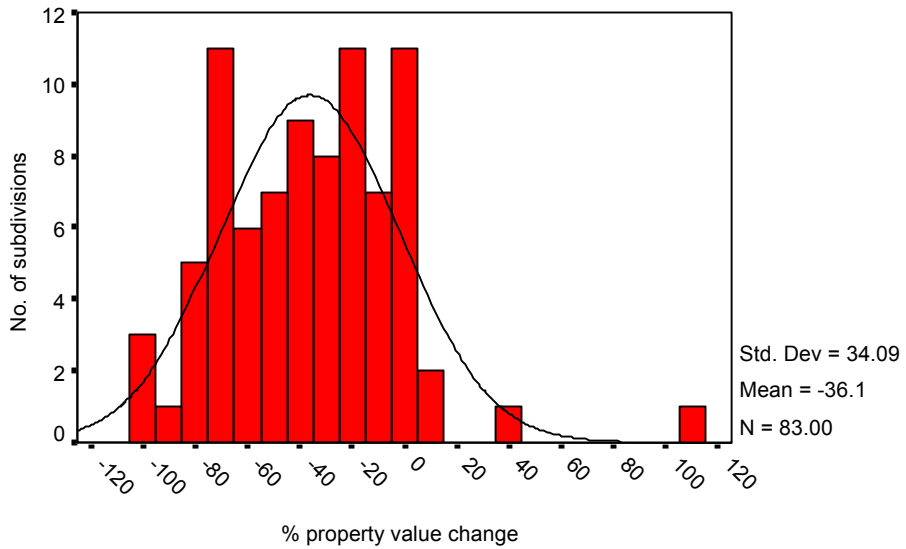


Figure 10. Downtown 1.0-Mile Buffer Subdivisions
1996-2000

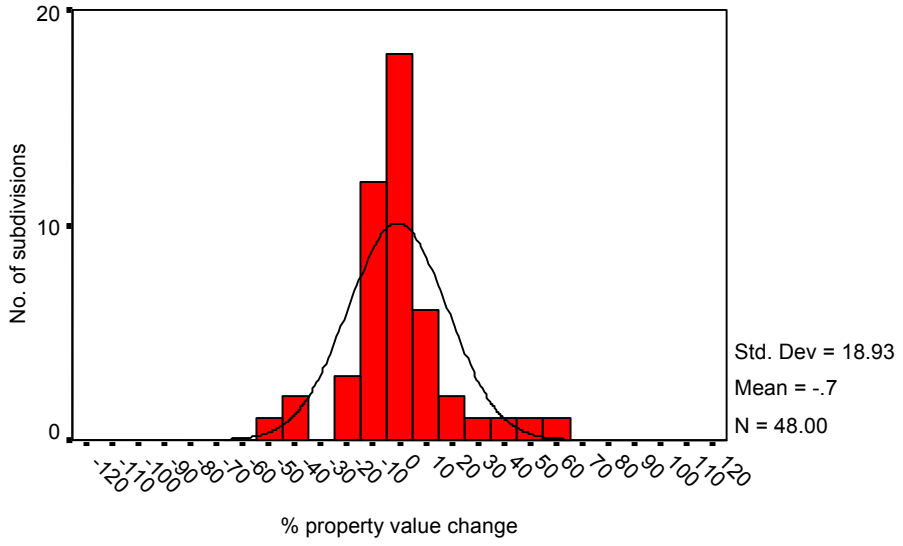


Figure 11. Medical Facility 0.5-Mile Buffer Subdivisions
1992-1996

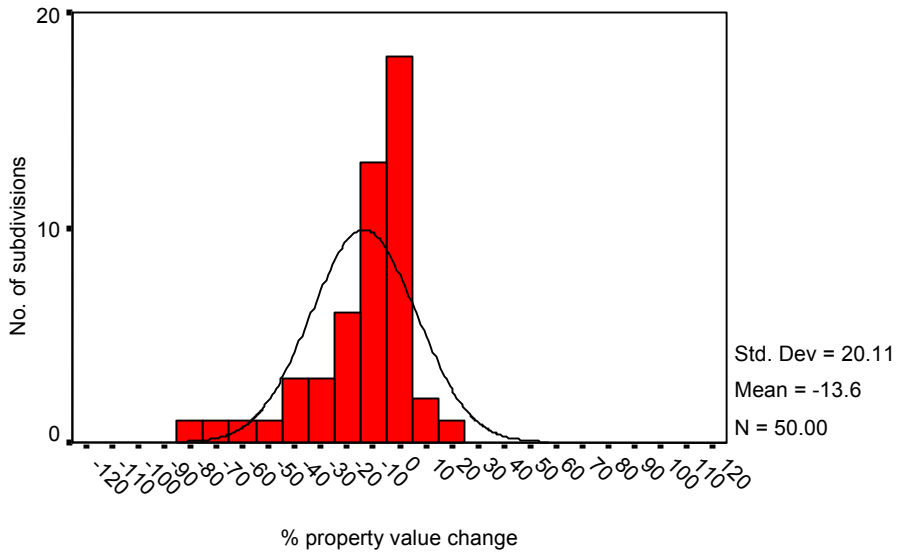


Figure 12. Medical Facility 0.5-Mile Buffer Subdivisions
1996-2000

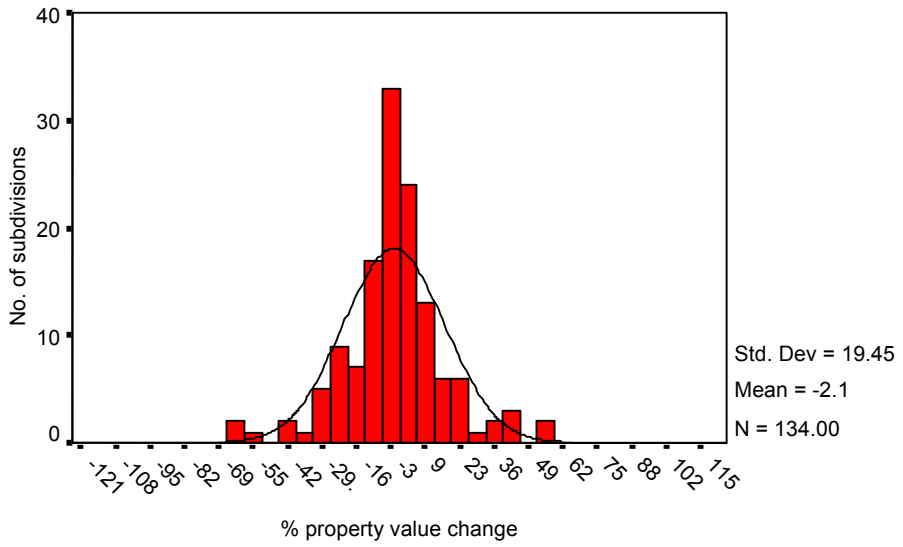


Figure 13. Medical Facility 1.0-Mile Buffer Subdivisions 1992-1996

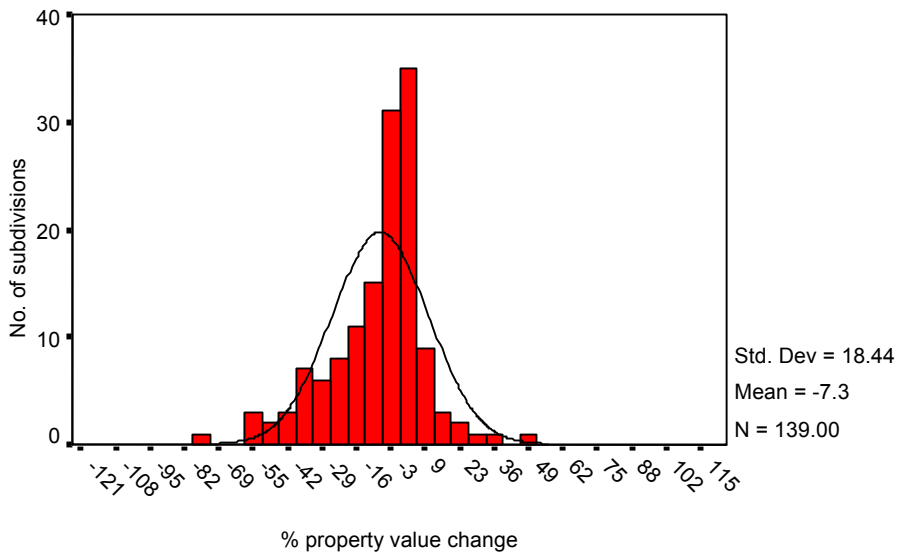


Figure 14. Medical Facility 1.0-Mile Buffer Subdivisions 1996-2000

seems fitting that the patterns in the areas reflect patterns in the buffers that comprise the areas.

The information that the buffers are intended to convey, however, is the effect that geographic distance from the brownfield redevelopment site (represented by the 0.5- and 1.0-mile intervals) has on changes in property value in the surrounding properties. Specifically, differentiation between buffers in the mean, standard deviation, or the shape of the distribution of each buffer would describe that geographic distance effect. But this differentiation does not exist. The lack of differentiation between buffers and areas suggests that using geographic distance intervals to categorize the geographic location of properties relative to the brownfield sites is not an effective method for evaluating the change in the property value. Nor does the graphic analysis support any conclusions about gradual or uniform effects of brownfield redevelopment on surrounding investment.

Statistical Interpretation

Although geographic distance intervals might not be an appropriate method, the subjective nature of graphical interpretation makes it necessary to quantify the measurements. The conclusion that distance intervals are inappropriate was based on qualified observations. These qualified observations can give only an impression about the contrasts and similarities between the means and the distribution shapes. While they may be informative, the impressions are imprecise and irreproducible.

The purpose of the statistical interpretation is to quantify those graphic-based observations. Specifically, the statistics can quantify whether the mean (location) of any

buffer's distribution is significantly different from any other buffer. The statistic for the mean (location) of the distribution is the ANOVA F-statistic.

The purpose of the ANOVA is to test whether the mean percentage property value change of any one buffer is significantly different from the mean of the other buffers. While none of the buffers' means are identical, the ANOVA calculates a statistic based on the relative differences of the variation of individual property value changes within each buffer and the variation of the mean property value change between each buffer. The results of the within-buffer/between-buffers comparison indicate at 99 percent confidence that at least one of the buffers' means is different from the other buffers' means (Appendix 2, Tables 1 and 2).

Since the ANOVA itself does not identify which buffer's or buffers' means differ from the rest, this analysis uses a Post Hoc test to identify the unlike buffers. The Post Hoc test used is the Scheffe Test (Shaw and Wheeler 1998), which identifies unlike buffers by comparing the differences of each buffer's mean from every other buffer on a case-by-case basis (Appendix 2, Table 3).

The results of the Post Hoc test indicate that there are two buffers that are the most unlike the other six buffers. The two buffers are the 0.5-mile and 1.0-mile buffers around the downtown brownfield during the second assessment interval from 1996 to 2000. This analysis confirms the conclusion reached with graphical interpretation that the means of all buffers are similar except for shifts between the first assessment interval (1992-1996) and the second interval (1996-2000).

For proper interpretation, ANOVA requires the satisfaction of four assumptions. The distribution of each variable must have a normal shape, and the standard deviations

of each variable must be approximately equal. Each variable must be independent of every other variable, and the analysis must randomly select sample points for the measurement of each variable (Devore and Peck 2001).

The research design explicitly violates the fourth assumption. The subject brownfields are the sample points. The thesis's section on Site Selection describes the process for selecting the brownfields. Since this process consisted of selecting brownfields from an official list based on the sites' level of development, the site selection was not random.

The research design either did not test or implicitly violated the remaining three assumptions. A cursory examination of data distributions suggests that not all variables have equal standard deviations. The analysis contains neither a test to verify if each variable has a normal distribution nor a test to verify if variables are independent of each other. Although these tests are available (Kolmogorov-Smirnov test and spatial autocorrelation test, respectively), this analysis does not include them.

Because the analysis violated or failed to test the assumptions, interpretation of the results requires caution. This does not represent a serious shortcoming of the analysis, however, because the results of ANOVA do not support any additional conclusions beside those obtained from graphical interpretation. Since the ANOVA is not being used to support any substantive new conclusions, it does not require rigorous satisfaction of the assumptions.

The statistical results do provide a modest quantitative validation of the graphic-based conclusion. That graphical conclusion suggests that the only exceptional buffers are both the 0.5- and 1.0-mile downtown buffers for the 1996-2000 interval. Therefore,

the best measure for differentiating property value changes is to use time intervals rather than distance intervals. The technique of using distance from brownfields, then, does not provide much geographic knowledge about redevelopment or effects on surrounding geographies.

Cartographic Interpretation

Cartographic mapping of property values provides the ability to analyze redevelopment with more detail. Choropleth mapping of property values of each subdivision allows for a finer resolution than the half-mile buffers used to categorize data for the statistical analysis. Mapping also allows for the physical identification of outliers, which were necessarily eliminated from the dataset to enable statistical analysis.

Four maps (Figures 15-18) display the cartographic information for both downtown and medical sites during both assessment intervals. Each map displays the percentage change in assessed property value over the assessment interval. The variable is classified by the standard deviation method.

The standard deviation method of classification assigns a category to each property subdivision based on the location of its variable relative to the mean of the variable. Subdivisions are classified into one of six categories, with three categories each for subdivisions with variables that are either greater or lesser than the mean. The three categories contain subdivisions with variables that differ from the mean by less than one standard deviation, between one and two standard deviations, and between two and three standard deviations. Variables that exceed three standard deviations are classified as outliers, which may be either positive or negative. The map displays the entire area for

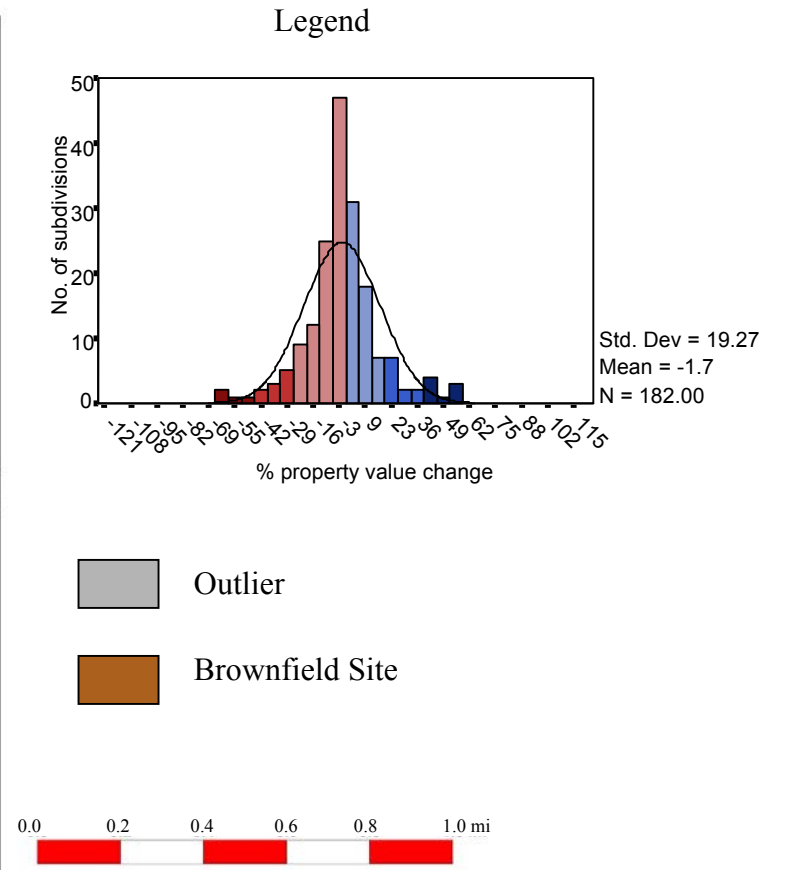
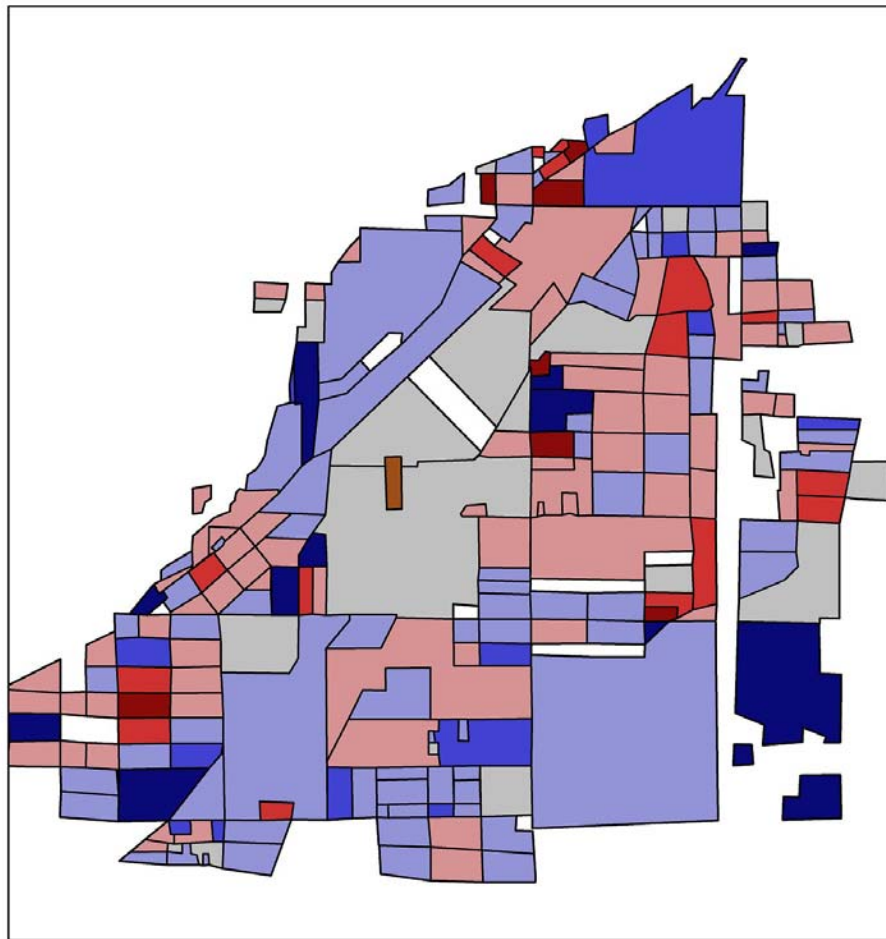


Figure 15. Property value change for subdivisions in medical facility area between 1992 and 1996

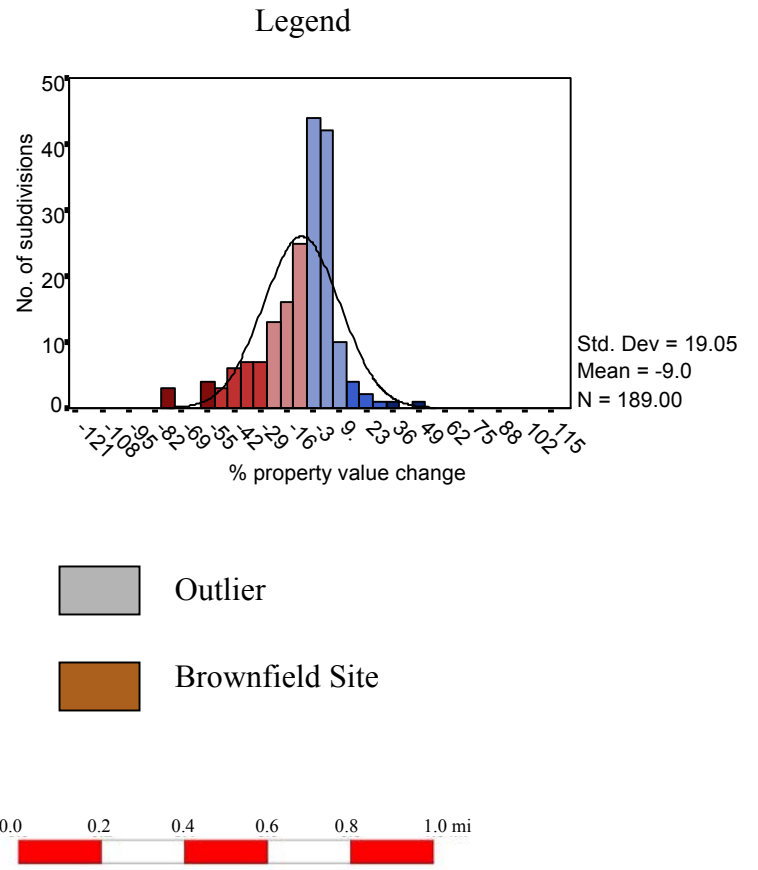
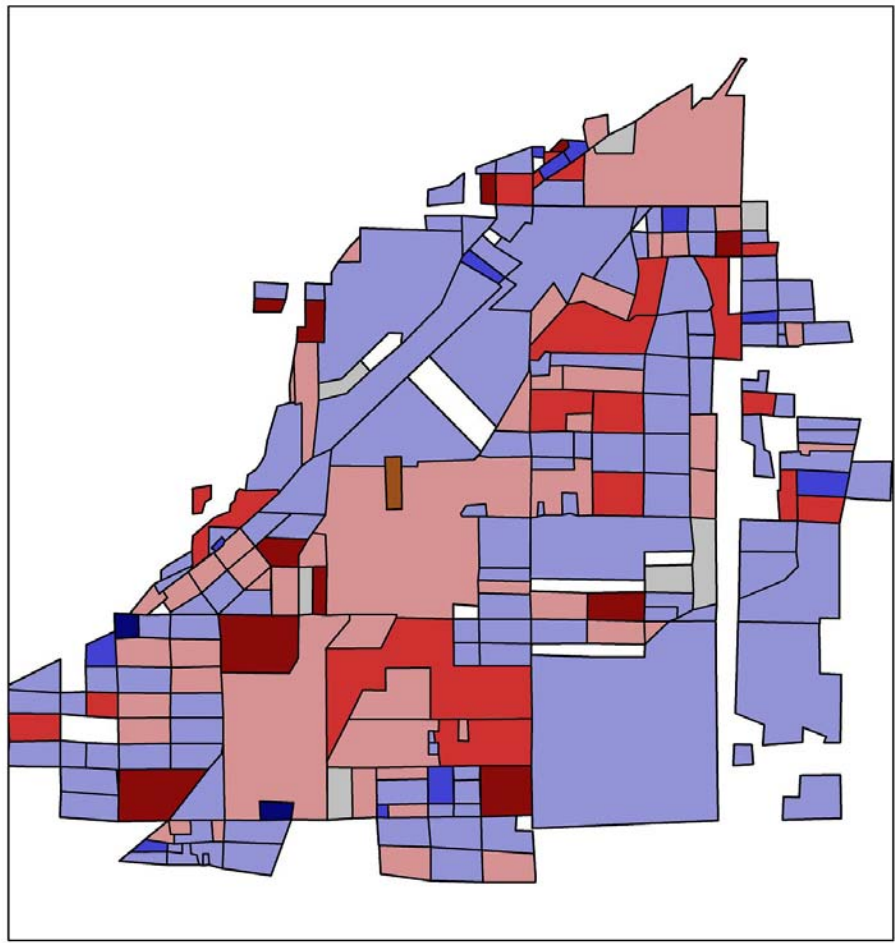


Figure 16. Property value change for subdivisions in medical facility area between 1996 and 2000

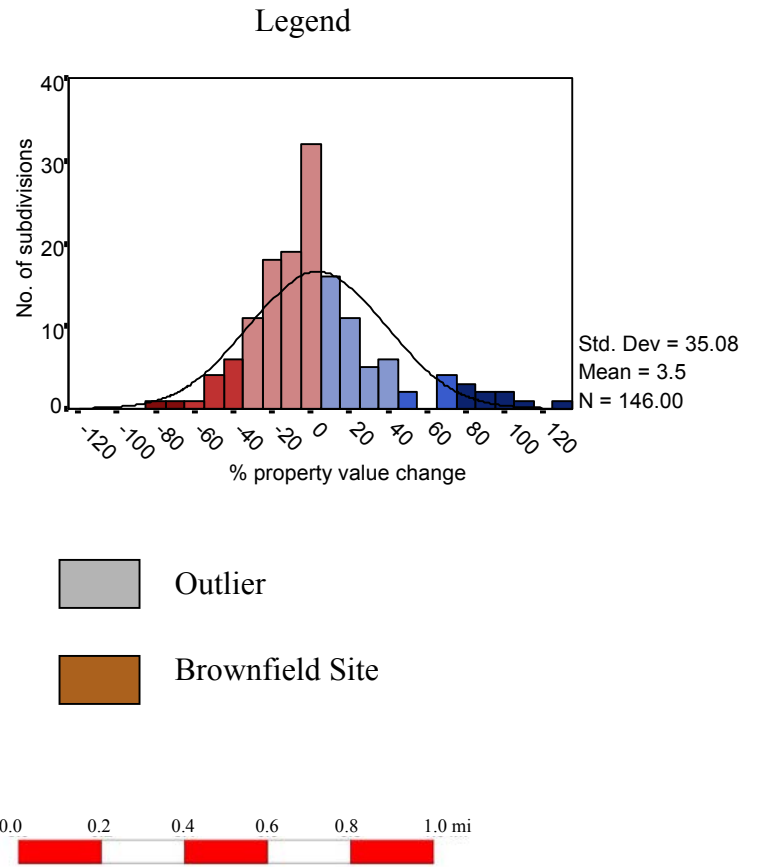
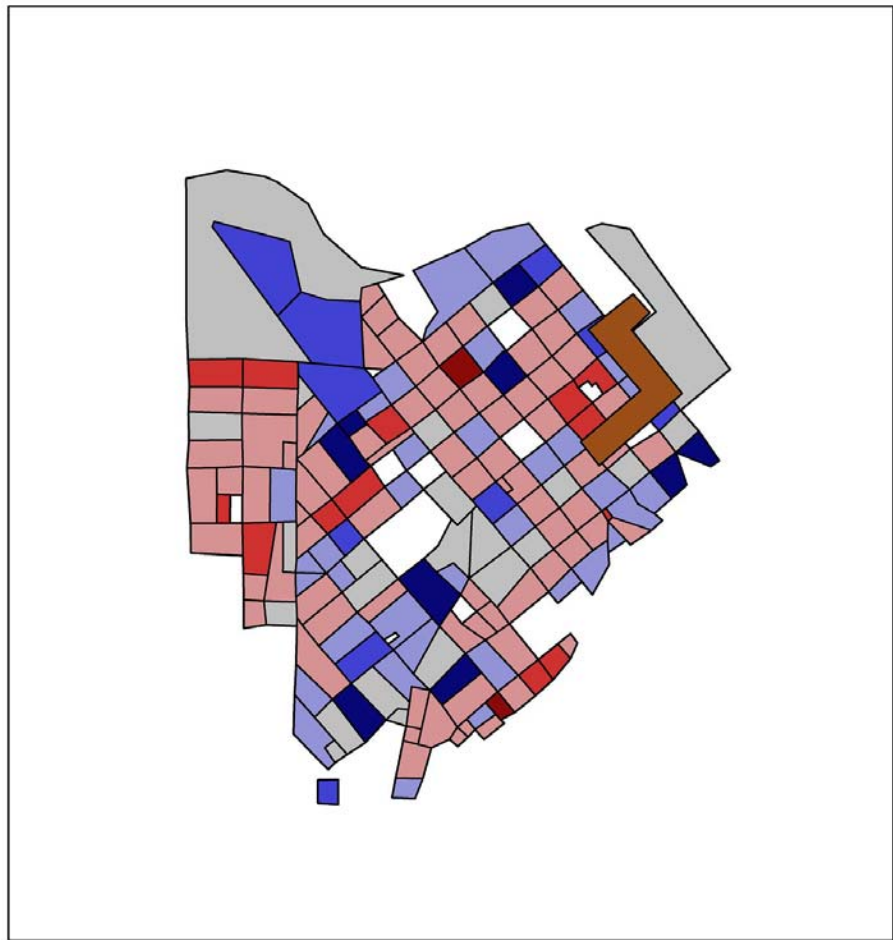


Figure 17. Property value change for subdivisions in downtown area between 1992 and 1996

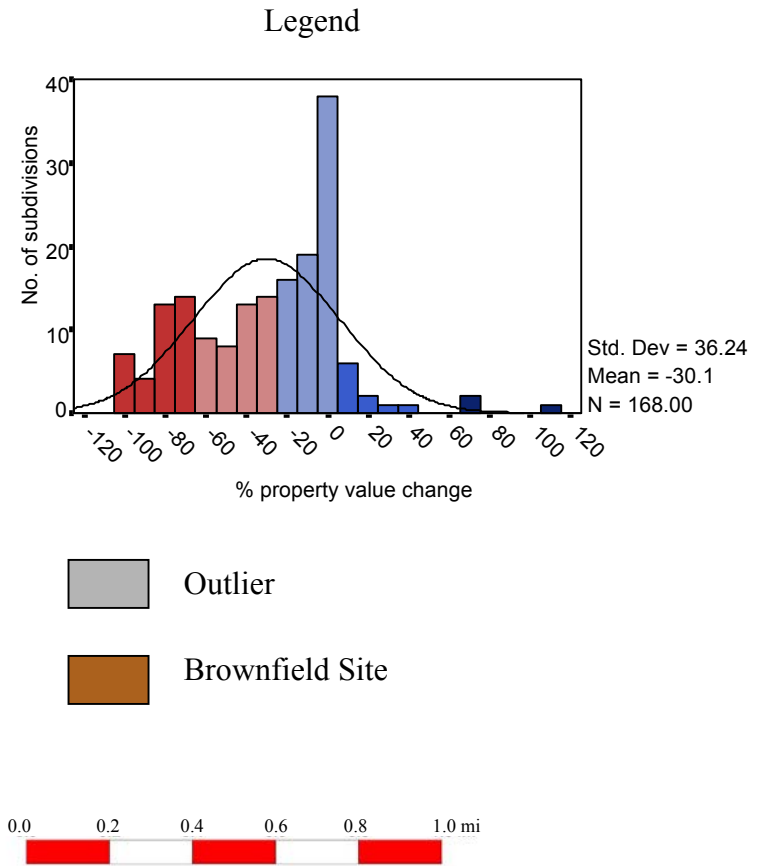
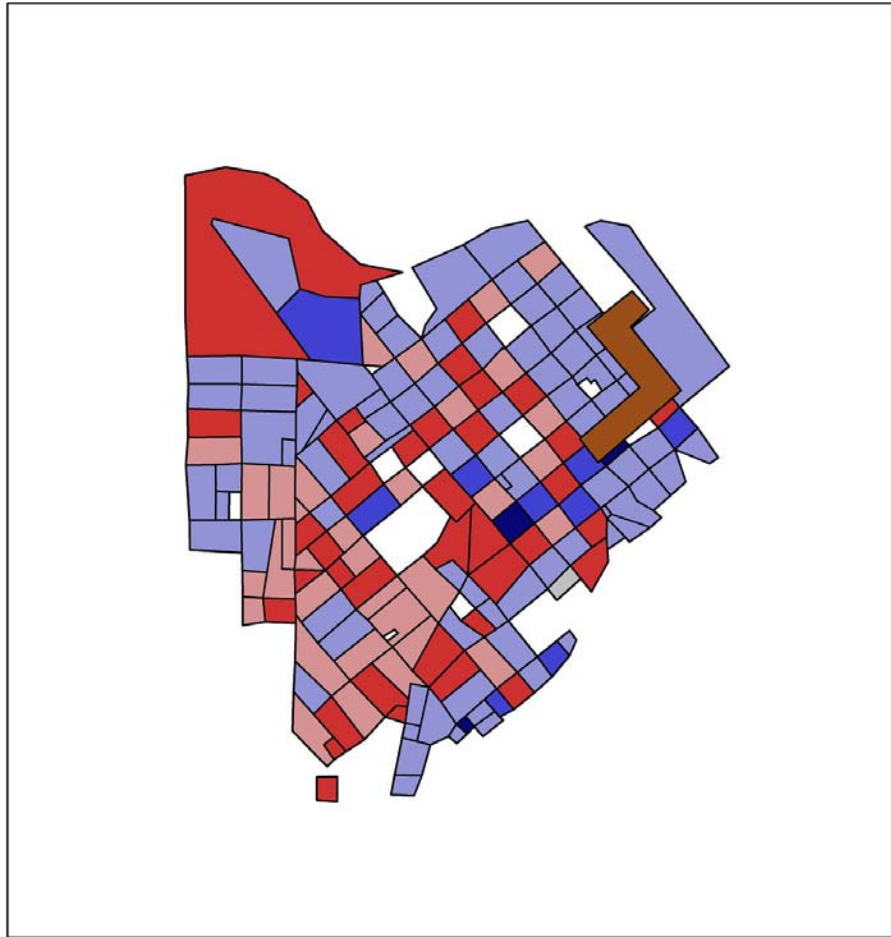


Figure 18. Property value change for subdivisions in downtown area between 1996 and 2000

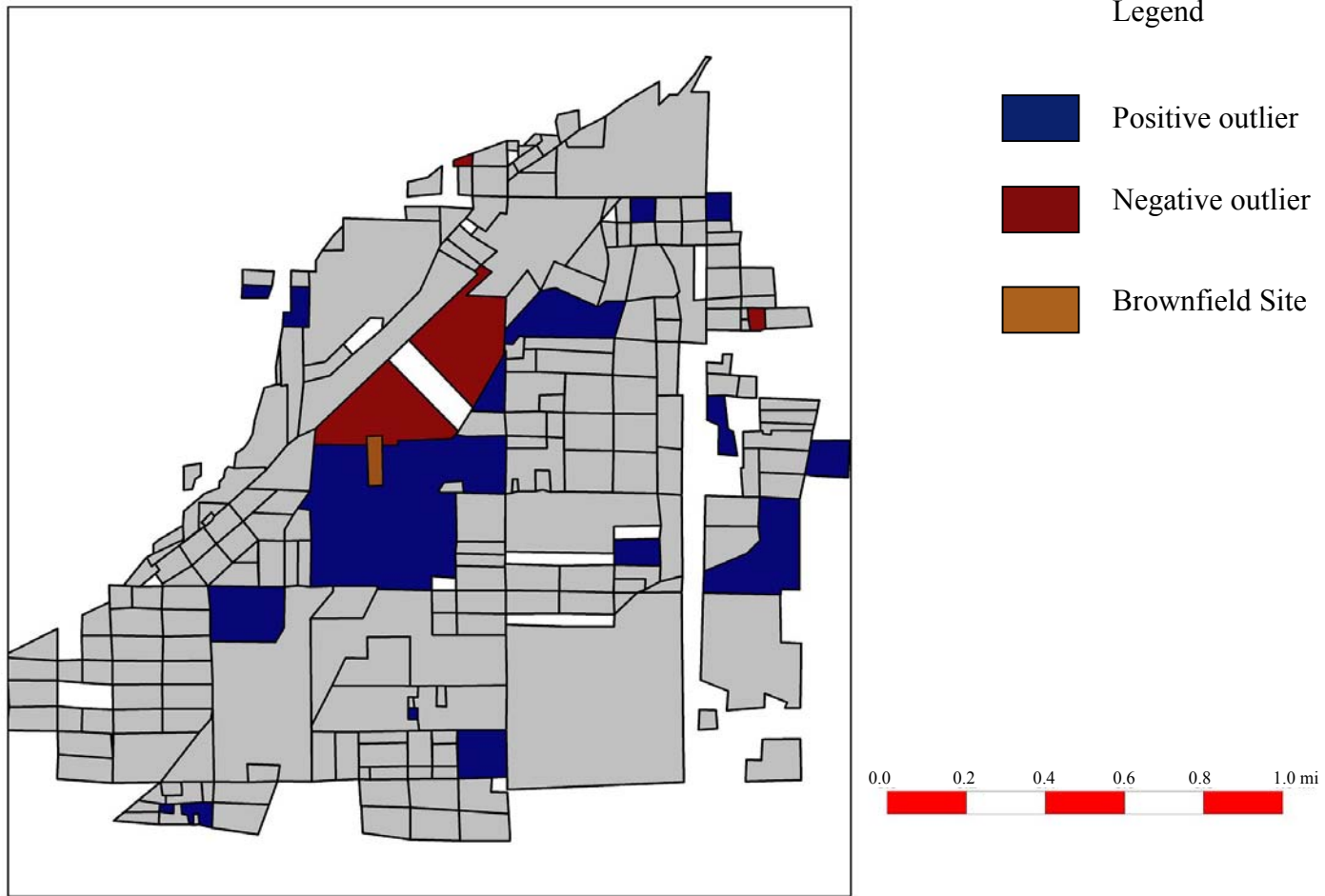


Figure 19. Outlier subdivisions in medical facility area between 1992 and 1996

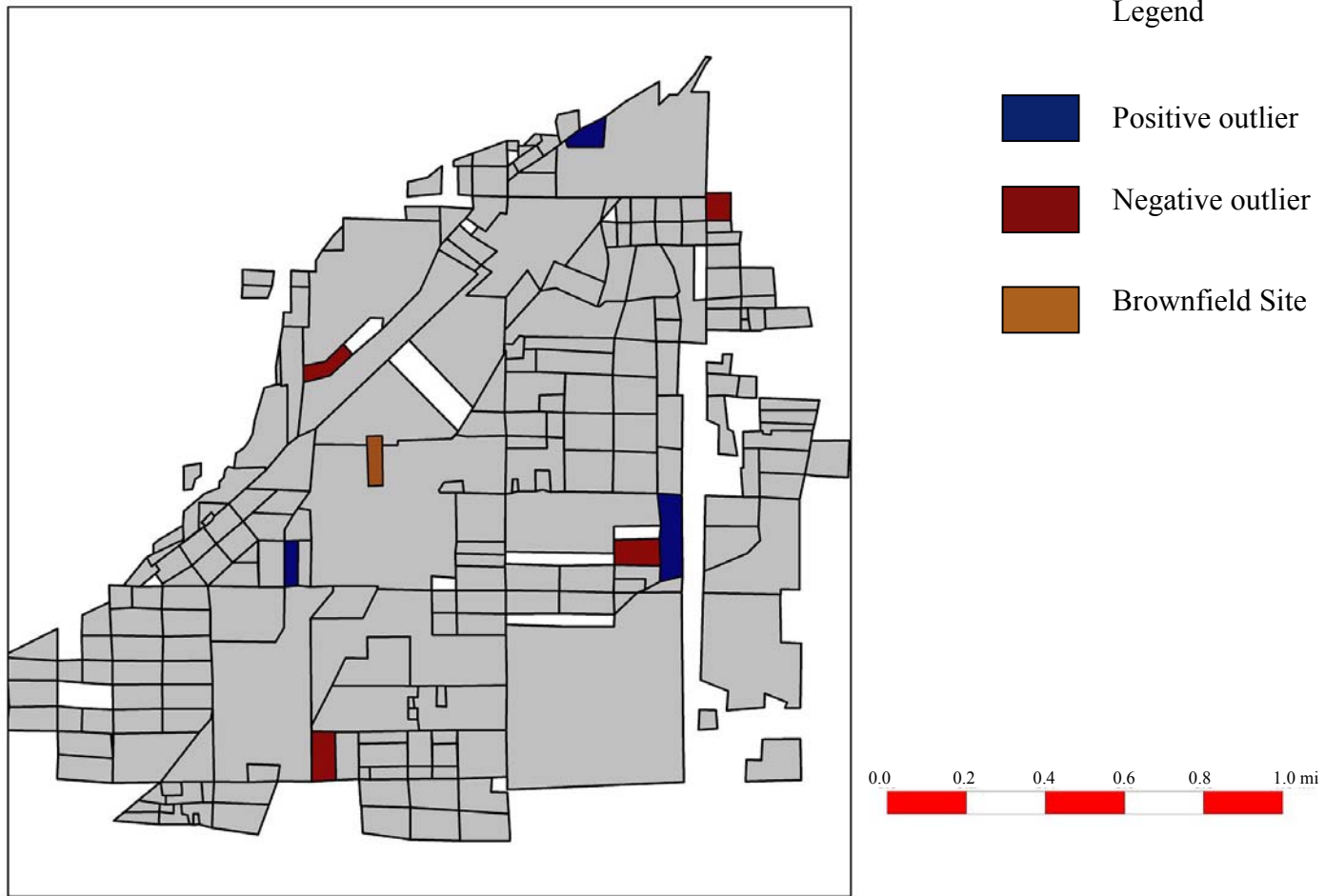


Figure 20. Outlier subdivisions in medical facility area between 1996 and 2000

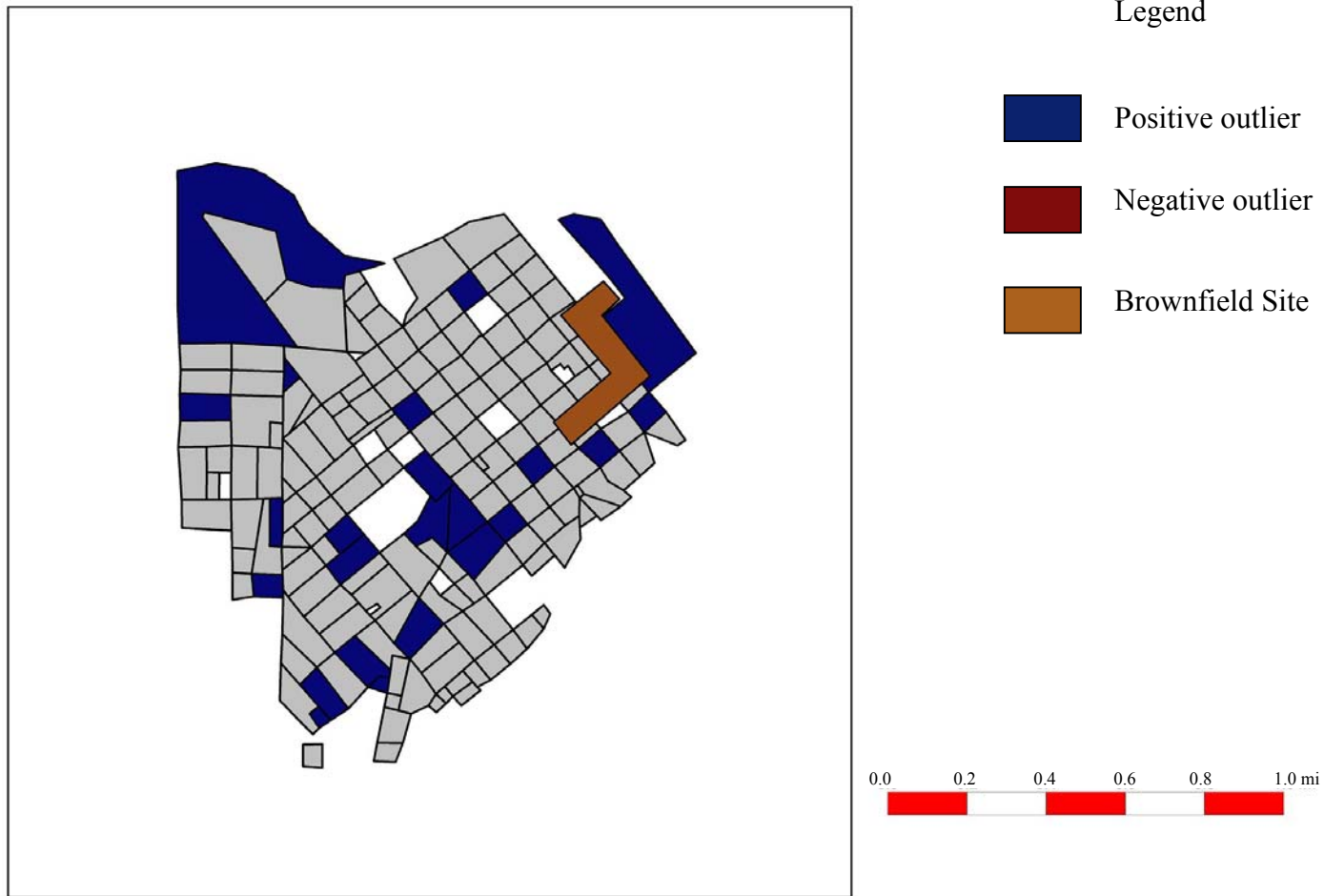


Figure 21. Outlier subdivisions in downtown area between 1992 and 1996

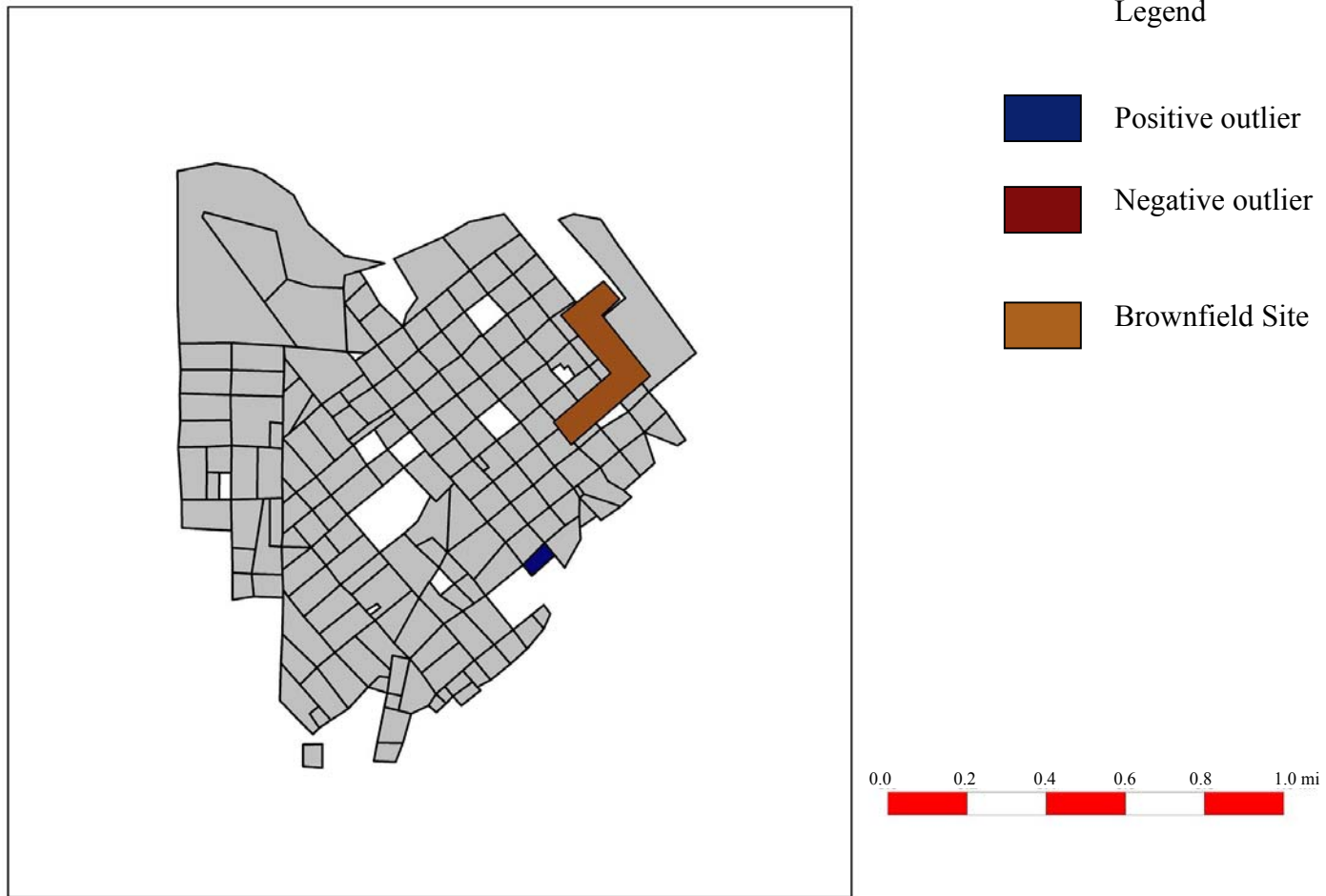


Figure 22. Outlier subdivisions in downtown area between 1996 and 2000

each brownfield site, so the mean and standard deviation used are those for the entire area, rather than for a buffer.

By using the standard deviation method of classification, the maps serve to complement the statistical analysis. Displaying subdivisions based on their variable's position within the combined area's data distribution allows for comparisons of cartographic and graphical (i.e., histogram) data. Further, classifying subdivisions by standard deviation allows for the identification of outliers, which were excluded from both graphical and statistical analysis. Figures 19-22 map the locations of outliers and identify them as positive or negative.

Medical Brownfield Area

Despite the greater detail obtained by mapping property values by subdivision, the medical brownfield area maps do not indicate any specific spatial patterns of property value changes. There may be groups of subdivisions, particularly in the southwestern corner of the map and east of the brownfield site, that exhibit a cluster of similar property values changes. But these groups are not uniform, and they contain several subdivisions with value changes both greater and less than the mean for the entire area. Because they are heterogeneous, it is not appropriate to conclude that either of these groups comprise a cluster.

The irregular sizes and shapes of the subdivisions in the medical brownfield area make the identification of clusters difficult. Even though calculating the percentage change normalizes the property value data, the large areas of some subdivisions still

distort interpretation of the maps. In addition, the presence of large-area subdivisions may have distorted the 0.5- and 1.0-mile buffers used for statistical analysis, especially when these large subdivisions overlapped the buffer boundary.

This area contains several warehouses and truck terminals, which accounts for the presence of some of the large-area subdivisions. Some of the warehouses and terminals serve the U.S. Postal Service or private shipping firms. Other warehouses contain industrial and electrical supply firms. The large warehouses and parking lots that these business activities require contribute to the large areas and irregular shapes of some of these subdivisions.

Because the maps do not support any conclusions about spatial patterns or clusters, they do not indicate the presence of any spatial outliers. These are properties that have substantially different values from their neighbors. Since the maps do not indicate any patterns, they cannot demonstrate any outliers within those patterns.

The maps do, however, allow for the verification of numerical outliers. The outliers' extreme distance from the mean of the distribution makes them ineligible for statistical analysis, but the outliers still represent real property.

Some of the subdivisions appear as outliers because of a shortcoming in the data collection procedure. The property tax rolls for 1992 and 2000 list only properties that are required to pay property taxes, while the roll for 1996 also lists properties that are exempt from taxation. These properties include churches, schools, and parish facilities. Some of these types of activities are located near the medical brownfield, including several schools and churches, plus the offices and equipment lay-down yard for the Caddo Parish Department of Public Works.

Certain other subdivisions, however, appear as outliers not because they are tax-exempt but because they were the sites of substantial investment, such as construction or renovation. Two subdivisions of this type of outlier house facilities operated by hospitals within or near the area. A private hospital operates a cultural and educational center in a renovated mansion on one of the sites, and a Louisiana State University teaching hospital operates a children's speech and hearing center on another site.

These types of sites are noteworthy because they contribute to a group of health care service facilities in and near the medical brownfield area. The hospitals that operate these facilities are located in or near the area, and the LSU hospital operates health clinics in another facility. There are two construction sites that will house new health care facilities, including the brownfield site itself, which will become a medical instrumentation research and design laboratory. Field verification that two of the outliers contained health care facilities supports the identification of a pattern of development and investment to enhance health care provided by the two operating hospitals.

This pattern of health care investment in Shreveport fits into the typical pattern of urban development. The area surrounding the medical facility appears to have been an industrial and wholesale district that was established along a railroad corridor. The thesis does not contain any historical evidence to support this conclusion, but this area of Shreveport resembles typical railroad-industrial corridors. As the geography of the industrial district changed as a result of urban development, sites in the area that were previously occupied by industrial activities were abandoned and later redeveloped to support the health care industry. This redevelopment represents urban development

processes of industrial decline, sectoral shift (from manufacturing or wholesaling to health care), and reinvestment following an inactive intermediate period.

Downtown Brownfield Area

Like the medical area maps, the downtown brownfield area maps do not indicate any specific spatial patterns or spatial outliers. While the complicating factor in the medical area was the large, irregular areas of some of the subdivisions, the nature of the numerical outliers in the downtown area is the factor that confounds spatial analysis.

Most of the subdivisions identified as positive outliers during the 1992-1996 interval are tax-exempt properties. The cluster of positive outliers in the southwestern corner of the map houses facilities for city police and government administration, while the positive outlier cluster in the northwest corner includes the city water and sewage pumping station. Several churches, along with a city fire department station, are located in the positive cluster near the map's center. Due to limitations in the data collection method, these subdivisions, which house tax-exempt properties, appear as positive outliers during the 1992-1996 interval and as extreme property-value-declining locations during the 1996-2000 interval.

This pattern of subdivisions gaining value during the first interval and losing value during the second interval occurs consistently throughout the downtown area. Examples of this pattern include the area along the western boundary of the map in the north-south/east-west street pattern and the area to the southeast, which contains the city police and government administration offices. Another example is the section of downtown close to the river. All of these groups of subdivisions display similar

tendencies to reverse the direction of their value change from one assessment period to the next.

Although many of the outliers are tax-exempt subdivisions, some outliers represent properties that have experienced substantial investment. These properties are located near the brownfield site itself in the eastern and southeastern sections of the downtown area. The riverfront property that houses two casinos is a major site of investment, and this subdivision displays the most extreme increase in property value of all of the subdivisions surveyed in this thesis. Two hotels near both the casino and the redeveloped brownfield occupy either outlier properties or properties with large increases in value. Also occupying value-increasing properties are two high-rise buildings, one with industrial offices and another with apartments.

Like the investment outliers in the medical brownfield area, these outliers are the sites of investment to support dominant downtown economic activities. Investing in industrial management, entertainment, and permanent housing properties exemplify the efforts to revitalize underused downtown areas.

This process of downtown revitalization in Shreveport, like health care investment, matches the typical pattern of urban development. The provision of downtown residences and recreational activities aims to assert the cultural importance of the city's downtown. The establishment of managerial economic activity reflects the role of urban downtown areas as administrative centers for business. Casinos and hotels are spectacular flagship developments intended to attract both visitors from out of state and businesses to the downtown area. All these types of development are present in

Shreveport. The redeveloped brownfields in Shreveport, which include residential and commercial-recreational activities, are closely linked to these types of development.

Evaluation

The graphical and statistical analyses supported few conclusions about the influence of brownfield redevelopment on investment in surrounding properties. The most substantial shortcoming of these two analyses was their inability to differentiate property value changes between buffers. The similarity between a majority of the buffers indicates that buffers are not an appropriate tool to use with this type of analysis to interpret investment and redevelopment. Instead, these analyses indicated the most significant change was a change over time, from the first assessment period to the second period around the downtown site, rather than over geographic distance.

The lack of substantial results may be the result of the data aggregation method. The aggregation method consisted of calculating the sum of all properties within a subdivision then by mapping data at the subdivision level. Either of these aggregation methods, summing or mapping at subdivision level, may be eliminating too much information.

Another limitation may result from transplanting methodology from environmental assessment to economic analysis. The buffer size and structure from the ASTM assessment procedure accounts for the transportation of chemical contaminants along solid, liquid, or airborne pathways based on the chemical and physical property of the contaminant and medium. These variables, which define the buffers, are quite different from the variables that contribute to changing economic and cultural geographies.

In addition to aggregation, investment in Shreveport's urban areas may be too complex to be adequately described in terms of the study period. Property value data was only measured at four-year intervals. While this was the most frequently updated data available, it still may not have had sufficiently high resolution through time to capture investment trends.

It is also possible that urban investment is too complex to be quantified solely in terms of brownfield redevelopment. Urban development is a complex process that operates at multiple geographic scales. Perception may play a prominent role in brownfield redevelopment, as sites with a less severe perception of pollution may receive greater investment than those perceived to be worse. The interactions of all of these processes likely overwhelmed the explicitly visible effects of brownfield redevelopment. Since the thesis did not measure the effects of these interactions, they may simply have appeared as random patterns.

The statistical analysis did not support any additional conclusions from the graphical analysis. The statistical analysis did confirm most of the graphical conclusions, although that outcome is mainly a confirmation of the author's skill in graphical interpretation.

By contrast, results of the cartographic analysis are informative. Because outliers are available to cartographic analysis, the results support conclusions that graphical analysis precluded through generalization. Some outliers are the results of errors in measurement, such as the use of tax-exempt property rolls for only one of the assessment years.

Several positive outliers, however, in both medical facility and downtown areas appear to be the outcome of high investment levels in properties intended to support dominant or expanding economic activities. These activities consist of health care services in the case of the medical facility and entertainment services in the downtown area. These investment sites were invisible to graphical and statistical analyses, which had eliminated outliers.

These outliers were actually significant indicators of urban development. The outliers occurred at properties that were the sites of substantial investment to support either the health care industry or service and recreation industry. The health care industry and service industry are expanding in development districts in the old industrial rail corridor and downtown area. Patterns of changing economic and cultural geographies, as part of urban development processes, support both of these industries. Urban development is the context in which brownfield mitigation has occurred, and the redeveloped uses of the brownfields support the new geographies of the surrounding areas.

Chapter 6: Conclusion

This thesis analyzed the process of brownfield redevelopment by investigating brownfields with the hazards-of-place theory. Hazards-of-place is an approach that interprets vulnerability as a process that involves not only the likelihood of a hazardous incident but also the processes of hazard creation and mitigation that occur within social and geographical context. The research questions of this thesis asked how the processes of brownfield creation and redevelopment fit into the hazards-of-place theory, with a special emphasis on the context of the redevelopment process.

According to hazards-of-place, hazard potential results from a combination of risk and mitigation. The social context, along with its geographic consequences and influences, convert hazard potential into vulnerability. Biophysical, or technical, vulnerability combines with social vulnerability to influence the vulnerability of a specific place. Place vulnerability affects the risk of hazardous incidents and the mitigation steps taken to prevent the hazard. Risk and mitigation re-cycle to begin the process of converting hazard potential to vulnerability.

In cities, processes of urban development provide the social and geographic context of brownfield hazards and mitigation. The term urban development does not refer solely to the construction of new residential neighborhoods, office parks, or shopping malls. The processes by which populations relocate within the city and firms abandon industrial or warehouse sites constitute urban development as well.

These urban processes act to reconfigure the city's economic and cultural geography. Although the inputs to these processes combine in complex interactions, it is useful to organize urban development in terms of the exploitation of new technology and

the exercise of governmental authority. Promoting economic development, creating new cultural geographies, exploiting technology, and exercising governmental authority have an impact on both urban development and brownfield hazards.

In the typical historical pattern of urban development, cities grow larger and more populous, and the shape of the city alternately expands into new territory and consolidates the expansion. When organized in terms of transportation technology, cities transform from compact walking to irregular streetcar cities. Early limited use of automobiles provides increased flexibility and allows for new development to fill in the irregular gaps in the streetcar city, resulting in a new compact (if larger) city. Expanded ownership of automobiles and the use of highways allowed the expansion of the freeway city.

Innovations in transportation are not the sole factor in urban development. The alternating pattern of urban expansion and consolidation corresponds with alternating dominant political ideologies. These alternating political ideologies and related policies are part of the historical and geographical response by government to periodic economic crises. Since cities are substantial participants in economic activity, it is logical that policies intended to address economic crises should have a significant impact on urban development.

Changes in city shape related to technological innovations and political ideologies contributed to changing economic and cultural geographies as well. New residential, retail, and industrial districts developed alongside commuter and freight rail lines. As railroads drew some economic and residential activities away from the central city, spectacular department stores and office skyscrapers in the central city represented both

the economic and cultural importance of the downtown. Later, freeway suburbs represented the ideal combination of rural and urban settings. As suburban populations grew, manufacturing and administrative services relocated from cities to suburbs, making the suburbs less dependent on the central city.

The factors of economic and cultural development, new technology, and governmental authority influence the creation and mitigation of brownfield hazards. In many cases, processes of industrial suburbanization are directly responsible for the creation of brownfields. Governmental authority contributes to brownfield hazards both indirectly, with policies that support suburban relocation and sectoral shifts, and directly, with environmental liability laws that discourage redevelopment.

Economic development can contribute to brownfield mitigation. A popular method of mitigating brownfields is to redevelop the sites and return them to active use. This strategy often involves attracting private sector business to the site. Therefore, the decisions made by firms to invest in former brownfield sites are substantial factors in brownfield mitigation.

Governmental groups exercise their authority to promote brownfield redevelopment. These efforts at mitigation often come in the form of economic incentives to private firms to redevelop brownfields. These incentives seek to reduce the risk and the cost of redevelopment. Reducing risks and costs could include assistance with environmental assessment and remediation, guidance in the regulatory process, or policies to educate environmental workers.

The analysis of brownfield mitigation in this thesis found evidence of these influences in the case of two brownfields in Shreveport, Louisiana. The two study sites

are a medical research facility currently under development and a series of recently completed residences and recreational areas in downtown Shreveport. In terms of typical urban development patterns, both of these sites are located in areas of the city likely to house abandoned or disinvested sites. The medical facility is located in an industrial railroad district, and the residences and recreational areas are located in downtown. Typically, both of these areas of the city would have experienced disinvestment and abandonment as businesses and residences relocated to the suburbs.

Redevelopment of these brownfields also reflected patterns of urban development. Private firms operate most of the new activities at both of the sites. Governmental institutions at various jurisdictions were instrumental in the redevelopment process. City development official designated which brownfield sites were eligible for federal redevelopment funds. State environmental officials monitored each step of the environmental remediation process and maintained records documenting the process.

The environmental records provide evidence of how governmental authority can promote a specific concept of risk. Environmental regulators and environmental service firms use the quantitative concept of vulnerability to define remediation standards. This quantitative concept defines vulnerability as an estimate of quantitative measures of risk, and this concept influences the biophysical outcomes of environmental assessments and remediation.

This does not mean, however, that the quantitative risk assessments are inadequate to assess the broader hazard. One of the dangers of quantitative assessments, in general, is that relevant (but not necessarily available) information will be excluded by the limits of the scope of the study. The environmental assessments reviewed for the

study sites indicate that the project scope does attempt to include some non-quantitative information. Evidence of this includes standards for defining the physical boundaries of the site, standards requiring offsite investigations, historical research, interviews with knowledgeable individuals, and cultural assessments. Although these practices are specified within the ESA procedure, they demonstrate how a quantitative study attempts to identify aspects of the social and geographic context that may influence the quantitative study.

The redeveloped uses of the brownfields resemble patterns of changing economic and cultural geographies in urban development. New activities at both sites support dominant activities in the surrounding area. Several hospitals and other facilities that support the health care industry are located near the medical facility. Downtown brownfield development is linked to other efforts of downtown development, including casinos, hotels, entertainment, and administrative centers, that are intended to revitalize downtown and symbolize its cultural importance.

This thesis employed two methods of analysis to interpret the relationship of brownfield development to surrounding urban development. The two methods were graphical and statistical analysis and cartographic analysis supported by fieldwork. They resulted in different degrees of success.

The statistical analysis did not yield any meaningful results. This analysis was based on comparing buffers located at two distances from both brownfield sites, but none of the buffers proved to be of much use at either distance from either site. The conclusion of the statistical analysis, therefore, is that buffers are not an appropriate tool

for comparing property values at the property subdivision level. An analysis that cannot distinguish between its enumeration units is not very useful.

The irregular size of some subdivisions and the exclusion of outliers are two possible reasons why the statistical analysis did not yield any useful results. In the medical brownfield area, several of the subdivisions have large areas with irregular shapes, which is likely to have distorted the results. The exclusion of outliers is a major shortcoming of the statistical method. Although it is necessary to meet requirements of the tests, exclude outliers, in the case of this study, excluded much of the useful information.

The cartographic analysis, which included the outliers, was more informative. By identifying outliers with a combination of mapping and field verification, this step in the analysis identified a pattern in redevelopment and investment. Some of the outliers were the results of measurement error, and field verification was needed to determine which outliers were artificial.

The legitimate outliers, however, indicate a pattern of development that links brownfield redevelopment to investment in a major economic activities of the surrounding area. For the medical brownfield site, the major activities health care services, while for the downtown site, the major activity is entertainment services.

Redevelopment of brownfields represents an attempt to both mitigate the hazards of brownfields and cope with the changing geographies that contributed to their creation. Complications facing redevelopment of brownfields result not only from the uncertain nature of their contamination but also from the changing geographies of population, transportation, and investment that caused initial site abandonment. A robust

redevelopment strategy would both address the issue of environmental liability and identify the types of activities that the new geography will support.

The patterns of redevelopment and investment in Shreveport may provide an illustration of this inclusive solution. By cooperating with local official and state environmental regulators, developers have been able to return several of the brownfield sites to active use. The new uses at these sites complement other new activities in the area. These remediated brownfields may be successfully mitigated if they can be integrated into the geography that supports these new developments.

It is important to note that this pattern of brownfield redevelopment does not support the basis for the research questions. This is the hypothesis that brownfield redevelopment will spill over and increase investment and value at surrounding sites, with the brownfield serving as an “island” of investment. This process was not apparent in Shreveport. Rather, brownfield redevelopment was a component of existing development programs, based on industry-specific expansion. While brownfield redevelopment in Shreveport might be a part of sustaining development, it does not appear to serve the purpose of initiating development in otherwise derelict areas.

Fieldwork proved to be the critical step in identifying these patterns. It would not have been possible to distinguish the patterns of health care expansion and downtown revitalization solely on the basis of statistical and cartographic analysis. These two analyses were useful in suggesting sites for more detailed investigation. The most significant contribution of this thesis, however, is the identification of patterns of brownfield redevelopment and the linking of that redevelopment to broader processes of changing economic and cultural geographies enabled by fieldwork.

Fieldwork further increased understanding of brownfield geography to allow for refinement of research design for future studies. The use of buffers defined by the ASTM assessment procedure (and designed to measure environmental toxicology) are not appropriate for analyzing the economic aspects of brownfield mitigation. Based on the centrality of industry-specific development of brownfields, analyzing the redeveloped uses in terms of the geography that supports new industries in the surrounding area would be an improved research design.

Another improvement to the research design would be to bracket the study period based on Master Plans implemented by development authorities. Development is a process that occurs over time, and city planners and officials in the health care industry often publish and implement comprehensive strategies known as Master Plans. Because of the importance of these industries to brownfield redevelopment, defining the study period in terms of these Master Plans would better account for decisions made by drivers of development. This would be an improvement on the technique of defining the study period based on the availability of property value data.

Several general concepts elucidated by fieldwork are the basis for these improvements to research design. Brownfield redevelopment is a process that occurs over time, and it is linked to other urban development processes that also occur over time. Accounting for time and the development of other industries enhances understanding of brownfield geography. Brownfield studies could also incorporate industry-based comparisons of cities with and without extensive brownfield initiatives, or they could consider the importance of perception in the decisions of development drivers. Fieldwork was a significant step in identifying these further directions for research.

The purpose of this thesis was to analyze brownfields as hazards in terms of the hazards-of-place model. Industrial decisions and environmental regulations represent the social fabric that contributes to the creation of brownfields, as spatial shifts and suburbanization represent the geographic context. The quantitative environmental assessments represent the influence that concepts of vulnerability, as social fabric, have on the definition of risk. The patterns of brownfield redevelopment and complementary investment identified by cartographic analysis suggest the importance of geographic context to mitigation. A brownfield development strategy that considers these elements of hazards-of-place will not merely redevelop the property but will also mitigate the hazard.

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Appendix 1: Boxplots for Outlier Identification

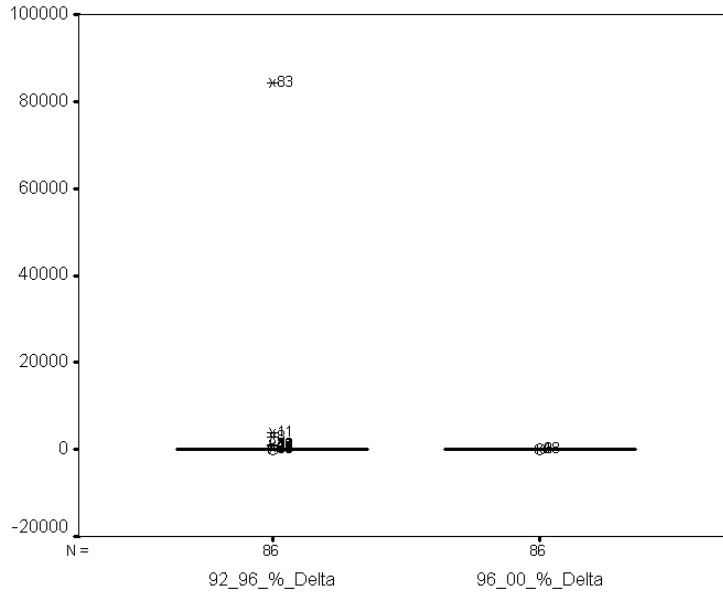


Figure 23. Downtown 0.5-Mile Buffer Boxplots
Initial Data

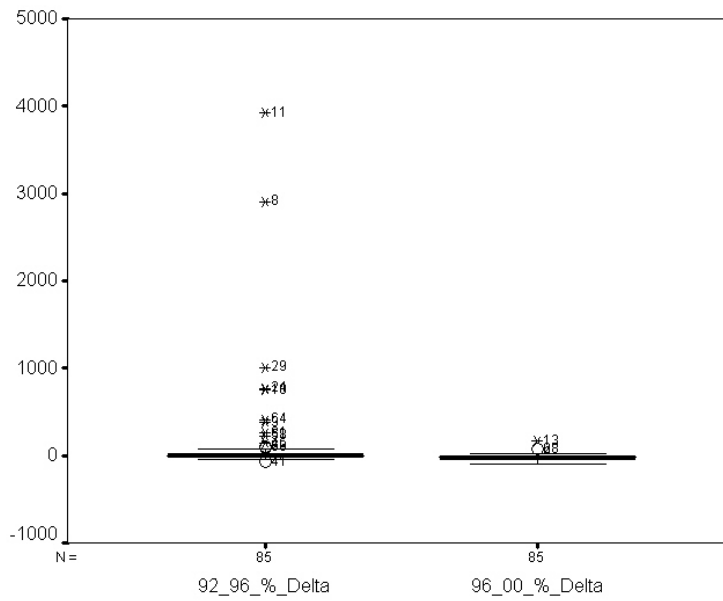


Figure 24. Downtown 0.5-Mile Buffer Boxplots
First Reduction

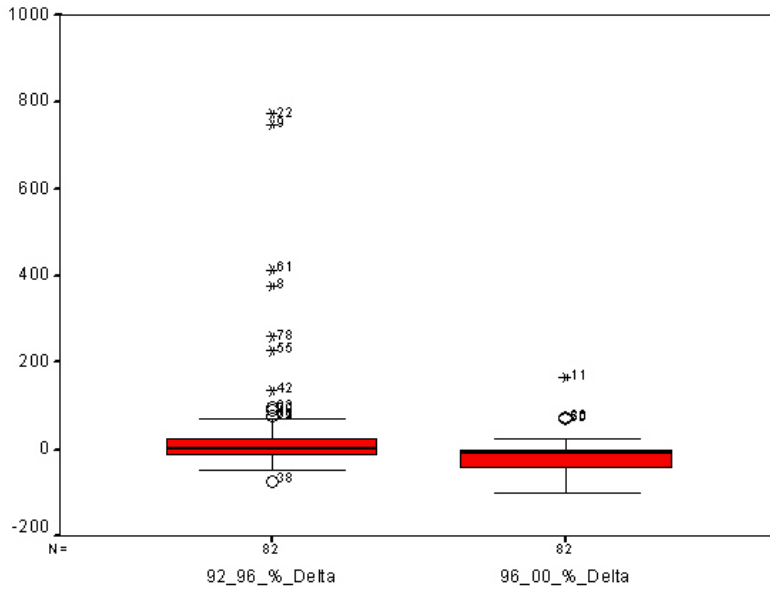


Figure 25. Downtown 0.5-Mile Buffer Boxplots
Final Reduction

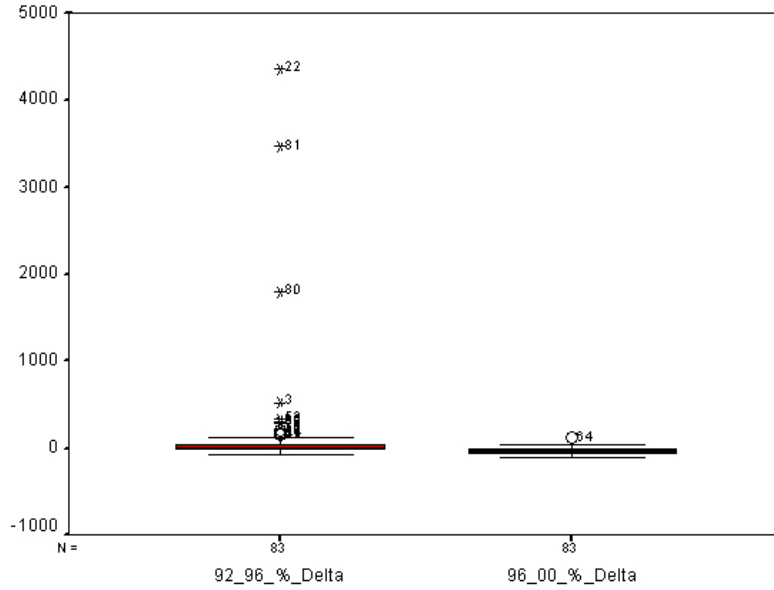


Figure 26. Downtown 1.0-Mile Buffer Boxplots
Initial Data

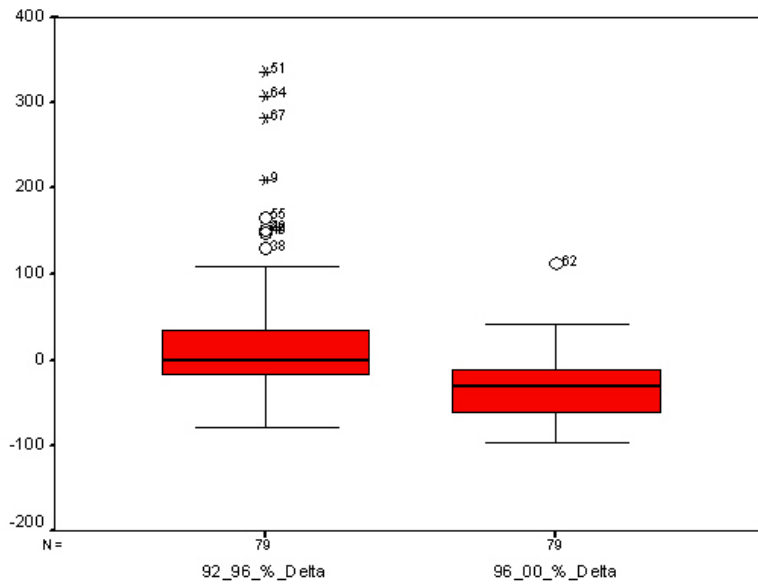


Figure 27. Downtown 1.0-Mile Buffer Boxplots
Final Reduction

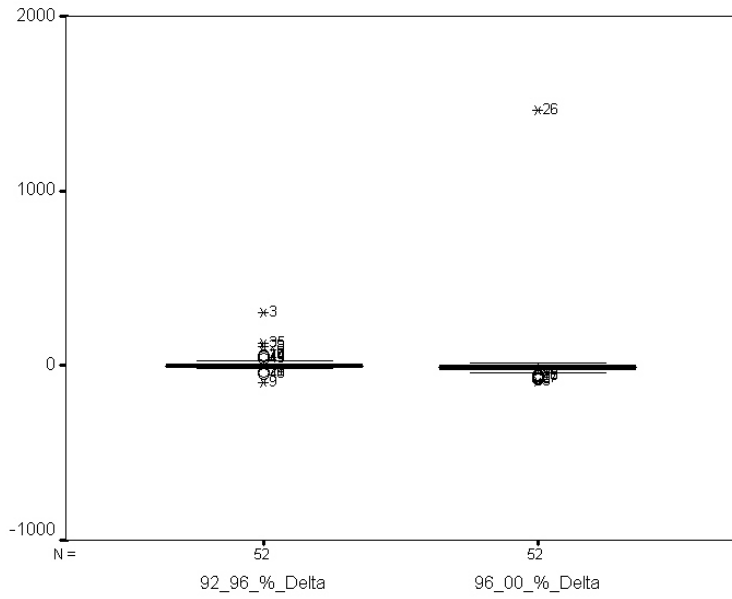


Figure 28. Medical 0.5-Mile Buffer Boxplots
Initial Data

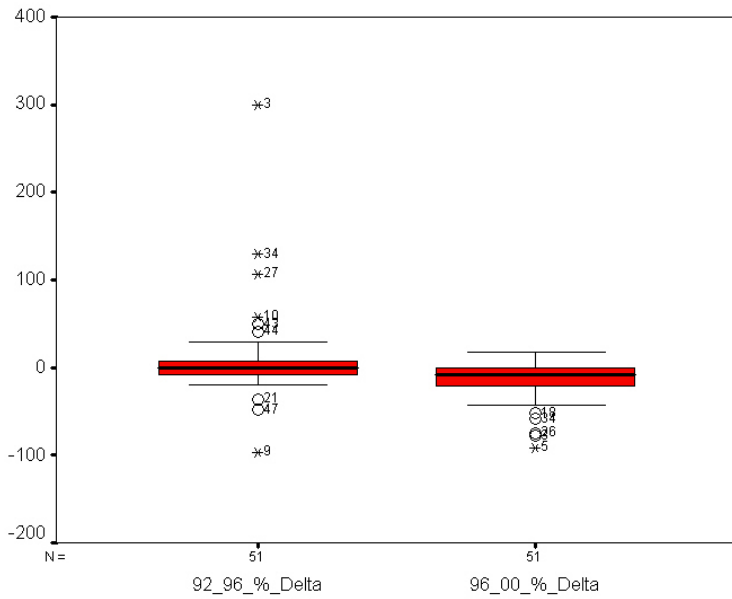


Figure 29. Medical 0.5-Mile Buffer Boxplots
Final Reduction

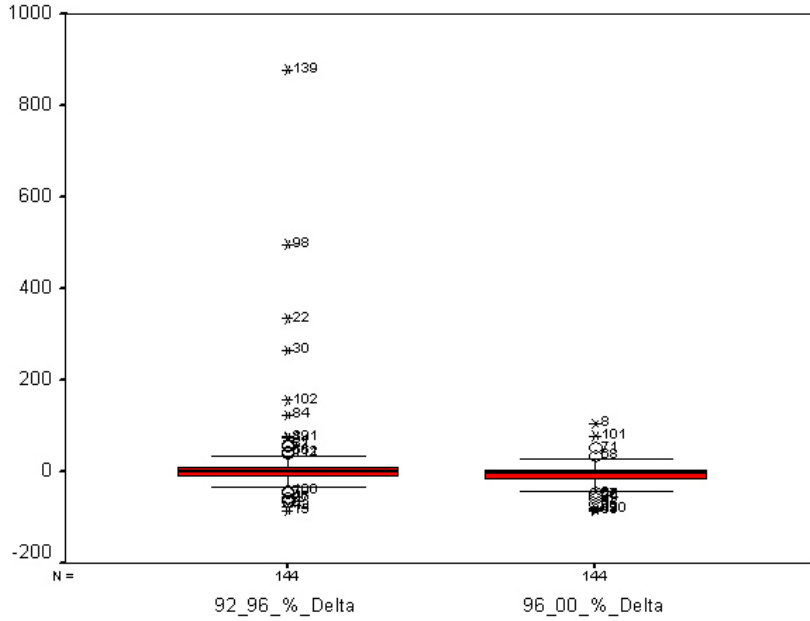


Figure 30. Medical 1.0-Mile Buffer Boxplots
Initial Data

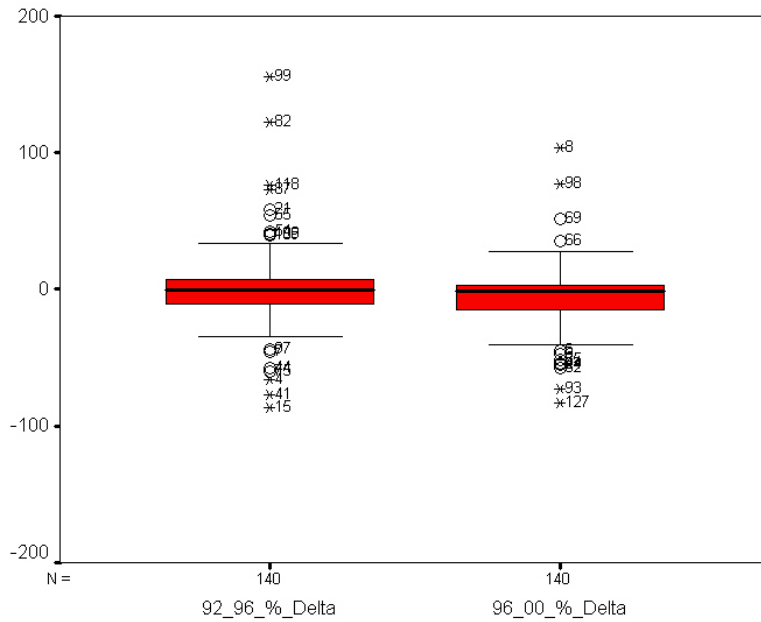


Figure 31. Medical 1.0-Mile Buffer Boxplots
Final Reduction

Appendix 2: Statistical Output

Table 1: Descriptive Statistics for Buffer-Level Percentage Property Value Change

Site	Period	Buffer	Index	N	Mean	Std. Deviation	95% Confidence Interval for mean		Min	Max
							Lower Bound	Upper Bound		
Downtown	1992-1996	0.5-mile	1	75	2.753	31.1598	-4.4162	9.9222	-72.08	96.28
	1996-2000	0.5-mile	2	85	-24.2789	37.4931	-32.366	-16.1918	-99.55	74.52
	1992-1996	1.0-mile	3	71	4.2187	39.0041	-5.0134	13.4508	-79.63	129.44
	1996-2000	1.0-mile	4	83	-36.1282	34.0907	-43.5721	-28.6843	-98.02	111.84
Medical Facility	1992-1996	0.5-mile	5	48	-0.6774	18.935	-6.1755	4.8208	-48.56	57.98
	1996-2000	0.5-mile	6	50	-13.6462	20.1115	-19.3618	-7.9306	-77.86	17.39
	1992-1996	1.0-mile	7	134	-2.1037	19.4459	-5.4265	1.219	-65.7	58.44
	1996-2000	1.0-mile	8	139	-7.3415	18.4416	-10.4344	-4.2487	-72.67	51.55
		Total		685						

Source: SPSS analysis of calculated dataset

Table 2: ANOVA Statistics for Buffer-Level Percentage Property Value Change

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	114607.392	7	16372.485	21.088	.000
Within Groups	525617.484	677	776.392		
Total	640224.877	684			

Source: SPSS analysis of calculated dataset

Table 3: Post-Hoc Test Results using Scheffe Test

(I) INDEX	(J) INDEX	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1	2	27.0319(*)	4.41429	0	10.4201	43.6437
	3	-1.4657	4.61378	1	-18.8282	15.8969
	4	38.8812(*)	4.43915	0	22.1758	55.5866
	5	3.4304	5.15041	1	-15.9516	22.8124
	6	16.3992	5.08721	0.17	-2.7449	35.5434
	7	4.8568	4.01819	0.984	-10.2645	19.978
	8	10.0946	3.99217	0.495	-4.9288	25.1179
	2	1	-27.0319(*)	4.41429	0	-43.6437
3		-28.4976(*)	4.47986	0	-45.3562	-11.639
4		11.8493	4.29978	0.371	-4.3316	28.0302
5		-23.6015(*)	5.03079	0.003	-42.5334	-4.6697
6		-10.6327	4.96607	0.71	-29.321	8.0556
7		-22.1751(*)	3.86368	0	-36.7149	-7.6354
8		-16.9373(*)	3.83661	0.007	-31.3752	-2.4994
3		1	1.4657	4.61378	1	-15.8969
	2	28.4976(*)	4.47986	0	11.639	45.3562
	4	40.3469(*)	4.50436	0	23.3961	57.2976
	5	4.8961	5.20672	0.996	-14.6978	24.4899
	6	17.8649	5.14421	0.101	-1.4938	37.2236
	7	6.3224	4.09012	0.935	-9.0695	21.7144
	8	11.5602	4.06456	0.326	-3.7355	26.856
	4	1	-38.8812(*)	4.43915	0	-55.5866
2		-11.8493	4.29978	0.371	-28.0302	4.3316
3		-40.3469(*)	4.50436	0	-57.2976	-23.3961
5		-35.4508(*)	5.05262	0	-54.4648	-16.4368
6		-22.4820(*)	4.98818	0.005	-41.2535	-3.7105
7		-34.0244(*)	3.89206	0	-48.671	-19.3779
8		-28.7866(*)	3.86519	0	-43.3321	-14.2412
5		1	-3.4304	5.15041	1	-22.8124
	2	23.6015(*)	5.03079	0.003	4.6697	42.5334
	3	-4.8961	5.20672	0.996	-24.4899	14.6978
	4	35.4508(*)	5.05262	0	16.4368	54.4648
	6	12.9689	5.63051	0.623	-8.2199	34.1576
	7	1.4264	4.68709	1	-16.212	19.0648
	8	6.6642	4.6648	0.957	-10.8904	24.2187
	6	1	-16.3992	5.08721	0.17	-35.5434
2		10.6327	4.96607	0.71	-8.0556	29.321
3		-17.8649	5.14421	0.101	-37.2236	1.4938
4		22.4820(*)	4.98818	0.005	3.7105	41.2535
5		-12.9689	5.63051	0.623	-34.1576	8.2199
7		-11.5425	4.61756	0.512	-28.9192	5.8343
8		-6.3047	4.59493	0.966	-23.5963	10.9869
7		1	-4.8568	4.01819	0.984	-19.978
	2	22.1751(*)	3.86368	0	7.6354	36.7149
	3	-6.3224	4.09012	0.935	-21.7144	9.0695
	4	34.0244(*)	3.89206	0	19.3779	48.671
	5	-1.4264	4.68709	1	-19.0648	16.212
	6	11.5425	4.61756	0.512	-5.8343	28.9192
	8	5.2378	3.37336	0.933	-7.4568	17.9324
	8	1	-10.0946	3.99217	0.495	-25.1179
2		16.9373(*)	3.83661	0.007	2.4994	31.3752
3		-11.5602	4.06456	0.326	-26.856	3.7355
4		28.7866(*)	3.86519	0	14.2412	43.3321
5		-6.6642	4.6648	0.957	-24.2187	10.8904
6		6.3047	4.59493	0.966	-10.9869	23.5963
7		-5.2378	3.37336	0.933	-17.9324	7.4568

Notes: 1. Index numbers refer to buffers' indices listed in Table 1

2. Asterisk (*) indicates significance at 0.05 level

Source: SPSS analysis of calculated dataset

Vita

David Farritor was born and raised in Baton Rouge, Louisiana. He earned his Bachelor of Science degree in chemical engineering from Louisiana State University in 2000. David worked as an engineer for two years in a chemical manufacturing plant near Baton Rouge. In 2002, he returned to LSU to earn his Master of Arts degree in geography. Although the combination of these two fields was puzzling to many people he encountered during his studies, David believes that engineering and geography complement each other nicely. In June 2005, he was married to Kelly Rhodes, and he received his degree in August 2005. David plans to continue his career combining engineering and geography at the National Geospatial Intelligence Agency in Bethesda, Maryland.