URBANIZATION AND PUBLIC HEALTH:
A STUDY OF THE SPATIAL DISTRIBUTION OF INFANT MORTALITY IN BALTIMORE, MARYLAND, 1880

A thesis presented to
the faculty of
the College of Arts and Sciences of Ohio University

In partial fulfillment
of the requirements for the degree
Master of Arts

Sarah E. Hinman
June 2002
This thesis entitled

URBANIZATION AND PUBLIC HEALTH: A STUDY OF THE SPATIAL DISTRIBUTION OF INFANT MORTALITY IN BALTIMORE, MARYLAND, 1880

BY

SARAH E. HINMAN

has been approved for the Department of Geography

and the College of Arts and Science by

Christopher G. Boone
Assistant Professor of Geography

Leslie A. Flemming
Dean, College of Arts and Science
This thesis asks if land use is a factor affecting infant mortality patterns in the late nineteenth century using 1880 Baltimore, MD as a case study. Infant mortality rates remain high in late nineteenth century cities. Land uses in these cities tend to be mixed with industries locating near residences. Using 1880 Vital Statistics Death Records, the 1876 Hopkins Atlas, and the 1890 Sanborn Fire Insurance Atlas, a geographic information system is constructed to display the spatial distribution of infant deaths. The resulting infant death and land use data are analyzed using spatial statistics, grid, and visual analysis. Industrial land use in 1880 Baltimore appears to have had little affect on infant mortality patterns. The patterns are uneven and tend to cluster in low-lying areas. This study of infant mortality provides a glimpse into the state of public health and the urbanization process of late nineteenth century American cities.

Approved: Christopher G. Boone
Assistant Professor of Geography
Acknowledgments

As with all major pieces of work this thesis could not have been completed without the help of a number of people. First, this research was funded through cooperative agreements (Award Numbers 01-CA-11242343-042 and 01-CA-11242343-085) with the United States Forest Service, Northeastern Research Station. Thank also to Morgan Grove from the United States Forest Service for his suggestions and enthusiasm in regards to Baltimore Ecosystem Study research.

I would like to thank my thesis committee members, Geoff Buckley and Nancy Bain, for reading my thesis and offering feedback at my defense. My thanks also go to Shannon Cummins, April Luginbuhl, and Abby Porter for reading parts of this thesis, offering feedback when I encountered problems, and generally providing support. I am grateful for their generosity and friendship throughout this entire process.

There are two people without whom this thesis would never have gone beyond the initial data entry. Keith Jackson, an undergraduate research assistant, who stared at microfilm and placed dots on a map week after week without complaint, without his efforts I would still be entering data. My thesis advisor, Chris Boone, I cannot thank him enough for his enthusiasm for this research, editing suggestions, and constant encouragement during the past two years.

Finally, thanks to Mike Zarnetske and my family for their unwavering support and encouragement.
# Table of Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>3</td>
</tr>
<tr>
<td>Acknowledgments</td>
<td>4</td>
</tr>
<tr>
<td>List of Figures</td>
<td>6</td>
</tr>
<tr>
<td>Chapter 1: Introduction</td>
<td>7</td>
</tr>
<tr>
<td>Chapter 2: Background</td>
<td>27</td>
</tr>
<tr>
<td>Chapter 3: Methods of Data Collection</td>
<td>44</td>
</tr>
<tr>
<td>Chapter 4: Analysis and Discussion of Results</td>
<td>56</td>
</tr>
<tr>
<td>Chapter 5: Conclusion</td>
<td>78</td>
</tr>
<tr>
<td>References</td>
<td>84</td>
</tr>
<tr>
<td>Figure</td>
<td>Description</td>
</tr>
<tr>
<td>--------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>2.1</td>
<td>Table of Baltimore’s Population, Area, and Wards Between 1730 and 1888</td>
</tr>
<tr>
<td>2.2</td>
<td>Baltimore’s Industrial Districts in 1860</td>
</tr>
<tr>
<td>2.3</td>
<td>Population Distribution by Ward in Baltimore, 1880</td>
</tr>
<tr>
<td>3.1</td>
<td>Image of an 1880 Infant Death Certificate</td>
</tr>
<tr>
<td>3.2</td>
<td>Section of an 1876 Hopkins Atlas Sheet</td>
</tr>
<tr>
<td>3.3</td>
<td>Section of 1890 Sanborn Fire Insurance Map, Sheet 8</td>
</tr>
<tr>
<td>4.1</td>
<td>Map of Infant Deaths and Ward Boundaries in 1880</td>
</tr>
<tr>
<td>4.2</td>
<td>Results of the Chi-squared Test</td>
</tr>
<tr>
<td>4.3</td>
<td>Residual Map of the Chi-squared Test</td>
</tr>
<tr>
<td>4.4</td>
<td>Map of Infant Deaths and Elevation</td>
</tr>
<tr>
<td>4.5</td>
<td>Graphical Depiction of the Map Calculator Process Used in the Analysis</td>
</tr>
<tr>
<td>4.6</td>
<td>Zoomed in Image of the 16th Ward</td>
</tr>
<tr>
<td>4.7</td>
<td>Zoomed in Image of the 15th Ward</td>
</tr>
<tr>
<td>4.8</td>
<td>Zoomed in Image of the 9th Ward</td>
</tr>
<tr>
<td>4.9</td>
<td>Zoomed in Image of the 2nd Ward</td>
</tr>
<tr>
<td>4.10</td>
<td>Zoomed in Image of the 3rd Ward</td>
</tr>
</tbody>
</table>
CHAPTER 1: Introduction

The following call for a comprehensive sewer system by the Board of Health for Baltimore City, MD clearly describes the condition of Baltimore’s streets in 1881.

A great defect is observable in the streets of our city, namely: the surface drainage. House sweepings, kitchen slops, etc., find their way into the open gutters; pools of water collect at various depressed points, giving rise to miasms [sic] and odors that are anything but conducive to health during the hot weather, and in winter time invade the adjoining pavements by extension of layers, forming broad sheets of ice, dangerous to life and limb. All of this nuisance can be obviated, and the streets kept dry and free from offensive and pestilential odors, and sidewalks free from ice, by a proper system of sewerage (Board of Health 1881).

This description could be applied to most nineteenth century cities prior to the building of comprehensive sewer and piped water systems. Few people recognize how much cleaner and healthier cities are now than they were just over a century ago. Before storm and sanitary sewers and regular garbage removal, industrial and household wastes were dumped into open street gutters to be washed away by rain (Galishoff 1988). As the Baltimore City Board of Health report describes, this waste removal system created an unhealthy environment for urban residents.

One key indicator of a community’s health is its infant mortality rate (IMR).¹ Infants are more sensitive to contaminants in food and their local environment than children or adults since infants’ immune systems are not fully developed at birth. Weaned infants, in particular, are more likely than nursing infants to come in contact with contaminated foods and water that their immune systems cannot combat. Contamination

---

¹ The IMR is calculated as the number of deaths of those under the age of one year per 1000 live births.
of food and water is more likely to occur in places with poor environmental conditions often stemming from a poor water supply or a lack of modern sanitary sewers (VanDerslice et al. 1994). Baltimore’s IMR in 1880 was 246.14 (Howard 1924). In that year almost 1 in 4 infants would die before their first birthday.

Until the mid-1880s, the urban IMR was much higher than the rural IMR, but the two rates began to converge in the 1880s and by the mid-1890s the urban IMR in the largest cities dropped below the rural IMR (Preston and Haines 1991). At the same time the urban and rural IMRs converged and American cities entered into a period of rapid population and industrial growth that altered the urban landscape. In the early part of the nineteenth century, cities were small with manufacturing, commerce, and residences mixed together throughout the city. During the middle part of the century land uses began to separate into areas of industries, commerce, and residences, but limited means of transportation kept different land uses close to one another. It was not until the 1890s and early twentieth century that a distinct and dramatic separation of land uses occurred, after the development of electric streetcar systems that allowed even working class residents to travel throughout the city for an affordable fee (Knox 1994).

In the mid-nineteenth century, a movement began to improve public health conditions in order to combat the unhealthy conditions in American cities. This movement focused on cleaning streets and the water supply, but did not address the lack of regulation controlling urban land use. At this time, no comprehensive regulations limited where industries could locate, so industries could locate in close proximity to residences or vice versa. Businesses that produced chemicals or processed animals could do so with little regulation of location or waste disposal, allowing the dumping of wastes
into the streets along with the neighborhood’s residential wastes (Rosen 1997). Nuisance laws did keep most noxious industries away from residences. The public health movement in Baltimore eventually achieved the goal of comprehensive sewers in 1905 (Euchner 1991). Around the same time some industries underwent locational changes that shifted them from the central city to more peripheral locations (Lewis 2000). Effective land use regulation in American cities did not occur until the first zoning ordinances were passed in 1916 in New York City, and Baltimore followed with its own zoning ordinance in 1923. Just prior to these changes in the urban landscape and the decrease in the IMR cities had extremely high IMRs and mingling of multiple land uses. Given the combination of the high IMR, mixture of urban land uses, and the apparent unhealthy state of cities, is land use a factor in explaining infant mortality patterns in 1880 Baltimore?

**Hypotheses**

The research question springs from a number of hypotheses: first, the geographical distribution of infant deaths will be uneven with infant deaths appearing to cluster. Second, clusters of infant deaths will be near industrial districts and low-lying areas. Third, documentary evidence will show that the Baltimore City Board of Health worked to improve public health in response to infant mortality patterns, especially in certain neighborhoods where they identified key problems. The original proposal of this thesis intended to consider the improvements to public health implemented by the city government and Board of Health in response to infant mortality patterns and to identify the locations of piped water and sewer service. These parts of the study were not
conducted due to the limits of time and available resources. A cursory incorporation of the Board of Health annual reports was included in the analysis of the results, but not to the extent proposed.

**Baltimore Ecosystem Study**

This thesis is part of a larger research endeavor called the Baltimore Ecosystem Study (BES). The BES is one of two long-term ecological research (LTER) studies in the United States (the other is Central Arizona – Phoenix). The purpose of the BES is to assess and monitor ecological change in Baltimore since the first settlement to the present and 100 years into the future. In order to achieve an understanding of ecological change over time researchers recognize that humans play a role in creating the ecosystems in which they live. Therefore, studies of both the natural ecosystem and the social and political organizations whose decisions developed the urban ecosystem are necessary. Additionally, since the past environment and past decisions are the ones on which the current environment developed there is a need to investigate what the past environment was like and how it affected the quality of life for Baltimore’s residents (Boone 2001). One of the larger goals of this thesis is to understand the late nineteenth century urban environment and try to uncover how that environment affected the health of Baltimore’s infants.

**Literature Review**

Nineteenth century cities were hazardous places for all urban residents, but cities were especially hazardous for infants. In the 1880s, 1 in 4 infants living in Baltimore died
before reaching their first birthday. Infants in rural areas were more likely to survive their first year, though urban and rural IMRs began to converge during the last two decades of the nineteenth century. Something about the urban environment in the nineteenth century made life more dangerous for infants. Preston and Haines (1991), two leading researchers on infant and child mortality in the nineteenth century city, call this the “urban effect.” Although they recognize the difference in infant mortality figures between urban and rural areas, they are unable to account for specific environmental conditions in the city that made it less healthy than the countryside.

In general, infant mortality research fails to adequately correlate the urban effect with patterns of infant mortality. Instead, most researchers concerned with nineteenth century infant mortality succeed in correlating household characteristics with patterns of infant mortality. Unlike the urban effect, household characteristics can be defined as income, class, and cultural practices, among other factors. A number of researchers have worked to determine which household characteristic was the most important, but they do not lose sight of the fact that the city was also a key variable determining infant mortality patterns (Haines 1995; Lee 1991; Vögele 2000; Thornton and Olson 1991, 1997, 2001; Watterson 1986, 1988; Williams 1992). Two primary household characteristics appear in the literature, socio-economic status and cultural practices, but the literature tends to return, regardless of household characteristic findings, to the importance of the urban effect.
Socio-economic

Both Lee (1991) and Vögele (2000) identify an urban-rural difference in infant mortality and as a result focus their studies on the impact of changes within cities that could have lowered the IMR. Lee uses infant mortality data to assess regional patterns of health improvement as indicators of “economic and social well-being” (Lee 1991, 56). Instead of considering potential health inequalities from the more typical social class perspective Lee chose to consider the issue geographically. When testing the social and economic factors that could account for regional differences Lee found industrialization, which can be considered a measure of urbanization, and employment structure to be the most significant explanatory factors in the regional differences. While concluding that more testing is needed concerning the convergence of health as a function of improving prosperity, the results of this study indicate that increased wealth in the twentieth century improved health conditions (Lee 1991).

Like Lee (1991), Vögele (2000) identified the differences between urban and rural infant mortality, and then within the urban system identified socio-economic forces that made the city more hazardous for infants. Investigating the impact of an improved urban milk supply and the creation of infant welfare centers, Vögele hypothesizes that certain social changes may have helped to lower the urban IMR in late nineteenth century Germany. He showed that a large proportion of infant deaths were from gastro-intestinal diseases that could have been reduced by a cleaner milk supply and infant welfare. Since gastro-intestinal diseases caused so many infant deaths, a reduction in gastro-intestinal deaths could have decreased the overall urban IMR. Yet, Vögele found the improved milk supply and infant welfare were not significant factors in the decline of infant
mortality. The implementation of these health measures did not help the target population because they tended to be cost prohibitive or inconvenient. Instead, he suggests socio-economic and demographic changes to explain infant mortality decline (Vögele 2000).

Haines (1995) not only identifies the socio-economic factor of income as the primary variable determining late nineteenth century infant and child mortality decline, but also speculates on urban sanitary improvements as a factor decreasing the urban IMR more rapidly than the rural rate. Using data from the 1911 census for England and Wales, Haines found that infant and child mortality levels declined more rapidly for the more privileged social classes. He also found that families living in larger dwellings tended to have lower child mortality rates, and various (he did not specify) marriage duration cohorts saw mortality decline as income increased. However, income alone appeared unrelated to the pattern of mortality decline. Greater decline was seen for those with urban occupations, likely reflecting sanitation improvements of the late nineteenth century. Still, infant and child mortality rates were higher in urban areas than in rural areas. His final conclusion is that all social classes experienced some degree of infant and child mortality decline near the end of the nineteenth century, but those of the wealthier classes experienced a more rapid decline (Haines 1995).

Haines (1995), Lee (1991), and Vögele (2000) were not the first to identify income as a key variable to infant mortality. Rochester (1923) singled out income as the key variable to determining infant mortality in 1915 Baltimore. Unable to assess urban environmental variables due to the scale of the study, Rochester nonetheless considered almost every possible household characteristic including income, ethnicity, literacy, race, mother working outside the home, feeding practices, and many other variables. Yet,
Rochester continued to return to socio-economic status as the primary reason why an infant did not survive its first year. By extracting a favored group of infant deaths that was adjusted for differences of race, ethnicity, literacy, and mother’s employment, she still found poorer homes were more likely to have an infant die during its first year. This rate fell as income increased. Rochester explained the emphasis on income over other variables in the following way: a small income can remove access to good food, fresh air, and consistent medical care therefore removing basic amenities that could help an infant to survive. While Rochester suggests socio-economic factors were the most important, she indicates that the scale of analysis limited consideration of the neighborhood environment. Infant mortality data were aggregated to the ward level. Rochester acknowledged that the wards contained a mixture of poor and wealthy neighborhoods, industrial and commercial districts, high infant mortality rates and low infant mortality rates. In the end, Rochester’s study found “the effect of the neighborhood as distinct from economic status [could] not be either proved or disproved [with] the present data…” (Rochester 1923, 109).

Socio-economic status is not the only variable determining a household environment although, as Rochester (1923) argues, income can control access to many important amenities infants need. Child-rearing practices are another aspect of the household environment that affect infants. Prior to widespread childcare education, which began during the nineteenth century public health movement, childcare knowledge was likely shared among female family members and neighbors (Meckel 1990; Thornton and Olson 1991, 2001). This passing down of information especially in a family could then pass along cultural traditions both good and bad.
Identifying and accepting the city as a more hazardous environment for infants, Thornton and Olson (1991, 1997, 2001) attempted to define household and/or urban environmental variables accountable for infant mortality patterns in nineteenth century Montreal. In the 1991 study Thornton and Olson hypothesized that socio-economic variables would determine infant mortality patterns in 1859 Montreal. Yet, they found ethnicity was the most significant variable. Controlling for socio-economic variables, French-Canadian households were more likely to have an infant death than Irish-Catholic or Protestant households. Location of the home was not a significant variable. Instead of location or socio-economic factors, they suggest that primarily cultural characteristics, such as breast-feeding practices, birth spacing patterns, and rapid replacement of infants or children who died, may account for the high IMR among French-Canadians (Thornton and Olson 1991). The 1997 study of 1879 infant deaths found the same cultural pattern of infant mortality in Montreal as in 1859, but in 1879 within each cultural group, both income and habitat played a secondary role in infants’ survival. The difference between income groups in 1879 varied by cultural group. This secondary income and habitat pattern was not apparent in the 1859 data (Thornton and Olson 1997).

A recent study by Thornton and Olson (2001) investigated infant mortality patterns in Montreal from 1860 to 1900, expanding the study period to a forty-year range. They again found cultural factors to be the most important explanatory variables for infant survival. In this third study, Thornton and Olson also found that in addition to a cultural effect a “neighborhood effect” influenced infant mortality patterns. While in the
city as a whole French-Canadian infants were more likely to die in their first year, if that infant’s family lived in a culturally mixed neighborhood that was dominantly English-speaking the infant’s chances of survival rose. The reverse was also true. An infant from an English-speaking family living in a primarily French-Canadian neighborhood had a decreased chance of survival. The implication here is that the influences of neighborhood dynamics between families, such as cultural practices, property interests, ethnic politics, and spatial segregation, may affect an infant’s chances for survival. Since income does not explain infant mortality patterns in late nineteenth century Montreal and a comparison of rent districts could not help to explain this neighborhood effect, instead the authors turned to geopolitical explanations. Geopolitics could impact the distribution of environmental health resources and therefore paint a neighborhood-cultural picture. They argue that political discrimination stemming from residential segregation affected sanitary conditions and allocation of resources thus affecting public health and infant survival (Thornton and Olson 2001).

Thornton and Olson are not alone in their singling out of cultural practices. Wolleswinkel-van den Bosch et al. (2000) found cultural practices and urbanization to be the key variables in infant and child mortality in The Netherlands during the late nineteenth century. Cultural group was the key variable explaining infant mortality while urbanization was the key variable explaining child mortality in this study. In the case of The Netherlands, Roman-Catholics were more likely than Protestants to have an infant die in the first year. Again, the cultural practice of weaning infants early is suggested as a reason for this cultural effect. Wolleswinkel-van den Bosch et al. (2000) note that their
findings contrast with the findings from England and Wales where urbanization plays a significant role in infant mortality levels and decline.

What seems clear is that household characteristics do not operate separately from the surrounding urban environment. Regardless of the focus of these studies of the household effect on infant mortality, each author acknowledged that urban areas play a role in infant and child mortality rates and decline near the end of the nineteenth century. Still, defining and quantifying household characteristics is simpler than defining and quantifying the urban effect. Additionally, determining that there is a difference in mortality between urban and rural areas is easier than defining the urban effect. Nonetheless, some researchers have attempted to test environmental factors associated with urban infant mortality but have met with mixed results.

Environmental Factors

Measuring the impact of urban environmental improvements on residents’ health is not an easy task. Logically there should be a connection between clean piped water and the building of sanitary sewers and a lower mortality rates in cities, especially infant mortality rates. Proving this, especially with the available data, is difficult.

One of first studies to make a connection between health and the environment was conducted by Dr. John Snow when he suggested there was a link between infected water and cholera in 1849. Snow mapped fatal cases of cholera in South London between 19 August and 30 September, 1849. The map showed that the cholera cases clustered in one particular water district of the city, and in this area most people got their water from one particular well on Broad Street. Believing there was a connection between the water from
the well at the Broad Street pump and cholera Snow published a pamphlet, *On the Mode of Transmission of Cholera*. While ignored in 1849, when cholera struck London again in 1854 Snow again mapped the locations of fatal cholera cases and again found them clustered near the Broad Street pump. This time the expanded publication *On the Mode of Transmission of Cholera* still received little interest from the medical community, but given the body of evidence Snow presented he was able to convince enough people that the Broad Street pump should be closed. The closure of the pump, while not permanent, did stop the further spread of cholera in 1854. Snow’s work did not gain much acceptance at the time, but his theories stirred up curiosity in some, and later when germ theory took hold, Snow’s study of cholera was recognized as one of the first effective, however temporary, epidemiology and medical geography studies. The relevance of Snow’s work to infant mortality is that he managed to effectively connect an environmental condition to the health of residents (Snow 1936).

In more recent studies researchers continue to search for a link between the environment and infant mortality, but tend to meet with mixed findings. Meeker (1972) attempted to draw a connection between public health improvements and the improvement of urban health between 1850 and 1915. He developed a regression equation to assess the statistical significance of improved public health measures and other variables such as literacy, level of living, and proportion of the population living in urban areas. The problem Meeker faced, though, was finding a quantitative measure of public health improvement. Identifying cities’ expenditures on sewer and piped water as a possible measure of public health improvement, Meeker discounted this measure since each city had unique expenditures depending on drainage conditions, crowding,
proximity to a fresh drinking water supply, and the extent to which the drinking water needed treatment regardless of the city’s health. While unable to measure the extent of public health improvements on urban health, Meeker still concluded that there was most likely a connection between mortality and public health improvements.

While using piped water and sewer expenditure as a measure of public health improvement is a weak measurement, Condran and Crimmins-Gardner (1978) chose this variable for their study of late nineteenth century urban mortality to assess the extent of sanitary reforms in a number of American cities. Condran and Crimmins-Gardner consider only the impact of water and sewer pipes on mortality while Watterson (1986) groups water and sewer improvements with other environmental improvements, like housing improvements. Comparing the effect of expenditure on disease-specific mortality rates of known water borne diseases, such as typhoid and cholera infantum, Condran and Crimmins-Gardner concluded that water and sewer reforms were not primary factors in urban mortality decline. Instead, they suggest that income might be a primary explanatory factor in the patterns of urban mortality (Condran and Crimmins-Gardner 1978).

Income is likely related to the effectiveness of environmental improvements as Watterson (1986, 1988) suggests. In a study of early twentieth century England and Wales, Watterson (1986) investigated whether or not environmental improvements had more of an effect on infant mortality decline than freedom from poverty. She also considered whether freedom from poverty strengthened the effect of environmental improvements on infant mortality decline. She concluded that increasing income alone without environmental improvements would not create a decline in infant mortality. On the other hand, environmental improvements without an increase in income would create
a decline in infant mortality, but rates would decline faster as income increased. These findings appear to be in loose agreement with Haines (1995). While testing different questions, Watterson and Haines both found the most rapid infant mortality decline among wealthier groups in urban areas with improved sanitary conditions (Watterson 1986, Haines 1995).

In a second study, Watterson (1988) again found residential environment to be the most significant variable concerning infant mortality. In this study she used the weak proxy of the father’s occupation as an indicator of the residential environment to consider infant mortality decline in the late nineteenth century. By using father’s occupation a number of other variables enter into the equation since father’s occupation often determines income, housing quality, and housing location. In the regression model constructed, Watterson considered the following additional variables from the 1911 Census for England and Wales, fertility decline, social class (based on skill of labor), and urban versus rural for environmental effects. She concluded that fertility decline did not change by occupation. The residential environment regardless of income positively affected infant mortality, but the higher or more steady the income the better the infant’s chance of survival. Again, there appears to be a connection between environmental conditions and income (Watterson 1988).

Taking this connection between the environment and socio-economic conditions one step further is Williams (1992) who attempted to separate the two variables in order to assess if the urban population shared poor sanitary conditions equally. Using death registration data for 1870-71 Sheffield, England Williams first mapped the distribution of infant deaths and found them concentrated in low-lying areas along the river. Next,
Williams divided the city into three sanitary areas based on topography, a district following the river, one along the valley where there slopes are steeper, and the third designating areas above 200 feet. From this point she considered seasonal infant mortality levels and found a spike in infant deaths during the summer months. This seasonal effect many researchers agree is related to poor environmental conditions (Vögele 2000, Mooney 1994). Given the distinct seasonality of infant mortality and its environmental relationship Williams then compared each sanitary districts’ IMR by season. As expected the sanitary district along the river showed a significant spike in infant deaths compared to the two better-drained districts. Since it is possible that income was the reason why infant mortality was concentrated along the river as that might be where low rents were concentrated Williams compared social class to seasonal deaths as well. In the comparison of socio-economic groups the infants of unskilled workers fared the worst, again with a pronounced spike in summer infant deaths. While both environmental factors and socio-economic factors appear to have been at work, Williams’ primary question is whether infants in wealthy families faced the same summer threat when living in poor environmental areas. To answer this question Williams further divided the data by considering just the infants of skilled workers to the IMR in the city as a whole, in the river district, and in the rest of the city. She then applied the same geographic categories to the infants of unskilled workers. This comparison showed a significant spike in infant deaths for both the skilled and the unskilled worker groups living near the river district, although infants of unskilled workers in the river had, by far, the highest IMR. During the summer all areas of the city experienced high infant mortality regardless of socio-economic group, but those living near the river were at a
distinct disadvantage. Williams (1992, 89) concluded that the “environmental difference in the seasonality of infant mortality is slightly greater than that by socio-economic status but both components, nevertheless, are important.”

In many ways, Mooney (1994) builds upon Williams (1992) assessment of the importance of environmental conditions especially to seasonal infant mortality rates. Mooney also recognizes urbanization as a key element to many infant mortality arguments, especially in terms of sanitary reform. He therefore questions if the steps towards a more sanitary city actually had the desired effect on seasonal infant mortality in London between 1870 and 1914. Mooney considered the relationship between seasonal infant mortality and sanitary conditions and reforms over this forty-four year period.

Infant mortality in the nineteenth century and earlier tended to experience a seasonality. Since the majority of infants died during the summer months (June, July, and August), a decrease in the summer IMR therefore could be an indication of improved health conditions. In addition to the seasonality of infant mortality a majority of these summer deaths were among urban infants who died from gastro-intestinal diseases. These diseases are usually caused by contact with contaminated water and food, prior to appropriate sanitary measures in the nineteenth century city they could be magnified during the hot and dry summer months. Mooney calls attention to two variables greatly influencing the chances of an infant dying during the summer months, breast-feeding and sanitary management. Breast-feeding helps protect infants from contamination in alternative food sources. Proper sanitary management can reduce the number of flies feeding on refuse. Since many diseases are spread by either direct contact or indirect contact with mediums such as flies a reduction in the number of flies should have a positive impact on infant
mortality. Mooney suggests that while others may debate the importance of over-crowding and poor sanitation on infant mortality, sanitary reforms followed by mother’s care failed to create a safe and healthy environment for infants. This is demonstrated through the advances in sanitation that should have decreased the summer IMR between 1870 and 1914, but instead British cities during the 1890s saw an increase in the summer IMR (Mooney 1994).

It is difficult to draw conclusions about past environmental conditions and their actual effects on urban population since we cannot see them for ourselves. Current studies of developing world countries and their urban IMRs help to support the environmental aspect of the infant mortality debate. Many locations in Africa and Asia are currently undergoing the process of industrialization and are facing many problems similar to those faced by the Western world in the late nineteenth century, such as rapid urbanization and changing demographic patterns. Studies of infant mortality in developing world cities can therefore offer an informed look at possible factors in infant mortality decline. Part of the advantage of considering developing world cities is that current medical understanding can be applied to situations similar to those in the nineteenth century when certain aspects of medicine were still misunderstood. Folasade (2000) and Gupta and Baghel (1999) compared two cities in Nigeria and India respectively to ascertain the primary variables causing high infant mortality rates. Both studies group environmental conditions among the many other variables tested and measured those environmental conditions in terms of access to piped water, types of toilets, housing material, and drainage. These studies found the larger city in both cases to be more hazardous than the smaller city and that environmental conditions played the
most important role in an infant’s chances of survival (Folasade 2000; Gupta and Baghel 1999). Still, Gupta and Baghel explain that all of the variables they tested play some role in infant mortality and that it is not the environment alone that is accountable for high infant mortality (Gupta and Baghel 1999). Returning to the idea of the “urban effect” Folasade (2000), while unable to pinpoint what it was about the larger city that caused a higher infant mortality rate, suggested it might be related to the concentration of industry and population (Folasade 2000).

This body of literature suggests there was something particular to nineteenth century cities that caused infants to die at a more rapid rate than infants in rural areas. While each study concerning urban, child, or infant mortality contributes different ideas to what might explain patterns and/or reasons for the decline in urban death rates, especially for infants and children, few consider how the city itself was constructed and how that might impact young lives. The series of studies considering the impact of different public health and sanitation measures all suggest either in the positive or negative whether or not sanitary reforms impacted mortality rates, but there is still no conclusive evidence one way or the other on this matter. Nonetheless, what this literature does support is the “urban effect” identified, but undefined, by Woods et al. (1988, 1989) and Preston and Haines (1991) played a role in nineteenth century infant mortality patterns and rates. Still, these studies do not address the jumble of land uses in the nineteenth century city and how that might have affected infant survival. Did an infant living next door to a tannery have a reduced chance of survival? If so, did changes in urban form that began in and around 1880 help to decrease infant mortality rates?
Two general fields of study that take a spatial approach to the study of disease are epidemiology and medical geography. The goal of epidemiology is to ask questions to help uncover the patterns of different diseases. This discipline is concerned with understanding what makes some people more susceptible to certain diseases. Since a number of factors likely play a role in disease patterns, epidemiologists observe the characteristics of large populations in search of answers. In order to determine or observe particular patterns, epidemiologists describe the occurrence of the disease within the populations first by being sure the disease is reasonably recognizable and second by collecting basic data about each patient. These data include the time of year the disease was contracted, location, personal attributes such as age, sex, race, and ethnicity, socio-economic data, aspects of the household and neighborhood environment, and diet. From this descriptive data possible causative factors of a disease may be uncovered from similar patterns of occurrence among the population. The causative relationship only forms a hypothesis that needs to be tested based on known facts regarding the disease. A key aspect to the discovery of disease patterns from an epidemiological perspective is the spatial distribution of disease. Recognizing that different places may experience diseases differently, for example because of climatic differences that might not support certain parasites, or because the concentration of population in urban areas allows for the easy passage of communicable disease, the spatial distribution of disease is therefore an important part of epidemiological studies (Fox et al. 1970).

Medical geography primarily analyzes the spatial distribution of disease and mortality. After addressing the patterns of disease and mortality medical geographers analyze the causes of this spatial distribution using cultural, environmental, and
demographic factors (Meade and Earickson 2000). While epidemiology and medical geography are quite similar and often overlap, the two disciplines approach their topics with different emphases. Epidemiology is concerned primarily with the reasons why certain diseases occur in certain populations, while medical geography is concerned primarily with the spatial patterns of diseases and the reasons for those patterns.

The second half of the nineteenth century was a period of significant change in industry, society, and cities in North America. Midway through the nineteenth century urban residents began to recognize infant mortality as a problem and so began to focus public health reforms on improving the local environment (Meckel 1990). The early public health reformers brought the ideas of cleaner streets and cleaner drinking water into urban consciousness. By the end of the nineteenth century, traditional compact cities in the United States were changing -- expanding in size with the help of increasingly sophisticated infrastructure. Fundamental changes in urban form began around 1880 and between 1890 and 1900 urban mortality rates in the United States declined rapidly (Condran and Crimmins 1980, Vance 1991). This thesis seeks to explain part of the “urban effect” as land use and to assess if land use in 1880 Baltimore can be linked to infant mortality patterns.
CHAPTER 2: Background

The city of Baltimore developed on the shores of the Northwest and Middle Branches of the Patapsco River. Jones Falls and Gwynns Falls feed these two branches of the river. The Patapsco River drains into the Chesapeake Bay and ultimately into the Atlantic Ocean. This location gave the city an ideal protected harbor in which to develop its early shipping and shipbuilding based economy.

Baltimore grew dramatically during the nineteenth century. The city’s population in 1800 of 26,514 residents approximately doubled to 53,189 residents by 1818. Quickly increasing in area after 1800 the city expanded its boundaries by annexing land from surrounding Baltimore County in 1818, making the city’s land area 15 square miles (figure 2.1). By 1880, the 15 square mile city contained 338,573 residents (Anderson 1977, Arnold 1978, Howard 1924).

<table>
<thead>
<tr>
<th>Year</th>
<th>Population</th>
<th>Area (square miles)</th>
<th>Wards</th>
</tr>
</thead>
<tbody>
<tr>
<td>1730</td>
<td>43</td>
<td>0.09</td>
<td>0</td>
</tr>
<tr>
<td>1818</td>
<td>53,189</td>
<td>15</td>
<td>12</td>
</tr>
<tr>
<td>1880</td>
<td>332,313</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td>1888</td>
<td>419,572</td>
<td>38</td>
<td>22</td>
</tr>
</tbody>
</table>

Figure 2.1 Table of Baltimore’s Population, Area, and Wards Between 1730 and 1888

The original city developed on a sixty-one acre plot on the western banks of Jones Falls in 1730 and by 1780 annexed the adjacent villages of Jones Town (later the neighborhood called Oldtown) and Fells Point (Arnold 1978). After the 1818 annexation the city was bound by North Avenue in the north, East Avenue in the east, and a diagonal line from the corner of North Avenue and Payson Street to Mill Pond along Gwynns Falls.
in the west. The city was divided into 8 wards in 1797. These wards made up much of the city’s political structure, and were reorganized as needed based on population growth. Reorganization of ward boundaries created 12 wards in 1818, and 20 wards in 1845 with a redistribution of the boundaries in 1860 (Lefurgy 1980). The streets were laid out in a grid pattern in 1822. While this early city plan contained numerous problems including a disregard for topographic features, it also gave the city its basic structure of east-west and north-south running streets. The dividing point for the east-west streets was Jones Falls and for the north-south streets it was Baltimore Street. While this division of the city into quadrants is quite arbitrary, it helps in explaining different features of the city. The central business district (CBD) in Baltimore developed a few blocks north of the wharves, along Baltimore Street west of Jones Falls and just to the east of Charles Street. From the CBD, as will be described later, most urban activities radiated outward (Muller and Groves 1979, Olson 1997).

Between the annexation in 1818 and the next annexation in 1888, many undeveloped areas were filled in both in the city center and on the periphery. The economy grew rapidly, and the population increased to 419,572 (Olson 1997, Howard 1924). Between 1818 and 1880 Baltimore was transformed from a small city with a commercially based economy into a city on the brink of industrial take off. During this period Baltimore’s population increased fifteen times. The population increase primarily came from European immigrants, but also rural to urban migration of both whites and a significant number of blacks. This was a period of filtering – separating land uses from a jumbled mess to more distinct clusters of industries and residences, and within those residential areas segregation of residents by class, race, and ethnicity. An inefficient city
government ruled by a political machine and operated on a ward-based system was responsible for Baltimore’s political decisions, but implemented few citywide improvements (Crooks 1968). Changes in the decades between 1830 and 1880 laid the groundwork by 1880 for the modern industrial city of later decades.

**Industrial Patterns**

In 1830 Baltimore was 15 square miles in area, the built up area was a significantly smaller area, reflecting a pedestrian-centric pattern of growth (Anderson 1997, Muller and Groves 1979). The need to walk and a desire to limit walking time produced mixed areas of residences, industries, and commerce that reduced walking time to both jobs and markets. Cities in what is typically termed a commercial or mercantile phase (1790-1840) of city growth, tended to remain small in size, rarely extending more than two miles from the downtown as the dominate form of transportation for all classes was on foot. The tendency for cities to concentrate in small areas placed a high demand on land, especially land near the commercial center. This in turn kept population densities high, which affected the health conditions of all social classes (Knox 1994). Baltimore’s compact structure and mixture of land uses placed a premium on land, which ultimately led to a filtering of land uses beginning in the 1830s and 1840s (Olson 1997).

Baltimore fit the pattern of a commercial city prior to the 1830s with most of its manufacturing at this time small in scale, serving primarily the local market. In 1833 six types of manufacturing activity could be identified in Baltimore: shipbuilding, repair and related activities; agricultural processing; raw material processing; construction materials, metal processing and products; and artisan dominated activities (Muller and Groves 1976,
The most numerous of these manufacturing establishments were the artisan-dominated activities, which consisted of tailors, cobblers, blacksmiths, tobacconists, and bakers. They were located throughout the city, intermixed with residential land uses, although the highest concentration was in the CBD. Shipbuilding and its related activities, such as sail making, remained important industries in Baltimore until the 1850s. These activities located on the waterfront and neighboring blocks, though these locations tended to be towards the periphery of the waterfront leaving the central locations to those transporting goods and people. The other manufacturing establishments usually occupied more peripheral inland locations, especially noxious establishments and those requiring waterpower along Jones Falls, such as textile mills.

Mercantile phase American cities tended to be commercially oriented and contained a tightly bound pattern of land uses with artisans, homes, small factories, and shops mixed together. In port cities, economic activity focused on the waterfront and so this area contained warehouses, wharves, and workshops central to a commercial economy. Beyond the waterfront churches, shops, public buildings, and the homes of the wealthy were typically found. Using vacant space in this ring of development and still more peripheral locations were the homes of artisans and laborers, and finally on the extreme periphery and along streams were noxious industries and industries needing large amounts of land or water.

The focus and primary purpose of Baltimore and other commercial cities was the exchange of domestic and foreign goods near a transportation node, which in Baltimore was the waterfront (Pred 1972, Knox 1994). As the city grew and markets and technology changed so did the patterns and scales of manufacturing. By the end of the Civil War
Baltimore’s ready-made clothing industry had expanded, though not yet supplanting the small-scale artisan tailors and shipbuilding that began to decline in the late 1850s. Still, there was a significant increase by the 1860s in the production of all types of goods to be shipped elsewhere either by sea or west by way of the railroad (Muller and Groves 1979).

Muller and Groves (1979) describe Baltimore as a city in transition from the small-scale commercial city depicted in 1833 into the industrial center of the 1880s and 1890s through changes in transportation, population, and markets between the 1830s and 1880. It is the transitional city that Muller and Groves (1979) focus their attention on in respect to industrial clustering and land use patterns between 1833 and 1860. By 1860, six distinct industrial clusters developed in Baltimore (figure 2.2). Just to the west of the CBD lay a thirty-block concentration of clothiers, warehouses, and workshops interspersed with residential areas and artisans. This district used some multi-story buildings to concentrate garment workers, but the putting-out system probably dispersed some of the work as well2. To the east of the CBD in the low-lying land near Jones Falls in Oldtown were artisans, food and material processors, sugar refining, brewing, saw milling, and other activities reliant on steam power. This district’s activities tended to remain consistent with the past and did not gain many new industries. This was probably due to the district’s susceptibility to flooding and the long-settled area left little room for new industries to locate. Along the wharves of Fells Point and a nearby eastern section of the waterfront clustered shipbuilding activities with six shipyards, and other related activities such as sail making, oilcloth, and brass fittings on the adjacent blocks. In South

---

2 The putting-out system used by the garment industry in the early nineteenth century used the labor typically of poor and immigrant women outside of the main workshop to manufacture items requiring unskilled labor in order to increase production at a low cost and without having to expand the actual workspace (Muller and Groves 1976).
Baltimore along the waterfront another cluster of maritime-oriented activities developed, though on a smaller scale than Fells Point. South Baltimore consisted of shipyards, foundries, machine shops, and food and material processing. Along the western edge of settlement in Baltimore was the district containing the Baltimore and Ohio Railroad machine shop, five large metal working establishments, two brickyards, and a woodenware plant. Many of these were undesirable industries that through nuisance ordinances and a need for space were kept from the more developed parts of the city. Finally, the sixth industrial district was located in the northern basin of Jones Falls containing the Baltimore and Susquehanna Railroad facilities, tanneries, distilleries, and a
flour mill all powered by steam engines. Also in this district were a textile factory, three marble cutting plants and several metal working plants. Each of the industrial clusters described located in an area consistent with the principal needs of the industry. Ready-made clothing factories needed to be close to unskilled labor, especially female labor, in the city and built their factories vertically to reduce land costs. On the other hand, shipbuilding required not only locations on the waterfront, but significant amounts of space. Many shipbuilders moved from the central waterfront to more peripheral waterfront locations with lower land costs (Muller and Groves 1979).

By 1860 the livestock market moved a few blocks, and slaughterhouses and related industries tended to locate along the city line, ultimately near where the railroads crossed the city line. These animal-processing industries drained into Gwynns Run, Gwynns Falls, or Chatsworth Run, which eventually drained in the Middle Branch of the Patapsco River (Muller and Groves 1979). Environmental restrictions to control which substances could not be disposed of in local waterways did not exist at this time. These waterways acted as natural disposal systems for many animal-processing by-products along with many other urban wastes that drained into the same channels (Olson 1997, Rosen 1997). Brickyards clustered on the southwestern periphery of the city. Breweries and flour mills scattered around the rest of the periphery. Artisans located in every ward in 1860 without clustering, but they tended to locate more often in the south and west of the city and in Fells Point, reflecting ethnic clustering patterns (Muller and Groves 1979). While some industries grouped together within the city, no ordinances other than nuisance codes regulated land uses. Therefore, while more orderly and clustered, land uses were still quite jumbled.
The period of transition Baltimore underwent between the 1830s and 1880 was typical of mid-nineteenth century American cities. Commercial cities began to change in the 1840s as cities entered a transitional phase that transformed the commercial city into an industrial city. The transitional phase (1840-1880) was one of marked industrial and demographic restructuring. The resulting urban patterns were ones of more distinct land use separations, significant increases in manufacturing, and significant population growth both from rural to urban migration and foreign-born migration to America. Advances in inter and intra-urban transportation aided much of the industrial and residential sector separations. Baltimore’s and other cities’ development of omnibus service in the 1830s and later horsecar routes in the 1850s allowed those with wealth to move away from the city center while retaining reasonable travel times to the city center. Concurrent with the well to do moving to the periphery, railroads were being built to connect cities to one another and to raw materials in the interior of the continent. This created a new area of premium development locations around the railroad depots that again reshaped patterns of land use (Knox 1994).

The transitional phase was one of tremendous urban growth, sometimes in actual size, but primarily in industry and population. Manufacturing was the driving force behind land use change. Those who could pay the high rents for key factory locations near the railroad or waterfront did so. The developing industrial clusters in Baltimore reflected both old patterns of clustering as well as new patterns resulting from changes in products, technology, and labor force characteristics (Muller and Groves 1979). Residential neighborhoods for the swelling working classes, who still walked to work, located near the factories. People were migrating to urban areas by the tens of thousands
each year filling the growing need for industrial laborers. The mechanization of agriculture freed up rural American laborers to move to the city, while agricultural mechanization and other forces pushed migrants from Europe across the Atlantic into American cities and the West. By 1880 Baltimore was a city transformed from a mercantile economy to an industrial economy that would become increasingly mechanized throughout the rest of the nineteenth century. In 1880 still a great deal of industry was labor intensive, but over the next twenty years machines created changes in the type and amount of labor needed. This clustering of land uses, the growth of industry, and population growth worked to transition the American city from the commercial phase to the industrial phase (Knox 1994, Muller and Groves 1979).

The industrial phase (1880-1920) throughout America was one of further growth both in population and city extent with further land use specialization. Industries became more mechanized using new steam and electric power technologies. New waves of immigrants came to America in even greater numbers during this phase from southeastern and eastern Europe, taking many of the new unskilled jobs in the growing manufacturing economy (Knox 1994). Baltimore had undergone some restructuring by 1880, but retained its unorganized past; nonetheless the city was coping with the pressure of a significantly growing population and problems associated with that pressure as it entered the industrial phase in 1880.

**Residential Patterns**

As the economy shifted in Baltimore and industries clustered into distinct districts so did the residential patterns of the city shift and cluster. In the mercantile city artisan
shops and small-scale manufacturing mixed with residences. Until the electric streetcars ran throughout the city in the 1890s, Baltimore remained primarily a pedestrian city, with the laboring classes’ journey-to-work rarely extending more than a mile. Still, omnibus lines organized in 1845, followed by horsecar lines in 1859, and gas main extensions after 1838 allowed residents who could afford to do so to move further from the city center. As the wealthy moved away from the city center those left behind sorted themselves out by race and ethnicity within the vacant residential spaces nearer downtown (Olson 1997).

The pattern of residential separation began with the easing of transportation and the premium placed on downtown land for growing businesses. In the 1830s the need for large warehouses near the waterfront increased, and the merchants’ old homes were torn down to create the space needed. These warehouses were not increasing so much in number but instead in size, increasing in both land area and height. In the 1840s the wealthy built new, larger houses near the cathedral on streets such as Charles, Preston, and Lexington Street near Pearl Street made accessible by omnibus, uphill from the wharves and original city. These new houses were not only larger, but included modern conveniences such as water closets, central furnaces, hot water systems, speaking tubes, and gas lighting. By positioning homes on higher ground, residents took advantage of natural drainage because they believed homes on higher ground were healthier. While maybe not understanding the medical reasons, people during the nineteenth century did recognize that dampness, filth, and standing water, especially when combined with summer heat in and around their homes, had a negative impact on their health (Olson 1997).
The separation of land uses and the redistribution of population created an uneven distribution of population across the city, with few people living in the CBD (figure 2.3). The wealthy moved uphill, and the vacant spaces left behind were filled in by the middle classes who were replaced in their old homes by the working classes in a pattern of residential succession. In the low-lying areas of the city lived the working classes further divided into neighborhoods by ethnicity and race. The design of the city streets aided this residential separation. Baltimore, when platted in 1821, bound together pre-existing street patterns with through streets and developed a hierarchy of street widths – front, side, and alley – creating a social segregation mechanism that divided the city by class, race, and ethnicity. The alleys were narrow mazes of streets allowing access to the interior of blocks and creating residential spaces for the poor. The houses along these alleys were small, overcrowded, poorly ventilated, and poorly constructed. The poor drainage along improperly graded alleys, especially those in low-lying areas, allowed water to collect along them that bred disease in the summer and in the winter, completely blocked access to the alleys. Yet, these spaces were highly sought after by the newly arriving immigrants and blacks who could afford no other housing and needed to live near unskilled jobs available in the nearby industrial clusters (Olson 1997).
The working class, when they could afford better housing and services, moved first from the alleys to the side streets, then to the main streets, and finally to streets further from the city center. The first immigrant groups to arrive were the first to move out. In Oldtown, the 4th and 5th Wards, blacks shared the alleys such as Necessity, Half Moon, and Comet Alleys with some Germans in the early part of the century. Over time, Germans came to dominate the street fronts of Oldtown as their socio-economic position improved and they later moved to the northeast. Eastern European Jews ultimately replaced the German families in Oldtown on the main streets. By 1910, the residential
pattern of Oldtown consisted of Russian and Lithuanian Jews living on the main streets in the sub-divided houses of the former German residents. Blacks in Oldtown still clustered on the back streets and alleys with some Irish and Italians (Beirne 1988, Olson 1997).

One distinctive feature of Baltimore’s social fabric was the black population and its residential and occupational patterns. By 1810 free blacks outnumbered black slaves in Baltimore, unlike other Southern cities where slaves continued to outnumber free blacks until as late as the 1860s. During the nineteenth century, both before and after the Civil War, Baltimore was an important destination for blacks migrating north. It was not until the “Great Migration” of the 1920s that Northern cities were a major destination for migrating blacks. As a destination city, Baltimore absorbed a growing, if impoverished, black population into the housing stock and labor force during the nineteenth century (Groves and Muller 1975).

In the 1830s, the growing free black population in Baltimore tended to reside in Fells Point and found work in the shipping industry. In particular, blacks, including Frederick Douglass, often found positions as ship caulkers. While still a slave, Douglass’ caulking services were “leased” to an employer in Fells Point (Brugger 1988). After the Civil War a group of white caulkers from South Baltimore tried to replace black caulkers in Fells Point. Even in the racial climate during Reconstruction, employers refused to fire their black caulkers, as this group had established a reputation for their workmanship (Whitman 1997, Olson 1997).

Residential patterns of blacks in Baltimore reflected attitudes of segregation relegating blacks to the alleys and side streets of their neighborhoods. New immigrant groups, over time, replaced blacks in Fells Point alleys, but alleys elsewhere in the city
still housed a disproportionate number of blacks especially in the southwest and northwest of the city. By 1880, a concentration of blacks was identified to the northwest of the central business district, interspersed in the developing upper class neighborhood. This residential pattern again relegated blacks to the alleys and side streets while their occupational patterns probably involved employment in domestic service. In this section of the city blacks resided on streets such as Greenwillow, Sarah Ann and Raburg Streets, and Biddle and Chestnut Alleys (Olson 1997, Groves and Muller 1975).

While class distinctions in housing are easy to identify in nineteenth century Baltimore, it is generally more difficult to identify ethnic distinctions during Baltimore’s transitional phase. Clustering of ethnic groups happened at a scale finer than that of the ward; within one ward several ethnic clusters could exist each encompassing a few blocks or alleys or even just a few street faces. Additionally, these clusters were constantly changing. As each ethnic group arrived, assimilated, and advanced up the economic hierarchy, residential location reflected this process (Olson 1997, Beirne 1988).

**Politics**

Political decisions in an urban government shape many of the city’s features, including its physical shape, as well as some social and economic conditions. Government decisions and more often governments’ lack of decisions can have a dramatic effect on urban activities. In the case of nineteenth century cities, governments’ lack of action concerning public works development, for example, led to private companies providing water, gas, and sewers to those residents who could afford the services. The use of private companies to provide services only to those who could afford to
pay for them led to an unequal distribution of services that could have been more equitably distributed through a comprehensive city plan for public works. What Baltimore’s city government chose to focus on or ignore directed patterns of growth and the development of public works. Until Progressive Era politics in the 1890s professionalized and organized city government, few comprehensive, citywide policies could pass through the city council.

The ward-based political structure in Baltimore created a segmented leadership with each ward representative promoting the interests of his local ward. In addition to a segmented government, Baltimore’s government was dominated by machine politics. In many cities, traditionally growing out of social organizations, gangs, or volunteer fire companies, ward machines “emerged as a social institution capable of organizing the municipal voting behavior of neighborhood residents on the one hand, and the distribution of office, employment, and new municipal services on the other” (Fox 1977, 5). Needing to organize newly arrived voters from rural areas and overseas for particular political ends, political machines exchanged votes for jobs, basic welfare, and services. A party boss oversaw the whole machine and was the one who organized jobs and welfare for the machine’s supporters, in addition to selecting nominees for elected municipal offices. The ward machine system, by focusing on individual neighborhoods created a fragmented city rather than a cohesive one at time when the machine was in place to bring order to the social and ethnic chaos of the transitional city (Fox 1977).

In the case of Baltimore, a Democratic party machine ruled the city from the early 1870s until 1895. Overseeing the political machine was Boss Isaac Freeman Rasin, who worked his way up Baltimore’s political ladder until becoming boss in the early 1870s.
Boss Rasin concerned himself with votes and patronage, along with working with business and community leaders to plan and implement policies, but like most machine bosses, never held the office of mayor. Ward by ward Rasin gained more control of city politics until ultimately reaching the point of selecting many of the wards’ council nominees who would look to him for direction once in office. Trading votes for jobs and contributions, Baltimore’s political machine appeared to run smoothly, but the results of this system were a lack of comprehensive policies to give consistency to city growth and improvements during this transitional phase (Crooks 1968). In a history of Baltimore’s sewer system Euchner (1991, 276) comments on the problems of this fragmented political system: “The councilman promoted ward concerns great and small, such as grading and paving streets…Decentralized decision-making produced a tendency toward small projects.” Citywide concerns were rarely addressed. This system of local needs over the citywide needs in part delayed the implementation of comprehensive policies that would create a comprehensive sanitary sewer and piped water systems and later implement land use controls in the form of zoning codes (Euchner 1991).

Despite its inefficient government, by 1880 Baltimore was a city transformed from a disorganized mixture of land uses of the mercantile era to a city on the brink of industrial take off with residential and industrial land uses beginning to separate. Commercial and industrial land uses clustered near the city center, wealthy residents were moving uphill to the places peripheral to industries, and the poor living in low-lying areas of mixed land uses. New industrial capital, new immigrant labor, and new technology allowed Baltimore to undergo this transformation by 1880. Change continued throughout the remainder of the nineteenth century allowing further land use and
residential filtering, and improvements to infrastructure, but in 1880 the legacy of mixed land uses remained prominent on the landscape.
CHAPTER 3: Methods for Data Collection

In order to assess the relationship between infant mortality and land use in late nineteenth century Baltimore a number of historical sources were used to build a geographic information system (GIS) of infant deaths and land use. GIS is a powerful tool that can display spatial relationships in historical or current data. In her introduction to a special issue of *Social Science History* focusing on using GIS to analyze historical data, Knowles (2000) explains the often-overlooked importance of considering the spatial elements of history. She argues historical GIS “extends quantification and systematic empirical analysis to questions, scales, and evidence that few historians have considered” (Knowles 2000, 452). Historical GIS can be a time consuming approach to a question, as it requires the conversion of multiple layers of analog data into digital data. Yet, after this conversion process, the ability to visualize material once contained on a paper map and in a book of statistics can display patterns otherwise not visible (Knowles 2000).

Since the research question is inherently spatial, a GIS was chosen for the data analysis in this thesis for its spatial analytical capabilities. GIS offers a means of displaying data sets by attributing the data to fixed locations. The processes to make the infant mortality and land use data comparable in a GIS setting are time consuming, but once these data are input into the GIS, ArcView software can be used to assess and organize the data and search for possible correlations. In digital format, the data may be easily shared, an important consideration for this project since it will add important layers of information to the Baltimore Ecosystem Study data sets.
Data

The historical GIS built for this thesis incorporates data layers from three analog sources: Vital Statistics Death Records for 1880 Baltimore, MD, the 1876 Hopkins Atlas of Baltimore City and County, and the 1890 Sanborn Fire Insurance Atlas for Baltimore City. Microfilms of the death records, which are owned by the Baltimore City Health Department, Bureau of Vital Statistics and are held by the Maryland State Archives were acquired with LTER project funds. Death records became a requirement of the Baltimore City Health Department through Ordinance 86 in 1874, and mandatory record keeping began in 1875. I chose 1880 as a cross-section because it corresponds with a decennial census. The census year allows the possible use of the manuscript census for that year to incorporate other socio-economic data into the existing infant mortality database. Each death certificate was completed by the physician attending the death and contained the date of death, person’s full name, age (including years, months, and days, if they were known), race, place of death, both primary and secondary causes of death, duration of the illness, and sex (figure 3.1).
The 1876 Hopkins Atlas was used to create a land use layer for the GIS. These map sheets were scanned at Johns Hopkins University, and saved as TIFF images. The maps are in color with different colors representing different general land uses in the city and property owners in rural areas. They cover Baltimore City and much of Baltimore County. Within the city this set of maps show non-residential land uses ranging from
schools and churches to factories and railroad depots. These maps also include streets, street names, ward boundaries, and the city boundary. The Hopkins Atlas maps were chosen for their detailed depiction of non-residential land uses. While the maps pre-date the death certificates, the maps are the closest in date available. The assumption is that an insignificant amount of change occurred during the intervening four years (figure 3.2).

Figure 3.2 Section of an 1876 Hopkins Atlas Sheet

Methods

For this study, all deaths of those less than twelve months were extracted from the microfilm and logged in an Excel database. All of the extractable data were recorded from each death record, though for the purposes of this study, the field of primary
importance was the location of death. The complete database includes 2,306 infant
deaths. The 119 infants who died at St. Vincent’s Infant Asylum, University Hospital,
Nursery and Child’s Hospital, and 161 West Lombard Street (the Maternity Hospital)
while logged, ultimately were not mapped as those locations give no indication of where
the infant lived or the environment in which the infant lived. Other infant deaths were
excluded when their addresses were not clear enough to identify the place of the infant’s
death. These smeared addresses, addresses where the street name was illegible or
appeared to be spelled in a way that could not be deciphered, also fell into this second
group of excluded infant deaths, which totaled 662 infant deaths.

Once 781 of the un-useable infant deaths were removed the search for the best
way to geocode the data began. Geocoding is the process of spatially referencing data.
Geocoding uses text descriptors, typically address, to assign data a geographic location
with real world coordinates. Using ArcView one can use the geocoding function to match
addresses contained in an already geocoded file such as the 1990 TIGER street file to
those in a database such as the infant death database created here. TIGER, or
Topologically Integrated Geographic Encoding and Referencing, is a system and digital
database created and used by the U.S. Census Bureau to map and analyze decennial
census information. The TIGER files include geographic databases of railroads, rivers,
lakes, roads, political boundaries, and census statistical boundaries for the United States.
Each of the different files includes other relevant information pertinent to Census studies
such as latitude and longitude, and street address in the case of the street file (U.S.
Census Bureau 2002). These files were downloaded from the Environmental Systems
Research Institute (ESRI) website (http://www.geographynetwork.com/data/tiger2000/).
To use ArcView’s geocoding capabilities, the Excel database of infant deaths must first be saved in the format ArcView can read, database IV, and then opened in ArcView. Using the geocoding function with both databases open, ArcView scans both databases for matching addresses and maps the results. To check the possibility of using this ArcView function, a test was run using the first 200 infant deaths of 1880. Once the hospital deaths and other un-mapable deaths were deleted 160 were left for the geocoding test. This test resulted in a 30% success rate. ArcView could not place the other 70% of the deaths. Part of the poor success rate stems from the incompleteness of the 1990 TIGER street files. The TIGER files are intended for use by the U.S. Census Bureau for their mapping needs and, while available to the public were never designed to be 100% accurate or complete by a geographer’s standards. Instead, the Census uses these files to gain a general idea of geographic patterns that in their eyes are close enough (U.S. Census Bureau 2001). Additionally, it was discovered after this initial geocoding test that the address numbers in Baltimore changed in 1887. Therefore, the address numbers in 1990 do not match those from 1880 at all. After testing this data sample it became apparent that an automated method of mapping the infant deaths would not be possible. Instead, the infant deaths were mapped manually.

Before manually mapping the infant deaths, a base map, including street addresses of residences, needed to be located. While searching for such a base map, each of the 17 Hopkins Atlas sheets containing the city of Baltimore in 1880 were georegistered using the Image Analysis extension of ArcView. Georegistering, like geocoding, assigns geographic coordinates to a digital image. Images can be of anything that depicts locations on the earth, such as scanned air photographs, scanned maps, or
satellite images. In this case scanned maps were used. The process of georegistering involves either assigning latitude and longitude coordinates to particular locations on the map image or matching points, such as street intersections, on the map image to the same location on an already georegistered image, effectively “pinning” the two images together at that point. As coordinates or matching locations are added, ArcView shrinks or stretches the image evenly across the space between the pinned points which in some cases leads to unavoidable distortion. Unless the map image being georegistered gives the geographic coordinates of certain locations, the second method of georegistering is simpler. In this case the sheets were registered to Digital Raster Graphics (DRGs) of the 1953 U.S. Geological Survey (USGS) 7.5-minute topographic quadrangles, Baltimore East and Baltimore West. Each map sheet was registered in Universal Transverse Mercator projection, zone 18 which is the projection of the DRGs. The DRGs are available to download for free from the GIS Data Depot website (www.gisdatadepot.com). As these DRGs are georegistered and known to be geographically accurate, georegistering the Hopkins Atlas sheets to the DRGs produced relatively geographically accurate land use base maps. Each Hopkins Atlas map sheet ultimately was saved as an ArcView Imagine image once it was georegistered. While ArcView allows georegistered images to be saved as either Imagine images or TIFF images, the Imagine format is smaller and so saves space on the computer.

Once the Hopkins Atlas sheets were georegistered the land use digitizing began. Digitizing is the process of creating a digital map from an analog map source. A digitized feature can be a point, a line, or a polygon. Usually the analog map source to be digitized is scanned and georegistered like the Hopkins Atlas map sheets were in this project. Then
the images are opened as a “Theme” or layer in ArcView, and the desired features are added to one at a time to another Theme. For the purposes of this thesis, each city block was digitized as an individual polygon. Once a layer is digitized, usually it is given a series of attributes, essentially a database of information about each individual digitized feature in that map layer. Attributes can be quantitative (i.e. number of residents on a block) or qualitative (i.e. type of soil) in nature and each feature can have an infinite number of attributes depending on the nature of the data. In this phase each city block was digitized and attributed according to the land uses on the block as a whole. The attributes were as follows:

1 = residential/non industrial
2 = 25% industrial (at least 1 mid-sized factory building)
3 = 50% industrial (at least 3 small factories, or 2 mid-sized factories)
4 = 75% industrial (mostly factories, but also including some non-industrial uses)
5 = 100% industrial (only industrial land uses)
6 = commercial (warehouses, markets)
7 = other (transportation, parks)
8 = undeveloped

No calculations were used to determine the percentages of industry, instead it was left to the discrimination of the digitizer. A disappointing aspect of the Hopkins Atlas is its lack of information concerning commercial land uses. While warehouses and market places appear prominently, smaller features such as artisan shops do not appear at all and instead are grouped in with the shading for residential areas. Therefore, smaller scale commercial land uses could not be digitized or their potential impact on infant mortality analyzed in this study.

The Hopkins Atlas does not contain address numbers, so another map source containing address numbers was needed in order to manually map the infant deaths
correctly. The 1890 Sanborn Fire Insurance maps, the earliest for Baltimore City, were chosen as the base map for this process because they contain address numbers and detailed labels of the streets and most of the alleys (see figure 3.4).

Figure 3.3 Section of 1890 Sanborn Fire Insurance Map, Sheet 8

Each of the Sanborn map sheets was georegistered to the Hopkins Atlas sheets rather than the DRGs of the Baltimore East and Baltimore West quadrangles. The Sanborn map sheets each cover a small portion of the city, only six to eight blocks, so it was more efficient to use the larger scale Hopkins Atlas sheets rather than the DRGs. The DRGs are fairly coarse-grained images, that when zoomed in to the block level, become quite pixelated making it extremely difficult to identify any map features. While this choice may have compounded georegistration errors already contained in the georegistered Hopkins Atlas sheets, the Sanborns were needed only for their address numbers and could be used in combination with the already digitized land use map to place the infant deaths in the right locations.
The Sanborn maps of Baltimore are available online through the Enoch Pratt Free Library’s website, with a Pratt library card number. The maps can be downloaded in a PDF format only, so in order to bring them into the GIS, which can only read TIFF or JPEG formats, each map sheet was converted to JPEG format using Adobe Photoshop. The process of converting the PDF images into JPEGs involved opening each image in Photoshop with the setting RGB color and 300 dots per inch. Then each image was “Saved for Web” instead of using the “Save as” option since this option did not allow the image to be saved as a JPEG. The settings used to save the image as a JPEG were high resolution and quality = 60. Additionally, it was important to keep the box next to the option “Progressive” unchecked or the image would not open in ArcView. Once this conversion made each sheet compatible with ArcView, each map sheet was georegistered to the georegistered Hopkins Atlas sheets.

Once the Sanborn map sheets were georegistered, a problem arose with geocoding the infant deaths. When trying to map the first infant deaths in the database the address numbers were not appearing where they should have, if they appeared at all. The 1880 Baltimore city directory street index was consulted to determine if the address numbers on the Sanborn maps matched the address structure in 1880. The street index lists each street in the city, where it begins, and the address number at start of each block. The index was photocopied from microfilm of the 1880 city directory at the Enoch Pratt Free Library. Using the street index from the 1880, it can be determined which range of address numbers belonged on each block and these were not the numbers found on the Sanborn map sheets. After some further research into this problem it was discovered that the city’s address numbers changed and were given a more logical structure in 1887. The
street index in the 1887 Baltimore city directory includes both the old and new address numbers. This street index was acquired by photocopying the microfilmed directory at the Enoch Pratt Free Library and then finally the infant deaths could be geocoded manually. By cross-referencing the old address numbers in the 1887 street directory with the new address numbers on the Sanborn maps, the location of each infant death was located and digitized in an ArcView point theme. The resulting infant death data layer contains 1,525 of the recorded infant deaths for Baltimore City in 1880.

Not all of the infant death records included address numbers and the Sanborns did not cover the entire city. In some cases the location was recorded as “on West Baltimore, near Green” or “corner of South Ann and Canton.” To map these infant deaths an educated guess was made and the infant death was mapped as the death record indicated, near a particular intersection. Other infant death records included all of the address information needed to map the death, but the Sanborn maps did not cover that particular area. Using the 1880 street index these deaths were mapped on the correct block face. To differentiate between infant deaths that were mapped to the exact address and those that were mapped as closely as possible, an accuracy number was assigned to each infant in the database. The accuracy assignments were as follows:

1 = infant death mapped to the exact address location  
2 = infant death mapped to the correct block face  
3 = infant death mapped to the correct area, but unsure of which block face

While all of the infant deaths were not mapped to their exact address, this tiered system of mapping should not have affected the results as even the infant deaths with 2 and 3 accuracy assignments were mapped to the correct block or close to the correct block and
can be removed from the database should other research questions require more precision.

As implied by the description of the methods of data collection in this thesis the process of converting the analog data for this thesis into digital files is a time consuming process. Sorting through all of the death records for 1880 on microfilm to find only those for infants, georegistering the 212 Sanborn map images, and finding the correct address number in the 1887 street index in order to map each infant death among all of the other steps involved in creating this GIS required patience and attention to detail to make sure all of the data was geographically accurate. Nonetheless, the resulting database of infant deaths and land uses for Baltimore City combines in one place data previously incompatible for analysis. Despite the amount of work required to build any type of GIS, and especially an historical GIS, the ability to store, analyze, and display the information, in the end supersedes the temporary frustrations of the long data preparation process.
CHAPTER 4: Analysis and Discussion of Results

After mapping the infant deaths, analysis of their spatial patterns and possible relationship to industrial land use began. The analysis consisted of two phases, the first intending to assess the spatial distribution of the infant deaths throughout the whole city and the second intending to assess the patterns of infant deaths in selected wards. The first phase used four types of analysis to assess infant deaths in the city: (i) a visual assessment of the infant deaths; (ii) a nearest neighbor test; (iii) a chi-squared test by ward; and (iv) a grid-based analysis of the infant deaths and land uses. The second phase of analysis zoomed in on five wards that stood out during the first phase and compared the ward’s land uses to the infant death patterns to qualitatively consider the relationship between infant deaths and land uses.

Phase One: Visual Patterns

A first look at the infant death map for Baltimore displays an overwhelming number of dots, each representing an infant death throughout the entire city (figure 4.1). Upon closer inspection, separate clusters of dots begin to stand out, as well as areas with an absence of infant deaths. The center of the city contains few infant deaths. This area, primarily the 9th and 10th Wards is approximately the extent of the central business district (CBD). Few people lived in the CBD, so an absence of infant mortality was expected. Also, the 11th Ward contains few infant deaths, although more people lived there than in the CBD. In all of the wards that made up the city boundary infant deaths decreased in density closer to the city’s edge, following the patterns of residential settlement. This is particularly apparent in the 12th, 19th, and 20th Wards. Infant deaths
occur where people are living, so in most cases the absence of infant deaths in an area indicated an absence of residences.

Infant deaths clustered in a number of parts of the city. Some clusters were large, but others were limited to a few streets. One large cluster occurred southwest of the Basin primarily in the 15th Ward, but extended in the 17th Ward, and the southeastern portion of the 18th Ward. To the south of and almost adjacent to the cluster in the 15th Ward was a smaller cluster in the 18th Ward, though it extends into the 17th Ward as well. Two small clusters of note are in the northwest corners of the 13th and 14th Wards, to the west and
somewhat to the north of the CBD, at the edge of warehouse/workshop district. The neighborhood of Fells Point that made up the 2nd Ward contained a large infant death cluster in the southeast of the city. Infant deaths east of Jones Falls appear more concentrated than those west of the Jones Falls.

Many of the infant deaths in these clusters occurred on narrower streets, probably alleys. The clusters in the Fells Point area are the exception to this where deaths appear to be on main streets, side streets, and alleys. An interesting aspect of the Fells Point clusters is a distinct gap in the cloud of infant deaths along South Broadway Street that creates two almost separate clusters rather than one large continuous cluster. This gap may be the result of more shops and fewer residents locating along South Broadway near the Fells Point Market, but the Sanborn maps do not indicate many shops in this area.

While the visual patterns of infant deaths do not explain reasons why infant deaths are located in certain places, the readily apparent visual patterns do demonstrate that infant deaths did cluster. Additionally, not only did clusters appear, but the absence of infant deaths in the 9th and 10th Wards is also telling, since this is the area associated with the CBD. The absence of infant deaths in these two wards, and an absence of population, clearly displays some separation of land uses, marking these two wards as predominantly non-residential.

**Phase One: Nearest Neighbor Test**

While a rather crude type of analysis, as it does not indicate specific geographic locations, the nearest neighbor test can indicate at the city level if the infant deaths were clustered. The nearest neighbor test is a statistical test that calculates the distance between
each infant death and the nearest infant death to it, then calculates the mean distance between the points. The resulting statistic indicates one of three possible outcomes: random distribution, uniform distribution, or clustering. For this study a nearest neighbor test was conducted using nearest18.ave, an Arc Avenue script downloaded from the ESRI website (www.esri.com). Avenue is a programming language used in ArcView to write programs, called scripts that can expand ArcView’s capabilities beyond its original functions. A number of useful scripts are available to download from the ESRI website. In order to use the nearest neighbor script the GIS needed two additional pieces of data. First, the geographic coordinates (i.e. x, y coordinates) for each data point in the infant death shapefile needed to be generated and added to the shapefile’s table, and a single polygon shapefile with a calculated area was needed as the study area. The addxycoo.ave script, downloaded from the ESRI website, generated the coordinates. Once run, the script added the x and y coordinates for each infant death to attribute table in decimal degrees. The study area polygon, which consisted as much as possible of only residential blocks and excluded undeveloped areas, was digitized from the land use shapefile. Some landuses other than residential were included as they were located between two separate residential areas. Once the study area was digitized its area was calculated using calcapl.ave, a third script downloaded from ESRI. This script added both the area and the perimeter of the settled area shapefile to its table in meters. With all of the pieces in place the nearest neighbor script could be run.

Running the nearest neighbor script resulted in an R-value of 0.719 for the 1,461 infant deaths that fell within the settled area. Since the R-value was less than 1 the infant deaths tended towards clustering, rather than being randomly or uniformly distributed.
The script therefore rejected the null hypothesis and accepted the test hypothesis that the infant deaths tended to be clustered. Only 1,461 of the infants were included in this calculation as some infant deaths occurred outside of the settled area polygon. While this thesis argues that infant deaths primarily occurred in residential areas, some infant deaths appeared on blocks attributed as undeveloped. This is the result of either a form of settlement not appearing on the Hopkins Atlas or the discrepancy in the dates of the map and infant deaths, maybe an area appearing undeveloped in 1876, was developed and occupied in 1880.

The clustered pattern observed in the visual test was statistically supported by the nearest neighbor test, and supports the hypothesis of this thesis that the distribution of infant deaths in 1880 would be uneven. The nearest neighbor statistic does indicate clustering, but it does not identify the location of the clusters, how clustered the infant deaths were, or explain why the clusters occurred. Nonetheless, this test helps to support the results presented earlier in the visual analysis that infant deaths clustered, and indicates that some parts of the city that were probably less healthy for infants.

**Phase One: Chi-Squared Test**

Visually the patterns of infant deaths present a basic picture of the infant mortality distribution in 1880 Baltimore. Visual patterns do not, though, demonstrate if large numbers of infant deaths in certain areas are the result of large populations or the result of other factors. In other words, if more people lived in the 4th Ward than the 9th Ward, one would expect to find more infant deaths in the 4th Ward as there were probably more infants in that ward. To measure if the infant deaths in each ward were proportional to
each ward’s population a chi-squared test was conducted. The purpose of a chi-squared test is to determine if events occur evenly or unevenly across a category such as space. In this case, the chi-squared test was run to determine if the infant deaths in each ward were proportional to the population of that ward, or if some wards were over-represented in the infant mortality data. Wards were chosen as the areal unit of measure since they are the smallest unit of measure for Baltimore in 1880 with available population data. Birth data by ward would be more appropriate for this analysis, but was not available, nor was it accurately recorded in 1880.

The chi-squared test compares the number of deaths that occurred in each ward to the calculated number of expected deaths for each ward and determines if the differences between these two figures is statistically significant. If the test is statistically significant it indicates an uneven distribution of infant deaths - some wards have a disproportionately high number of infant deaths for the ward’s population and other wards have a lower than expected proportion of infant deaths for the ward’s population.

To calculate the chi-squared statistic first the ward boundaries were digitized from the Hopkins Atlas and each ward’s population from the 1880 U.S. Census was assigned to the appropriate ward. Then to determine how many infant deaths occurred in each ward the attribute tables for the infant death and ward shapefiles were spatially joined. In ArcView, there are two ways to combine, or “join,” attribute data from two different tables, an attribute join and a spatial join. Spatially joining tables joins the two tables by shared locations. In this study the ward polygon shapefile was joined to the infant death point shapefile. This resulted in a single table displaying each infant death, the identification number of the ward the death occurred in, and the population of that ward.
Once the two tables were joined the ward identification field was summarized to display how many times each ward identifier appeared in the joined table, or in other words, how many infant deaths occurred in each ward. With population and infant death data aggregated to the ward level, the next step was to calculate what percentage of the population lived in each ward. Then the number of infant deaths one could expect if the infants that died in each ward died in proportion to that ward’s population were calculated. All of this formation along with the calculated number of expected number deaths for each ward is summarized in figure 4.2.

<table>
<thead>
<tr>
<th>Wards</th>
<th>Deaths</th>
<th>% of Total Deaths</th>
<th>Population</th>
<th>% of Total Pop</th>
<th>Expected Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>131</td>
<td>8.6</td>
<td>27,190</td>
<td>8.2</td>
<td>125</td>
</tr>
<tr>
<td>2</td>
<td>98</td>
<td>6.4</td>
<td>14,097</td>
<td>4.2</td>
<td>65</td>
</tr>
<tr>
<td>3</td>
<td>76</td>
<td>5</td>
<td>12,985</td>
<td>3.9</td>
<td>60</td>
</tr>
<tr>
<td>4</td>
<td>42</td>
<td>2.8</td>
<td>9,521</td>
<td>2.9</td>
<td>44</td>
</tr>
<tr>
<td>5</td>
<td>53</td>
<td>3.5</td>
<td>12,966</td>
<td>3.9</td>
<td>59</td>
</tr>
<tr>
<td>6</td>
<td>82</td>
<td>5.4</td>
<td>15,402</td>
<td>4.6</td>
<td>71</td>
</tr>
<tr>
<td>7</td>
<td>114</td>
<td>7.5</td>
<td>27,327</td>
<td>8.2</td>
<td>125</td>
</tr>
<tr>
<td>8</td>
<td>51</td>
<td>3.3</td>
<td>14,250</td>
<td>4.3</td>
<td>65</td>
</tr>
<tr>
<td>9</td>
<td>51</td>
<td>3.3</td>
<td>6,978</td>
<td>2.1</td>
<td>32</td>
</tr>
<tr>
<td>10</td>
<td>53</td>
<td>3.5</td>
<td>9,533</td>
<td>2.9</td>
<td>44</td>
</tr>
<tr>
<td>11</td>
<td>24</td>
<td>1.6</td>
<td>12,492</td>
<td>3.8</td>
<td>57</td>
</tr>
<tr>
<td>12</td>
<td>37</td>
<td>2.4</td>
<td>14,747</td>
<td>4.4</td>
<td>68</td>
</tr>
<tr>
<td>13</td>
<td>43</td>
<td>2.8</td>
<td>10,358</td>
<td>3.1</td>
<td>48</td>
</tr>
<tr>
<td>14</td>
<td>63</td>
<td>4.1</td>
<td>11,206</td>
<td>3.4</td>
<td>51</td>
</tr>
<tr>
<td>15</td>
<td>85</td>
<td>5.6</td>
<td>14,664</td>
<td>4.4</td>
<td>67</td>
</tr>
<tr>
<td>16</td>
<td>84</td>
<td>5.5</td>
<td>19,867</td>
<td>6</td>
<td>91</td>
</tr>
<tr>
<td>17</td>
<td>91</td>
<td>6</td>
<td>18,220</td>
<td>5.5</td>
<td>84</td>
</tr>
<tr>
<td>18</td>
<td>146</td>
<td>9.6</td>
<td>29,037</td>
<td>8.7</td>
<td>133</td>
</tr>
<tr>
<td>19</td>
<td>117</td>
<td>7.7</td>
<td>30,941</td>
<td>9.3</td>
<td>142</td>
</tr>
<tr>
<td>20</td>
<td>84</td>
<td>5.5</td>
<td>20,532</td>
<td>6.2</td>
<td>94</td>
</tr>
<tr>
<td>Total</td>
<td>1,525</td>
<td>100</td>
<td>332,313</td>
<td>100</td>
<td>1,525</td>
</tr>
</tbody>
</table>

**Figure 4.2 Results of the Chi-squared Test.** Expected deaths in gray rows indicate a higher than expected number of infant deaths in that ward.
The chi-squared test was statistically significant at the .05 level with a calculated $\chi^2 = 90.09$ and a critical value of 30.14. The null hypothesis that the infant deaths were proportionally distributed among the ward populations was rejected, and the test hypothesis that the distribution of infant deaths was disproportionate to the ward populations was accepted.

When the residuals (observed number – expected number) of the chi-squared test were mapped, a clear spatial pattern appeared (figure 4.3). Wards with higher than expected numbers of infant deaths were in the southern part of the city. With the exception of the 16th Ward, all of the wards with lower than expected numbers of infant deaths were in the northern part of the city. Given Baltimore’s location on the banks of the Patapsco River, the southern part of the city is lower in elevation than the northern part of the city. When the infant deaths are then mapped against the current digital elevation model (DEM) of Baltimore, the infant deaths, especially some of the largest clusters, clearly occurred in the lower elevations (figure 4.4).

The results of the chi-squared test and the distribution of the residuals support the first hypothesis of this thesis, that infant deaths would be clustered, and part of the second hypothesis that those clusters of infant deaths would concentrate in low-lying areas. Low-lying areas tend to collect water and wastes along the streets, therefore creating a less healthy living environment. During the nineteenth century the usual methods of waste disposal in Baltimore were cesspools in the rear of lots for human wastes and tossing dirty water and garbage into the street gutters to be washed downhill by rain into the harbor. This system left only those living near the harbor to cope with the stench of decaying wastes (Crooks 1968). Given the use of street gutters for waste disposal people
living near the harbor not only dumped their own wastes into the streets, but as wastes from uphill were washed towards the harbor passed by low elevation homes leaving those residents with more matter deposited outside their homes than other parts of the city.

People living in cities during the nineteenth century recognized that lower elevations were less healthy and those who could afford to do so moved uphill. Both Williams (1992) and Olson (1997) refer to urban residents with money in Baltimore and Sheffield, England moving away from the rivers and low elevations because they recognized the adverse effect this had on their health. The annual reports by the Board of Health of Baltimore City also indicate a need to deal with poor drainage along many
about health and medicine in the nineteenth century, these misconceptions did not hide

streets and in vacant lots for health reasons. Two areas specifically mentioned in many of
these reports between 1876 and 1881 are east of City Dock where some north-south
streets did not extend to the harbor, and Wolfe Street and Ann Street between Chase and
Biddle Streets because these streets were not yet paved. Despite the many misconceptions
about health and medicine in the nineteenth century, these misconceptions did not hide
the fact that something about damp, low-lying urban areas impaired health. The
Baltimore City Board of Health recognized the need to pave streets and extend them to
the waterfront. Additionally, the Board of Health reports more than once called for a
comprehensive sanitary sewer system, separate from the storm water sewers, to be built
to dramatically decrease the number of preventable deaths brought on by the existing
system of waste disposal in street gutters and cesspools (Board of Health 1876, 1877;
Health Department 1880, 1882).

In 1879 the Board of Health identified children under the age of 5 as the largest
age group of deaths in that year. Two-thirds of these deaths were infants less than one
year. The board stated that reducing the child mortality rate would greatly reduce the
general mortality figures for the city. To achieve this goal the Board of Health referred to
the importance of sanitation improvement in the form of better drainage as a means to
reduce many of these preventable deaths (Health Department 1879).

**Phase One: Grid Analysis**

Grid-based analysis is another crude measure of whether or not there is a strong
connection between two mapped phenomena. Grid-based, or raster, analysis uses pixels
or “cells” of different values to represent the data. The above analysis is based on vector-
based GIS/analysis, which represents information using points, lines, and polygons. To
conduct the grid analysis the vector shapefiles of infant deaths and land uses were
converted into raster layers in ArcView using the Spatial Analyst extension. The infant
death grid layer used 3-meter square grid cells, which means the extent of the infant death
vector file was divided into 3-meter by 3-meter grid cells and every cell that contained an
infant death was given a value of 1. This proved somewhat problematic when multiple infant deaths were located closer to one another than 3 meters, especially those at the same address, since then only one pixel represented multiple infant deaths. Therefore, the resulted infant death grid layer contained 1,457 cells with a value of 1 representing the 1,525 mapped infant deaths. Once converted to grid the infant death layer contained cells with a value of 1 for an infant death and cells of “no data” for all other areas. To create a continuous surface of cells with numeric values and to make it easier to work with later in the analysis, the infant death layer was reclassified giving a value of 10 to all cells originally valued as 1, and a value of 0 to cells valued as “no data.” Then the land use shapefile was converted into a grid, of 3-meter grid cells, giving each cell the same numeric value as its land use attribute.

With the data layers converted into grid layer and the correct numeric values assigned, the map calculator was used to “add” the cell values of the layers together and generated a new grid layer. The map calculator can add, or perform other mathematical functions on, multiple layers of grid data. Since each grid cell has its own numeric value and each layer of grid data has the same number of grid cells that are the same size, they can be “laid” on top of one another, the values added together, and a new grid layer of the results generated (figure 4.5). The results then indicate on which types of land uses infant deaths occurred. This method of analysis determines if an infant died on an industrial block, but not if an infant died across the street from industry or an industrial block.

The results of the grid analysis indicate, as expected, that most infant deaths occurred on residential blocks. It is not surprising that 87.4% of the 980 infant death cells were on residential blocks. Given the rigid nature of the grid cells a number of infant
death cells overlapped with areas of no data on the land use layer, which excluded them in the map calculation process. The remaining 12.6% of infant death cells overlapped with other land uses. While no overwhelmingly high numbers of deaths occurred on any non-residential types of land uses, 4.6% of the infant death cells occurred on 25% industrial blocks, the other land uses all had smaller percentages of infant death cells.

While the results of the grid analysis do not provide much evidence about the relationship between land uses and infant mortality, they do indicate how much land was at least partly industrial. Thirteen and eight tenths percent of the land use cells were part of industrial blocks containing at least a mid-sized factory. Additionally, the grid analysis indicates that 23.8% of the grid cells were neither residential nor undeveloped, meaning that nearly a quarter of the city’s land was dedicated to industry, commerce, transportation, and in this case open space. Almost 7% of the land use grid cells were part of 100% industrial blocks, which is almost half the grid cells assigned to one of the four types of industrial categories. This is striking as an indicator of the growth of industry in the nineteenth century city.
How Map Calculator Works

Figure 4.5 Graphical Depiction of the Map Calculator Process Used in the Analysis
Phase Two: Detailed Analysis of Wards 2, 3, 9, 15, and 16

The second phase of analysis involved taking a closer look at five of the wards that stood out during the citywide analysis. Only the chi-squared test produced a map displaying patterns, so the five wards were selected from the residual map. The four wards with a significantly higher than expected number of infant deaths, Wards 2, 3, 9, and 15 were selected to examine if within those wards infant deaths clustered and if a relationship between the deaths and land uses existed. The 16th Ward was selected because it goes against the spatial pattern of the chi-squared residual map. The 16th Ward had a lower than expected number of infant deaths, but was surrounded by wards with higher than expected numbers of infant deaths. These five wards were analyzed visually and then the percentages of each land use type calculated to assess the possible relationship between proximity to large amounts of industry and infant mortality.

Since it did not fit the pattern generated by the residual map, the 16th Ward needed a closer look to determine what influences might explain its residual of -2 when the ward was surrounded by wards with higher than expected numbers of infant deaths. Of the 84 infant deaths in this ward only 22 of them form any type of cluster, and those 22 deaths are divided into 3 small clusters spread across the entire ward (figure 4.6). Given the dispersed nature of the infant deaths and the lower than expected number of infant deaths in the 16th Ward, what was the land use pattern? The number of blocks attributed as each type of land use was counted to determine if a low percentage of industrial land uses occurred in the ward. In the 16th Ward, 18 of the 124 blocks contained some type of industrial land use, or 14.5% of the blocks were at least 25% industrial. So in this ward, with 82.3% of its blocks dedicated to residences and a high
Land Use and Infant Deaths, 16th Ward

- Infant Deaths
- Land Uses
  - Residential/non-industrial
  - 25% Industrial
  - 50% Industrial
  - 75% Industrial
  - 100% Industrial
  - Commercial
  - Other
  - Undeveloped

Population of 19,867 the housing density was relatively low. Given its lower elevations, one might expect to find a higher number of infant deaths, but if industrial land use is related to infant mortality, then the 16th ward is an example supporting that hypothesis.

The 15th Ward is directly to the east of the 16th Ward and makes an “L” around the western and southern sides of the Basin (figure 4.7). The 85 deaths in this ward cluster in the southwestern corner of the ward with a few deaths scattered to the north and east of the large cluster. The lack of infant deaths in the southeastern part of the ward was probably related to the lack of residences in that area, as this part of the ward is almost entirely industrial so there were few residences where infants could have died. Since infants primarily died in their homes, one would expect to see more infant deaths in...
residential areas. Still, the influence of living in close proximity to industry is a potential factor affecting infant health. In the 15th Ward 25% if the blocks contained some type of industry, including 8 blocks that were entirely industrial. The population of 14,664 lived on approximately 67.7% of the blocks in this ward, indicating that the fairly large population in the 15th Ward lived on less land than the population of the 16th Ward and in closer proximity to a concentration of industry.

The 9th Ward had the lowest population in the city and along with the 10th Ward made up the CBD, which by nature tended to have few residents. The land uses in the 9th Ward are those expected in a waterfront ward that includes the CBD. Twenty-five percent of the blocks contained at least a mid-sized factory or more industry and 20% of the
blocks in the ward were used for either commercial or transportation purposes (figure 4.8). The infant deaths appear to be clustered in the northern part of the ward. Although blocks attributed are residential areas interspersed throughout the ward, the Hopkins Atlas did not indicate small shops, so many of the commercial land uses in the CBD could not be differentiated from residential land uses. A closer look at the infant deaths in this ward indicates that 20 of the infant deaths occurred at 57 St. Paul Street, which was the location of St. Elizabeth’s Home according to the 1890 Sanborn maps. While 18 of the infants who died at this location lived in Baltimore their whole lives, it is not possible in this study to determine if their deaths occurred because of external environmental conditions or if St. Elizabeth’s Home, probably some type of poor house, created its own hazardous conditions. What the occurrence of these 20 infant deaths in the 9th Ward does indicate is that concentration of infant deaths in St. Elizabeth’s Home increased the proportion of infant deaths for the ward as a whole. The 9th Ward was one with a great deal of commerce, industry, and transportation and a small population, with the infant deaths typically occurring north of non-residential blocks. Even considering the effects of the blocks north of the ward boundary, since the higher elevation position of these blocks would have affected the infants in the 9th Ward possibly more than the land uses to the south, does not add to the potential argument that industries affected infant health. The blocks to the north of the 9th Ward are primarily railroad related and residential.
The ward with the highest residual was the 2nd Ward, which made up most of the Fells Point neighborhood. This neighborhood in both the visual and chi-squared analysis displayed a high number of infant deaths. By far the 2nd Ward had more industrial blocks than any of the wards considered in this part of the analysis (figure 4.9). Of the 89 blocks in the 2nd Ward 32.6% contained some industry. Not only did the 2nd Ward have a high percentage of blocks that were at least 25% industrial, but half of the industrial blocks were 100% industrial. The residential blocks in the 2nd ward were mostly grouped together in the northeastern part of the ward. An interesting feature of the 2nd Ward is that at least 1 infant died on almost every residential block. Another interesting aspect of the
2\textsuperscript{nd} Ward is the residential density. The 15\textsuperscript{th} Ward had a similar number of residents to the 2\textsuperscript{nd} Ward, but only 57% of the 2\textsuperscript{nd} Ward’s blocks were residential, while 67.7% of the blocks in the 15\textsuperscript{th} Ward were residential.

The results thus far in the second phase of analysis seem to indicate that wards with higher percentages of industrial land uses tended to have disproportionately higher numbers of infant deaths compared to their populations. Yet, looking at the distribution of the infant deaths in each ward compared to the proximity to the industrial blocks, a land use-infant death relationship does not appear; clusters of infant deaths occurred both close to and distant from the industrial blocks. Given this scenario, the 3\textsuperscript{rd} Ward was
chosen for consideration, as it is directly north of the 2\textsuperscript{nd} Ward, and had a high residual in the chi-squared test. Sixteen more infants died in this ward than were expected. The proportions of land uses proved quite intriguing and contrary to the other findings (figure 4.10). Only 4 of the 63 blocks in the ward had any type of non-residential uses. The population of 12,985 lived with little to no industry nearby; even the neighboring wards contained little industry near the ward boundary, at a lower elevation, and had a proportionally high number of infant deaths. What this indicates is that infant deaths are not related to proximity to industry or to percentages of industrial land uses compared to residential land uses. Instead, the one aspect of land use that was likely to have an impact on infant deaths was \textit{residential density}.

\begin{figure}
\centering
\includegraphics[width=\textwidth]{Land_Use_and_Infant_Deaths_3rd_Ward}
\caption{Land Use and Infant Deaths, 3rd Ward}
\end{figure}

\textbf{Figure 4.10 Zoomed in Image of the 3\textsuperscript{rd} Ward}

\begin{tabular}{|c|c|c|c|}
\hline
\textbf{Land Use} & \textbf{Infant Death} \\
\hline
Residential/non-industrial & 75 & 25 & 0 \\
25\% Industrial & 50 & 25 & 25 \\
50\% Industrial & 50 & 50 & 0 \\
Other & 50 & 0 & 0 \\
\hline
\end{tabular}
How tightly packed were the houses? Residential density could increase the passage of communicable diseases. Most infants in the nineteenth century were dying from gastro-intestinal diseases, which can be passed more rapidly in high-density areas with poor sanitation because these diseases are spread through polluted water and contaminated food. In low-lying areas especially, wells were contaminated by filth percolating from unlined cesspools into the groundwater that flowed downhill. Public wells were shared by large numbers of people especially in high-density areas. Food could be contaminated easily by flies that fed on the filth in the street gutters, as well as the cesspools and privies in the rear of lots. When housing densities increased so did the density of privies. When looking at Fells Point on the Sanborn maps, not only were there tightly packed houses, those houses are narrow with no space between them, and in the interior of most blocks there are usually stables and probably privies and cesspools, although these are not identified on the Sanborn maps. The annual reports indicate that the Baltimore City Board of Health recognized the problems associated with high residential density. In 1884 a census of tenement houses by police district reported that the majority of these houses were unfit for living and in need of sanitary surveillance. The 1885 report repeated the call for sanitary surveillance of tenement houses citing that without monitoring the dangers to health from overcrowding and unsanitary conditions would continue (Health Department 1884, 1885). The combination of a high population density, a high housing density, low elevation, and poor drainage could easily have created a combined landscape lethal to infants.
CHAPTER 5: Conclusion

Industrial land use in 1880 Baltimore appears to have had little effect on infant mortality patterns. Industries were dirty, unsafe places to work, but this analysis suggests that living near them did not create an environment less healthy for infants. Something else in the city was more important in determining the spatial distribution of infant deaths. The pattern of infant deaths in Baltimore was decidedly uneven, and the most distinct clusters of infant deaths occurred in low-lying areas. Elevation cannot be the only factor influencing infant mortality patterns in Baltimore since not all low-lying areas experienced the same rates of infant deaths.

This thesis hypothesized that land use, in particular industrial land use, affected infant mortality patterns in 1880 Baltimore. Given the mixture of urban land uses that began to separate during the 1880s and the similar timing of the decline in infant mortality rates, the possible associations between land use and infant mortality posed an interesting question. While industrial land use does not appear to be a significant factor affecting infant mortality patterns, other aspects of the built environment may have impacted infant health. One aspect of the built environment that this thesis could not adequately measure was housing density. How tightly packed together were people’s homes? Houses are a type of land use, but the scale of analysis in this thesis limited the consideration of land uses to the whole block level and so it could not be determined if the number of houses on a block could have influenced infant mortality. Still, a high housing density, often resulting from proximity to unskilled jobs, may have influenced infant mortality patterns. Poor drainage in low elevations may have multiplied the effect.
A second aspect of the built environment not incorporated into the analysis was the location of sanitary sewers and piped water. As with many infant mortality studies, piped water and sewer data and maps were not available for the period of study. Nonetheless, the possibility that piped water and sewers may help to explain patterns of infant mortality is quite good. Again, the relationship between infant deaths and low elevations points to the unhealthy influence of using the street gutters to dispose of household wastes. With wastes flowing openly in the streets and ultimately collecting at the lowest point, it is not surprising that low-lying areas had high infant mortality rates. Additionally, indoor plumbing releasing into cesspools and exceeding their capacity increased leakage into the water supply. The contaminated water traveled downhill, just like surface water, polluting the water sources at lower elevations until drinking water chlorination was adopted in 1911 (Olson 1997).

This thesis contains a few shortcomings that may have impacted the results. First, land use is a difficult variable to correlate with infant mortality, or any other health related variable. Many different factors influence health and not all industries produced the same types of wastes or disposed of them in such a way that they could affect neighborhood health. It is possible that if studied at a finer scale, it would be shown that some industries might have created a hazardous environment in a localized area. Even current epidemiology studies that consider local environmental conditions in their study of disease causation tend to be inconclusive; the classic example of this is cancer (Gardner 1992). Some diseases are decidedly environment dependent, such as malaria, which will occur in hot, humid climates when there is standing water. Gastro-intestinal diseases also tend to be environmentally influenced, stemming from contaminated water.
Most infants in nineteenth century cities died from gastro-intestinal diseases. While surface land uses do not demonstrate a correlation to infant deaths in Baltimore, possibly the subsurface land use of piped water did directly affect patterns of infant mortality.

Two other problems with this study are with the Vital Statistics data. Not all of the infant deaths in 1880 could be mapped. Most of the infant deaths left off the map were excluded because the address on the death certificate was illegible. Even when attempts were made to read the addresses, not enough letters could be deciphered to identify the street name. Other problems were in the information on the death certificate itself. The physicians did not always include a house number, or distinguish whether or not the house was on the north, south, east, or west parts of streets like North Ann Street and South Ann Street. Some streets, while listed in the street index, could not be found on the Sanborn maps. This happened only in a few cases and usually involved alleys. Two-thirds of the infant deaths were mapped and those that were left out appear to have occurred at random and should not have affected the results. The second problem with data from Vital Statistics is that birth data were not available for 1880. For the chi-squared analysis a more accurate measure of infant mortality by ward would have been to know how many infants were born in each ward, rather than the entire population. Vital Statistics required the recording of births beginning in 1875, but they were not accurately recorded in 1880, as the requirement was difficult to enforce and carried little to no penalty.

Despite the limitations of the data, the results of this thesis help to define some aspects of the “urban effect.” The urban effect is a complex combination of urban, social, and environmental factors. While the urban effect is still undefined, I conclude for 1880
Baltimore that one part of the built environment that had little or no influence was industrial land use. Urban infants died in large numbers in 1880 Baltimore, but those deaths do not seem to be related to proximity to industrial land uses. Since the IMR remained high in Baltimore, some aspect or aspects of the urban environment must have influenced infant mortality patterns. The map of infant deaths with its distinct clustering shows that deaths tended to cluster in low-lying areas, a finding similar to Williams (1992) study that identified higher rates of infant mortality in low-lying areas of Sheffield, England. Since low elevation alone does not explain infant mortality patterns, further research is needed to investigate possible socio-economic reasons for this spatial pattern and other possible environmental factors that might have been at work, such as the location of sewers and piped water.

Contemporary observers understood that low-lying environments without clean water and sewerage were dangerous to health. The Board of Health recognized the need for improved sewers and drainage in the city as a whole and particularly in low-lying areas as a means for improving health. Despite the annual call for improved drainage by the Board of Health, the city council did not implement a comprehensive sewer system until 1905 (Boone 2002). City officials were aware of environmental problems in the city, but chose not to act upon that information.

A significant accomplishment of this research is the compilation of empirical evidence concerning the distribution of infant deaths in a North American city. North American infant mortality studies are limited by a lack of fine-scaled studies, which hampers the development of theory. The Vital Statistics death records for Baltimore provided a rich resource that provided a means to map each infant death and record the
cause of death. This map displayed patterns of infant mortality previously only suspected, demonstrating that infant mortality was uneven and concentrated in low-lying areas.

The results of this thesis and the database created in the GIS add to the long-term ecosystems research being conducted by the Baltimore Ecosystem Study. The GIS includes valuable data that reveal that state of public health in nineteenth century Baltimore. The land use database permits a picture of the city in 1880, where people were living compared to in particular its residential and industrial geography. The infant death map also paints a picture of Baltimore’s urban environment and what parts of the city were unhealthy for humans.

This study of infant mortality provides a glimpse into the state of public health in late nineteenth century Baltimore. Understanding the landscape of death and disease is important because it was a critical factor in the urbanization process. High mortality and morbidity rates discouraged investment in commerce and industry. Spikes of infant deaths in the summer months in low-lying areas encouraged early suburbanization to the piedmont. While immigrants moving to the central city persuaded wealthier Baltimoreans to move to the periphery, the high rates of disease associated with those areas was another reason to move out of the core, beginning a process of social, economic, and racial segregation that continues to define modern Baltimore. The spreading out of the city was supported equally by positive reactions to poor health, including the development of infrastructure. New sewer lines and piped water, made possible by comprehensive plans for city services, allowed city dwellers to move further out and continue to enjoy its amenities. The need to improve public health required comprehensive planning, and comprehensive planning required comprehensive
government focused on citywide needs instead of the needs of individual wards.

Progressive politics grew out of reform, but was also an inevitable consequence of the need to coordinate and professionalize urban governance, including the development of public health agencies and comprehensive infrastructure. Increasing government control over land use planning, building codes, public health, and other services defined to a great degree the shape, size, and characteristics of the twentieth century city.

The implementation of the public health improvements was a critical moment in urbanization. In terms of both technology and governance the need to improve public health and create comprehensive policies tended to force modernity on cities. Public health infrastructure expansion encouraged the spread of population and services, under the direction of new comprehensive plans, to peripheral areas both urban and suburban. At the same time that public health infrastructure brought health benefits, it altered urban hydrology, encouraged urban sprawl, and increased water consumption. The infrastructure built in the late nineteenth century in response to public health concerns radically altered the physical, social, and built-up characteristics of this town on the Patapsco.
REFERENCES

Secondary Sources


**Primary Sources**


Board of Health. 1876. *Annual Report of the Board of Health to the Mayor and City Council of Baltimore*.

Board of Health. 1877. *Annual Report of the Board of Health to the Mayor and City Council of Baltimore*.

Health Department. 1879. *Annual Report of the Health Department to the Mayor and City Council of Baltimore*. 
Health Department. 1880. *Annual Report of the Health Department to the Mayor and City Council of Baltimore.*

Health Department. 1881. *Annual Report of the Health Department to the Mayor and City Council of Baltimore.*

Health Department. 1882. *Annual Report of the Health Department to the Mayor and City Council of Baltimore.*

Health Department. 1884. *Annual Report of the Health Department to the Mayor and City Council of Baltimore.*

Health Department. 1885. *Annual Report of the Health Department to the Mayor and City Council of Baltimore.*


Department of the Interior, Census Office. 1880. *Compendium of the Tenth Census.*