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Philadelphia Before I-95: Uncovering the Lost Wealth and Neighborhoods Destroyed by the Delaware Expressway

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Dedication

This thesis is dedicated to the memory of my father, Donald Raymond Edmonds Jr., who passed away suddenly during the course of my research for this work. An avid lover of the outdoors and adventure, he instilled in me an interest in geography and maps at an early age that led me to pursue an education and then a career in this field. He had deep roots in Philadelphia as an ironworker in the city for 30+ years, and I know he would have found the historic structures and lost neighborhoods that this thesis uncovers just as fascinating as I have. There were many times I wished I could have asked him about this pivotal period in the city's history. This thesis is dedicated to honor the legacy of his life and his example of living with a greater hope.

"For he waited for the city which has foundations, whose builder and maker is God."
(Hebrews 11:10)

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Along with my father, my mother has been a source of constant encouragement in my educational and professional pursuits. She taught me early on the importance of pursuing higher education and has never stopped supporting me in all my endeavors.

Above all, I would like to thank my amazing wife. She has gracefully endured my absence between my full-time job during the day and my graduate studies at night. Whenever I felt discouraged over the seemingly unending nature of this thesis, she has always swooped in and uplifted me to keep going. I am incredibly thankful for her companionship and support during this time. This thesis is a shared accomplishment with her.

Abstract

This case study investigates the demolished structures and lost wealth due to the construction of the Delaware Expressway (I-95) along Philadelphia's Center City waterfront. The history of the Delaware Expressway is embedded in a larger freeway-building era in the United States that led to the destruction of urban neighborhoods throughout the country. Yet the neighborhoods that once occupied these corridors have fallen out of the collective memory, and there exists a lack of research analyzing the original conditions of these areas before freeways permanently changed them. This thesis seeks to understand the historical context of freeways in the United States that led to the construction of the Delaware Expressway, calculate the tax revenue potential if the residential dwellings in this corridor still existed today, and digitally recreate one of the impacted neighborhoods, Southwark, in a 3D environment. By using a comparatives sales method, the results of the fiscal analysis determined that the current tax value of these dwellings would be $8.23 million annually if the structures still existed today. This historical perspective is especially relevant given the passage of the 2021 Bipartisan Infrastructure Law, which authorizes a level of funding unseen since the Federal-Aid Highway Act of 1956. As transportation planning in the United States enters the next chapter of its history, this research provides an important analysis and historical context of how freeways impacted the built environment during 1950s-1970s in order to better guide transportation infrastructure going forward.

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The history of transportation planning and infrastructure has come into the national spotlight in recent years. With much of the highway infrastructure in the United States approaching or, indeed, passing their 50-year lifecycle, the federal government has long debated the need to address the backlog of maintenance requirements (National Public Radio, 2019). Most recently, the debates leading up to the sweeping Bipartisan Infrastructure Law passed in 2021 kicked off a nationwide conversation about the state of transportation infrastructure in the United States and the car-centric system it predominantly supports. Within the sweeping $1.2 trillion in federal funding that the bill authorizes, $550 billion is dedicated to new spending on roads, bridges, broadband, public transit, power grids, water systems, and more (McKinsey & Company, 2021). Unsurprisingly, it has received criticism from both sides of the political aisle. While some political leaders have expressed concern over the size of bill and inclusion of projects not traditionally seen as infrastructure, others have argued that is does not go far enough in addressing social and environmental issues (Hulse, 2021; Cochrane and Weisman, 2021). Notably, it has also provoked criticism from a growing anti-highway expansion coalition in the United States. These organizations argue that the bill funds much of the same car-centric infrastructure projects that will only contribute to the growing maintenance backlog after the end of the next infrastructure lifecycle (Strong Towns, 2021). They point out that large infrastructure projects burden local and regional governments with long-term liabilities that they cannot afford to maintain while inducing demand for more traffic that negates any congestion relief the extra capacity would initially provide (2021). These debates at the local, state, and federal level have propelled the history of freeways and their role in society to the forefront of the nation's consciousness.

To better understand the widespread role that highway infrastructure plays in the lives of Americans, it is important to review the Federal-Aid Highway Acts of 1944 and 1956, which created the nation's interstate system as it exists today. In contrast to the mixed reaction the 2021 Bipartisan Infrastructure Law has recently received, these Federal-Aid Highway Acts were universally applauded and celebrated (Rose and Mohl, 2012, p. 84). Although very few observers foresaw the impending destruction this new freeway network would cause in cities, most private and public perceived freeways as the salvation of the mid-20th century city (DiMento and Ellis, 2013, p. 106). Due to the sky-rocketing rates of car-ownership from the early 1900s, cities were overwhelmed with traffic congestion and desperate to modernize their roadways to accommodate the car (Brown *et al.*, 2009). Downtown businesses were concerned that if their customers could not easily access their stores, they would take their dollars and shop at the nascent suburban commercial scene instead (Teaford, 1993, p. 18). Moreover, cities were losing their populations to the suburbs at a concerning rate and were desperate to pave a way for them to return to the city (1993, p. 20). Urban freeways were thus perceived and presented as an unquestionable good for the city and county at large. Many influential voices in governments positioned freeways as a vital component in to achieving prosperity in postwar America, a sentiment echoed in the narratives surrounding pro-growth highway policy today (Rose and Mohl, 2012, p. 93; Strong Towns, 2021).

These Federal-Aid Highway Acts effectively established the car as the primary mode of transportation in the United States and fundamentally transformed the landscape in the United States to a degree unseen before or since (Rose and Mohl, 2012, pp. 95-96). The effect was especially devasting for cities. The traditional approach of incremental development in urban areas that had once centered around public transit systems was suddenly upended as highways enabled the creation of far-flung suburbs and low-density

sprawl (Baum-Snow, 2007). Urban residents who had means readily moved to these new suburban communities, leaving behind abandoned neighborhoods that fell into disrepair and quickly became blighted (Teaford, 1993, p. 11). As part of their effort to battle against decentralization and blight, cities implemented urban renewal campaigns that resulted in the widespread clearance of "blighted" neighborhoods to make way for public housing and freeway construction (Heller, 2009, p. 33). These freeways tore through vibrant neighborhoods, displaced residents, destroyed historic buildings and artifacts, and permanently transformed the city as a domain for automobiles. Often, freeway routes were purposefully routed through minority communities under the guise of "blight clearance" in order to displace and further marginalize these populations (Archer, 2020). The recent debates around the 2021 Bipartisan Infrastructure Law have shed renewed attention on this problematic history, along with an increased awareness of the significant social, economic, and environmental harms freeways have wrought in cities (Nardone *et al*., 2020; Brown *et al.,* 2009).

As these freeway projects approach the end of their relatively short half-century lifecycle, local, state, and federal governments today are faced with considering their future. Increasingly, many cities are choosing to remove their freeways altogether as a way to reconnect fragmented neighborhoods and restore the urban fabric (Khalaj *et al.,* 2020). While there are many contributing factors that lead to the removal of a freeway, financial obligations are commonly cited (2020). Due to the massive funding required to redesign, repair, and maintain these megastructures, many state and local agencies have found it cheaper to remove freeways (2020). The literature contains many case studies that have documented the positive impacts that freeway removal has on a city's economy, environment, and social wellbeing (Seattle Urban Mobility Plan, 2008; Iskandar, 2014). Freeway removals

have caught the imagination of the larger public and have slowly become part of the national conversation around transportation planning (Mohl, 2012).

The Bipartisan Infrastructure Law, for the first time, has created a federal program aim at addressing the harms that freeways have caused communities. The "Reconnecting Communities" program has dedicated $1 billion of funds to local and state governments over five years on freeway mitigation projects. While this initiative symbolizes a notable step away from the infrastructure projects that normally receive funding, it pales in comparison to the $550 billion in new spending that was authorized for conventional projects. Moreover, there are state-funded highway projects in progress today that are on track to mimic the consequences of the original 20th century freeway projects (Horrox *et al.,* 2022). Far from being a relic of the past, the proposed destruction of homes, businesses, and natural areas for the construction of freeways is a current reality for many localities around the United States (2022). Now with the distribution of $1.2 trillion for a variety of infrastructure projects, anti-highway expansion advocates are urging state and local transportation departments to "resist the temptation to fall back on old habits and replicate patterns of behavior learned over the course of a century of highway-centric thinking in transportation policy" (2022). The prevalence of car-centric policies signals a need for deeper insight into how freeway projects impacted 20th century cities a. Presently, much of the literature on this topic analyzes the impact of highways on people and cities. There is a notable gap in investigating the "geographies of the past" and the neighborhoods that once inhabited the corridors where today's freeways are currently situated (Sauder, 1980, p. 212). The original state of many of these neighborhoods have fallen out of their city's collective memories and are long forgotten. As a result, local leaders and residents lack both the contextual background to understand what was sacrificed for the construction of freeways as well as a vision for what their communities could once again be. In order to "resist the temptation to fall back on old

habits" and imagine a new way forward, it is vital to recover these lost neighborhoods so that decisionmakers can implement informed transportation policies.

Philadelphia presents an ideal case study to recover these geographies of the past. Like many other cities during the first half of the 20th century, it suffered from decentralization, blight, and traffic congestion (Knowles, 2009). The mass adoption of the car led to more urban residents resettling in increasingly distant suburbs, taking their tax revenue with them, and creating intolerably long commutes to Center City. City leaders saw freeways as a vital component to a wider urban renewal program that would save the cites, recapture the tax base, and open up access to its central business district to suburban shoppers. (Bauman, 1990). Philadelphia began construction on several freeways before the Federal-Aid Act of 1956 unleashed unprecedented federal funding for highway infrastructure across the country. One of the most ambitious freeway projects it undertook under this new federal funding was the Delaware Expressway. This expansive freeway is the portion of Interstate 95 that falls within Philadelphia's jurisdiction, and its construction represents a controversial and contentious chapter in Philadelphia history. Running along the Delaware River, this project destroyed some of the most historic parts of one of the most historic cities in the United States and ultimately separated the city from its river (Kyriakodis, 2011). Many homes, businesses, and local institutions were also cleared for its right-of-way. In the several decades since its completion, the Delaware Expressway has drawn widespread criticism as an impediment to the successful development of the waterfront (Inquirer, 2007). Within the past decade, however, the city of Philadelphia has initiated a series of redevelopment projects aimed at reconnecting the city to its river through the non-profit Delaware River Waterfront Corporation (DRWC). Yet in their master plan for the waterfront, the DRWC does not include an analysis of the original state of this corridor that once linked the city to the river. As transportation policy continues to evolve in the United States and decisionmakers wrestle

between freeway removal and expansion, uncovering these geographies of the past is vital to guiding cities into the next chapter of American transportation planning.

Using an urban historical geography and planning theory framework, this study seeks to investigate the wealth that was lost with the construction of the freeway and demonstrate the ability of modern technology to render one of these historic communities in 3D (Golan, 2009; Fainstein and Defilippis, 2016). Specifically, this research addresses the following questions:

1) What is the contextual history around freeways in the United States that led to the construction of the Delaware Expressway?
2) Which buildings and parcels were destroyed as a result of the Expressway's construction?
3) What would be the current property and wage tax revenue of the residential dwellings that were destroyed if they existed today?
4) How can modern GIS technologies and game engines be used to digitally recreate historic areas, such as Philadelphia's Southwark neighborhood in 3D?

This thesis is organized in the following manner. This first chapter has given an overview of freeway planning and its relevance in today's world. The second chapter reviews the existing literature on the history of freeways and also covers a brief history of the Delaware Expressway. Chapter 3 outlines the methodology used to answer research questions 3-5 listed above. Chapter 4 presents these results and Chapter 5 discusses them. Finally, Chapter 6 gives the conclusion.

It should be noted that while this thesis uses the name "Delaware Expressway", this freeway is colloquially referred to by Philadelphians as simply "95". In this study, it is called the Delaware Expressway to specify the segment of I-95 within Philadelphia. Additionally, an online companion to this thesis can be found in the reference list (Edmonds, 2023).

Chapter 2: Literature Review

Introduction and Theoretical Framework

To understand the political, economic, and cultural context that led to the development of the Philadelphia's Delaware Expressway, it is important to first review the broader history of expressways in the United States. Due to wide-ranging nature of this topic both geographically and temporally, there are many different analytical approaches available to frame this history. This review, however, will approach the history of urban expressways in the United States within two specific frameworks: urban historical geography and planning theory (Golan, 2009; Fainstein and Defilippis, 2016). Urban historical geography seeks to uncover the geospatial relationship between the environment (natural and built) and the social fabric of the past (Winder, 2009; Van Sant, 2020). This framework also encompasses the macro-forces that influenced and shaped the evolution of cities and town (Golan, 2009). Meanwhile, Fainstein and Defilippis define the central question of planning theory as the following: "What role can planning play in developing the good city and region within the constraints of a capitalist political economy and varying political systems?" (2016). While planning theory has evolved and changed throughout its history, this question provides a common throughline that defines city planning as a function of the economic and political system it operates within. Using this dual lens of urban historical geography and planning theory provides allows this thesis to not only analyze the forces that shaped Philadelphia's geography of the past but also critically examine the planning decisions that produced this geography against a hierarchical value system with respect to what makes the "good city".

The history of freeways is long and complex. It involves many different actors, events, and perspectives that is difficult to distill down to a single narrative. Readers looking for a

comprehensive volume on this topic should explore other sources (Teaford, 1990; Rose and Mohl, 2012; Foster, 1981). However, the following historical narrative seeks to understand the contextual framework at the national scale that led to the demolition of a historical corridor in Philadelphia for the construction Delaware Expressway. This review will provide an overview of the chronological events that resulted in the rise of urban expressways starting with the early 20th century. It will then move to review the arrival of the automobile, the traffic this new transportation technology caused, and how cities tried to integrate automobiles into their urban fabric. The next section examines the federal government's highway funding in the mid-20th century and the impacts that the new interstate system, championed by engineers, had on cities. Next, the grassroots reaction to this top-down transportation planning is reviewed. Then, the historical overview concludes with a focus on Philadelphia's freeway history, specifically with the construction of the Delaware Expressway. Lastly, the literature around the fiscal impacts of freeways will be reviewed in order to identify gaps in the research and how the work presented in this thesis builds on a growing body of work around this topic.

Automobiles in the New Century

If city planners at the beginning of the 20th century could have foreseen how the mass adoption of the automobile would impact the American landscape for the next century – the decentralization of the city and the acceleration of suburban development – they would have rushed to welcome it with open arms (Brown *et al.,* 2009). Indeed, overcrowding in the city core was the major planning issue of the day, and early planners perceived the automobile as the great technological panacea to address their cities ills (2009; Burnham, 1909). The turn of the century marks a time when millions of hopeful immigrants and rural families were

pouring into American cities annually to find work in the Industrial Revolution's manufacturing scene, and city life was often characterized by a malady of woes brought on by this era: severe overcrowding, widespread poverty, unsanitary living conditions, dangerous working conditions, blighted neighborhoods, suffocating pollution, widespread slums, and an unending cacophony of noise (Foster, 1981). These horrific conditions were described by writers of the time in works such as Upton Sinclair's notorious "The Jungle" and Stephen Crane's "Maggie: A Girl of the Streets" (Sinclair, 2003; Crane, 1996). This dismal landscape was largely a manifestation of the city's limited transportation. Indeed, before the introduction of the horse-drawn streetcar in 1840, cities rarely extended more than two miles in radius from their downtowns (Foster, 1981, p. 15). And even after the innovation of the electric streetcar by the turn of the century, this distance was extended slightly to five miles (Teaford, 1990, p. 3). Up until the early 20th century, most city dwellers went about their daily routines strictly by foot, and their cities were accordingly scaled to this universal mode of transportation (Foster, 1981). While walkability allows residents to easily access their daily needs and is lauded by modern planners as a key component to achieving social equity, the sentiment was vastly different in the midst of the industrialized city (Grengs *et al*., 2013). Without building codes, sewage infrastructure, or land use regulations to help ensure the health and safety of the public, the landscape was dominated by overcrowded slums (Wirka, 1996; Fischler, 1998). The urban sprawl that developed from industrialization and rapid population growth put enormous pressure on the city core, and city planners eyed horizontal development as the key to help decentralize the population and relieve overcrowding (Foster, 1981).

When the automobile first arrived on the scene at the turn of the century, the streets of the American city's downtown was a chaotic jumble of wagons, pedestrians, horses, and electric streetcars. Horses especially were a nuisance in an urban environment. Not only did

they frequently jump, bite, and kick, but also contributed significantly to the city's already unsanitary waste disposal (Flink, 1975). Flink notes that during this time in New York City, 2.5 million pounds of manure were dumped on the streets every day and 15,000 dead horses had to be removed every year (1975, p. 34). Cities readily welcomed the innovation of the electric streetcar as a mode of transit, which helped decentralize cities by opening new land for development (Foster, 1981). This development pattern is still visible in many cities today, known as "streetcar suburbs" (King and Fischer, 2016). However, the number of streetcars converging on the downtown spiked as more trolley lines were built and thus further acerbated congestion on the narrow city streets (Foster, 1981, p. 18). The automobile, on the other hand, offered a greater degree of personal freedom. Initially viewed as "little more than toys for the rich", it soon caught the attention of city leaders as a potential tool for decentralization (Foster, 1981, p. 21). And its popularity soon sky-rocketed. By the year 1912, traffic counts showed that for the first time there were more vehicles on the road than horses in New York City (McShane and Tarr, 1997). As Ray Stannard Baker, an influential writer of the time, observed of the automobile: "the experimental plaything has become a practical necessity" (Baker, 1899). He also wrote on the cost-savings of owning and maintaining automobiles compared to the costs associated with horse-drawn carriages, claiming that within five years of ownership the automobile cost 20% less than its horse-powered counterpart (1899). The potential of automobiles to transform the city was also recognized by another burgeoning profession at the turn of the century – city planners.

The Automobile Meets the City

Although city planners had initially welcomed the automobile as a catalyst for decentralization, by the 1920s it had become clear that the 19th century city was not prepared

for its mass adoption. Cities were overwhelmed daily with a flood of commuting motorists brought on by exponentially high automobile ownership. Between 1920 and 1929, the number of registered automobiles in the United States had tripled from 8.1 million to 23.1 million (Federal Highway Administration, 1997). At this scale, observers soon began to note the negative impacts associated with this new mode of transportation: constant noise, health concerns about the fumes, and the congestion of previously quiet residential streets (Foster, 1981). Cities also struggled to provide the space required by automobiles. A contemporary civil engineer noted this dilemma with an amusing metaphor: "it is a good deal as if our ladies and our men, also, wore a hooped skirt arrangement ten or twelve feet in diameters and went through the sidewalks. If that were done we should have a riot immediately" ("Proceedings", 1929, p. 574). And yet, the rates of car ownership showed no signs of slowing down. The automobile's quick ascendency into American culture was a result of decreasing manufacturing costs and the flexibility it offered its owners (Foster, 1981; Rose and Mohl, 2012). City residents were no longer bound to the sporadic schedules and outages of the streetcars for their daily needs– they could now work, shop, and enjoy recreational drives whenever they chose (Foster, 1981, p. 61). It was also increasingly seen as a status symbol (Foster, 1981). And although streetcar companies experienced their peak ridership during this decade, they began to suffer from a negative public image (1981; Barrett, 1983). Owned by a mosaic of private companies that lacked any coordination in route planning, these companies made enormous profits by selling off the land adjacent to their newly announced routes. Planners were also shifting away from streetcars. Due to their lucrative business in land speculation, streetcar companies were often involved in corrupt, backdoor dealings with public officials and thus were viewed suspiciously by planners and the public (1981). Foster notes that while many modern planners praise the old streetcar system, they "often forget that early trolley promoters, seeking profits first and foremost, were often far

more interested in selling land than in providing unified transit systems" (King and Fischer, 2016; Foster, 1981, p. 39-40). Rose and Mohl also paint a colorful picture of what the average streetcar scene looked like during this time: "travelers…often encountered traffic delays and hazards caused by tracks and wires, and all faced encounters with pickpockets, drunks, thugs, and the obnoxious. Streetcars themselves were dreadfully overcrowded. Passengers were 'packed like sardines in a box, with perspiration for oil'" (2012, p. 3). Thus, with the decline of mass transit and the negative impacts of mass car ownership, city planners began to draw up creative new plans to retrofit the city for the automobile.

The Planners and the Freeway

Between 1920 and 1940, planners proposed many creative solutions to address the traffic problem. Their first attempts focused on restructuring the existing built environment with incremental improvements such as with street widening, traffic control devices, and establishing road hierarchies (DiMento and Ellis, 2012, pp. 16-17). While these efforts provided some temporary relief, the ever-increasing rates of automobile ownership soon negated the value of any increased road capacity. Additionally, projects like street widening could be extremely expensive, especially if it involved the demolition of adjacent buildings (2012; Foster, 1981). Planners also lamented the rigid grid pattern that characterized the American city, which they complained did not leave "much chance left for tinkering" (Bel Geddes, 1940). It became increasingly clear that to address the issue of traffic congestion, a new type of roadway was needed. Planners and engineers looked to the parkway for such inspiration (Brown *et al*., 2009). Originally intended for recreational rides through the country, parkways exhibited two design features that allowed for smooth traffic flow: limited-access (i.e., controlled entry and exit points) and grade separation (i.e., elevated or sunken to avoid intersections) (2009). Ordin demonstrates that cities began to decouple

parkways from their recreational origins as they recognized their traffic-service potential (1992). During this time, the term "freeway" was coined to describe this new type of highway. While there are several variations of this term – speedway, limited way, superhighway, and expressway – this thesis uses the term "freeway", following the consistency of its use in the literature (Brown *et al.,* 2009; Foster, 1981; DiMento and Ellis, 2013; Rothstein, 2017). Planners and engineers soon began to incorporate these freeways into their plans, often in utopian ways. One of the first notable plans published during this time was produced by the Detroit Rapid Transit Commission in 1923. The plan recommended that the city build a sweeping network of 225 miles of dual-divided freeways with high-speed transit rail lines situated in the median (Foster, 1981, p. 81). The renderings for this plan contain elements of the parkway ideal, with tree-lined thoroughfares and pedestrians walking mere feet from the highway ("Proposed Super-Highway", 1924). DiMento and Ellis argue that such renderings, while common in the literature produced during this time, betray the ignorance of planners regarding this new technology (2013, p. 19). These idealized images did not show the roaring noise of thousands of high-speed traffic, the extensive pollution from exhaust, the traffic accidents and fatalities, and the fragmenting effect that freeways exhibited. Yet, planners recognized the freeway's potential as a tool for land use planning and were often willing to sacrifice their traffic-service function to achieve these goals (Brown, 2005, p. 4; DiMento and Ellis, 2013, p. 9). Brown *et al.* point out that the vast majority of these early freeway plans contained multimodal elements that wove into the existing urban fabric and exhibit a sensitivity to the surrounding built environment (2009). Such elements would not be out of place at a planning conference today. Harland Bartholomew, one of the most prominent planners of the first half of the 20th century, perhaps best exemplifies the planning view toward freeways. Throughout his career, Bartholomew positioned freeways as an integral part of a larger transportation system that should serve the needs of the city and its

residents over the needs of the motorist (Brown, 2005, p. 11). Advocating for a "society first" vision of freeways, he believed that urban freeway planning should be left in the control of local officials instead of state or federal highway engineers who were unfamiliar with the complexity of the urban environment (2005). This perspective was held by many planners who "saw *their* profession as the indispensable guardian of the city's physical form and assumed that they could play a leading role in determining the location and design of new urban highways" (DiMento and Ellis, 2013, p. 21). However, this "society first" vision of the freeway's role in the city was not shared by the profession tapped by the federal government to build the nation's freeway network: highway engineers.

The Highway Engineer and the Freeway

Highway engineering evolved out of the field of civil engineering in the late 19th century to help states design and route highways through rural areas (DiMento and Ellis, 2013, p. 14). State highway departments began to appear after the establishment of the Office of Road Inquiry, the nation's first transportation agency, within the Department of Agriculture. One of the primary goals of this new federal agency was to improve rural roads so that farmer could "get out of the mud", and thus began forming institutional channels with state highway engineers (2013). Soon after the reorganization of the Office of Road Inquiry into the Bureau of Public Roads in 1915, federal funding became available to states for rural road construction (Rose and Mohl, 2012). In response, states rushed to establish their own highway departments to capture federal funding and build their own highway networks (2012). This intuitional relationship between state and federal highway engineers was very influential in the construction of today's interstate system, as discussed below. However, it is important to note that highway engineering developed within a rural context, where engineers

could experiment with wide and straight road designs to facilitate quick and easy traffic flow, free from the conflicts of an urban environment. Whereas city planners drew up transportation plans that balanced the many competing interests of the city, highway engineers designed freeways with a singular focus: to move automobiles as quickly and as safely as possible (DiMento and Ellis, 2013, p. 80). This ideology was reinforced with the use of gasoline taxes to fund highway departments, and "because roads were financed from user taxes, or so went this reasoning, [highway engineers] had to produce benefits for them" (Rose and Mohl, 2012, p. 9). By the time cities had reached a crisis point of traffic congestion in the 1920s, highway engineers had a product that was in high demand. They also had powerful backing at the federal level. Under the careful direction of Thomas MacDonald, the commissioner of the Bureau of Public Roads from 1919 to 1953, highway engineering became perceived by important decisionmakers as an objective, scientific, and credible professional. Unlike planners, whose proposals were viewed as subjective, vague, and idealistic, engineers could point to their detailed calculations on traffic counts and desire lines to back their projects. This public image greatly aided their freeways projects in a way that planners lacked. Many prominent highway engineers, such as Robert Moses, openly sneered at the idealistic plans drawn up by planners: "I do not advocate rejecting, tearing down and rebuilding everything in the country, nor long-range academic planning of works which do not commend themselves to the average citizen and taxpayer" (Moses, 1943, p. 22). As a result, when federal funding became available in the 1940s and 1950s to construct freeways through cities, there was no doubt as to which professional would lead the campaign.

The Growing Pains of Decentralization

By the year 1940, cities were beginning to realize they had a problem. The centennial census figures demonstrated a worrying decline in urban populations driven by an exodus of white, middle class city dwellers to the surrounding suburbs (Teaford, 1990). With the affordability of the car and its expanding road network, these new and spacious suburbs were now more accessible than ever. The decentralization plans dreamed up by planners earlier that century had worked too well, it seemed. And as city neighborhoods were increasingly abandoned, blight settled in. "Blight" soon became the byword that city planners, officials, and business groups to describe the "the process of physical deterioration that destroyed property values and undermined the quality of urban life" (Teaford, 1990, p. 11). Rothstein, however, takes a more critical view, stating that "by the mid-twentieth century, 'slums' and 'blight' were widely understood euphemisms to describe African American neighborhoods" (2017, p. 127). These racial undertones – and sometimes overtones – are explored below. Nevertheless, the very real problems of decentralization and deteriorating building stock spelled doom for cities. Harland Bartholomew, who decades earlier had advocated for horizontal development to relieve the overcrowded urban conditions, now observed in 1940 that "the financial structure of cities, as well as the investment of countless individuals and business firms is in jeopardy" (Bartholomew, 1940, p. 61). The stream of residents moving to the suburbs brought along their tax revenue with them, and the neighborhoods they left behind were a drain on the city's treasury. A study performed around this time in Cleveland demonstrates the stark insolvency cities were facing. It was found that a deteriorating neighborhood in the city generated $10.12 tax revenue per person, but the cost of services per person was $61.22 (Navine *et al*., 1934). The problem was exacerbated by the emigration of poor, minority communities into major cities that occurred during the mid-20th century. Seeking to escape racial segregation, oppression, and outright violence, millions of black Americans migrated to northern industrialized cities and found cheap housing in the

emptying inner cities. This influx of black residents had the effect of hastening the exodus of white residents, who gradually saw the city as "becoming a black domain and thus off limits" (Teaford, 1990, p. 5). Thus, by the dawn of World War II, cities were struggling against white flight, rising racial tensions, and decentralization.

Federal policies also appeared bent on hollowing out the city. In response to the collapse of homeownership during the wake of the Great Depression, the federal government implemented several policies aimed at boosting rates of homeownership in the 1930s. Up until this point, homeownership had been out of reach for working-class families. Bank mortgages required 50% down, interest-only payments, and full repayment within five to seven years (Rothstein, 2017, p. 63). Default loans were a huge risk, and there was no federal system to insure mortgages with more favorable terms to potential homeowners. In 1933 and 1934, President Franklin D. Roosevelt addressed this issue by creating the Home Owners Loan Corporation (HOLC) and the Federal Housing Administration (FHA), respectively (Jackson, 1985). The HOLC's purpose was to rescue mortgages that were at risk of defaults by purchasing the original mortgage and issuing a new one with more favorable terms for the homeowner (1985). To assess the risk of each new potential mortgage application across the country, HOLC created a series of maps that rated each neighborhood in major cities according to their perceived risk of default. Low risk neighborhoods were symbolized with green and high-risk neighborhoods were shown as red. In these now infamous redlining maps, the presence of black residents alone was enough to earn certain neighborhoods as high risk (Rothstein, 2017). The University of Richmond's Digital Scholarship Lab has thoroughly documented the racist rhetoric used in the justification for high-risk ratings ("The Digital Scholarship Lab", n.d.). Meanwhile, the FHA's purpose was to insure existing mortgages that were at risk of default. This agency actively discouraged local banks from providing loans to urban areas and instead supported insuring mortgages in new suburban

communities (Jackson, 1985). These policies wreaked havoc on cities and the growing minority communities that lived in them. Harland Bartholomew and other city planners heavily criticized these federal policies that essentially promoted the "abandonment of the older slum districts and, also, of practically all the blighted districts" and claimed that these policies had "the effect of accelerating decentralization and of undermining the value of property in three-fourths of the main body of the city" (Bartholomew, 1940, p. 64). The Housing Acts of 1937 and 1949 has a similarly detrimental impact on inner cities. Although their original intention to provide affordable housing during the postwar housing crisis was beneficial, it was used by local governments to clear slums and blighted areas populated by minority communities (Jackson, 1985). As federal policies disenfranchised urban areas and subsidized suburbia, planners leaned on the central business district as the lifeline of the city. The tax revenue generated from downtowns in many cases were enough to offset the decline of blighted neighborhoods, yet even these areas were suffering from the impacts of deterioration and traffic congestion (Teaford, 1990). As commercial activity followed the wave of residents leaving for the suburbs, the dominance of the central business district as the regional commercial hub was waning.

Post-War Physical Determinism

City leaders perceived the chief problem of the city as rooted in its built environment, specifically around the central business district (Teaford, 1990). If deteriorating neighborhoods could be cleared, blight held in check, and the automobile properly accommodated, then it was reasoned that property values could be stabilized and lead to an "urban renaissance" (1990). This mode of thinking finds its origins in the model of physical determinism that dominated early city planning thinking. McKee defines this perspective as

"the idea that manipulation and improvement of the built environment of homes, streets, commercial areas, and open spaces could strongly influence, or even control, social and economic outcomes" (2009, p. 61). The dominance of this theory reflects the victory of physical planning over social planning that played out between planners earlier in the century (Peterson, 2009). City leaders initiated a series of ambitious public works campaigns where "brick, mortar, and asphalt constituted the artillery in this initial offensive against the decline of central cities" (Teaford, 1990, p. 26). The freeway was an integral component of this new campaign, and it constituted the perfect "stone" for the "two birds" of blight and traffic congestion. Not only could highway-building help clear away blighted neighborhoods (and consequently their minority inhabitants), but also easily facilitate the suburban car's journey to downtown businesses. The freeway plans drawn up during this time were extremely popular across all interest groups (Teaford, 1990). Business firms, real estate interest, city leaders, the automobile lobby, highway engineers, city planners, and the downtown commuter all heavily pushed for the implementation of a freeway system. Indeed, they were increasingly perceived as the salvation of the city and integral to post-war prosperity (Rose and Mohl, 2012, p. 101). But such plans remained prohibitively expensive. Up until this point, all municipal roads were the responsibility of their local government, and the capital did not exist at the local level to build these unprecedented megastructures (DiMento and Ellis, 2013). This obstacle was soon overcome with several landmark highway bills.

The Federal-Aid Highway Acts and the New Freeways

In 1944, the Bureau of Public Roads under MacDonald published the *Interregional Highways,* which recommended as official policy for the first time that the nation build an interstate highway system. Acting on these recommendations, President Roosevelt signed the

Federal-Aid Highway Act of 1944, which called for a 40,000 miles highway network and provided 50% of all funding for highway construction (DiMento, 2009). These two documents solidified the dominance of automobiles and freeways in the post-war United States and designated 2,300 miles of interstates through metropolitan areas (Rose and Mohl, 2012). Through funding channels previously established between federal agencies and state highway departments, they accordingly appointed highway engineers, not planners, as the professionals to route and design the freeway network through cities (DiMento and Ellis, 2013). Yet the new interstate was left largely unbuilt, with state departments unable to make up their half of federal funds (Clair, 2014). Not until the landmark Federal-Aid Highway Act of 1956 was passed did the freeway plans that had been proposed for nearly half a century become possible. This legislation provided an unprecedented 90% of the funds for the new interstate system; states were to make up the remaining 10% (Jackson, 1985). Known also the National System of Interstate and Defense Highways, the defense implications of the 1956 Act have largely been debunked as little more than a way to gain bipartisan support for the bill (Clair, 2014). Yet for a country that had dreamed of a modern freeway system for decades, this bill was universally applauded (Rose and Mohl, 2012). The Act again tapped state highway engineers, with their strong institutional ties to the federal government, to lead the designing and routing of the new system through cities. The intricate plans drawn up by planners over the previous decades that had proposed a freeway system embedded in the existing urban environment were scrapped by highway engineers (DiMento and Ellis, 2013, p. 73). As discussed above, these engineers carried over their highway building experience from their rural practice and focused on a traffic service vision of freeways (Brown, 2009). They considered all other concerns as irrelevant (Rose and Mohl, 2012, p. 99). While this approach was suitable for the countryside, it was disastrous for cities.

The construction of the new interstate system through cities resulted in the displacement of hundreds of thousands of people in mostly minority communities, the fragmentation of vibrant communities, and destroyed countless historical sites and artifacts (DiMento, 2009; Brown, 2009; Rothstein, 2017; Kyriakodis, 2011, p. 163). Surprisingly, the federal government included no regulatory provisions to help relocate people after their homes were condemned until the year 1965, by which time most of the interstate had already been built (Rose and Mohl, 2012, p. 100). As discussed above, the destruction of minority neighborhoods, far from being an unintended consequence of urban highway building, was in reality a purposeful approach taken by federal, state, and local agencies (DiMento, 2009). When confronted with the displacement that his agency's proposed interstate would cause in urban areas, Thomas MacDonald claimed that dislocated residents could simply move to the new suburbs and commute to city jobs on new high-speed, multifunctional expressways (1950). Only until recently have studies shown the full impact that freeways have had on cities. Nall and O'Keeffe demonstrate that not only did freeways directly result in the net loss of housing stock through right-of-way demolition but also contributed to a legacy of disinvestment in the communities through which they were routed (2018). According to their estimations, urban freeways resulted in a loss of 200,000 housing units and 375,000 people, of which the vast majority were minorities (2018). Baum-Snow show that the construction of urban freeways greatly accelerated suburbanization and presents the counterfactual that central cities would have grown by 8% otherwise (2007). Furthermore, these highways were often routed through the oldest parts of America's oldest cities (Kobrick, 2010). The destruction of historic sites was so prevalent that in a hearing before Senate, a senator advocating for the National Historic Preservation Act claimed that of the 12,000 historic structures listed on the Historic American Buildings survey, half were destroyed (Muskie, 1966). The literature is clear that freeways also negatively impact the lung health of nearby

residents, disrupt sleep patterns from its noise, and decrease the walkability of neighborhoods leading to more auto-dependency (Brugge *et al.,* 2007; Park *et al.,* 2023; Faulkner *et al*., 2016). Instead of stimulating economic growth and prosperity, urban freeways continued to empty the city of its wealth and heritage.

Backlash to the Freeway

For all their promise, the negative consequences of urban freeways kicked off an anti-freeway movement that rejected the top-down planning they felt excluded from. Grassroots organizations comprised of a diverse set of community members formed to protect their parklands, neighborhoods, churches, schools, and historic sites from the destruction of highway building. Planners also soured on freeways. After witnessing their destructive impact on cities, planners and other observers openly critiqued the highway engineer's single-minded focus on traffic flow. Lewis Mumford, one of the most prominent writers to observe the effect of freeways on cities, wrote in 1963 (quoted at length):

> "Perhaps our age will be known to the future historian as the age of the bulldozer and the exterminator; and in many parts of the country the building of a highway has about the same result upon vegetation and human structures as the passage of a tornado or the blast of an atom bomb. Nowhere is this bulldozing habit of mind so disastrous as in the approach to the city. Since the engineer regards his own work as more important than the human functions it serves, he does not hesitate to lay waste to woods, streams, parks, and human neighborhoods in order to carry his roads straight to their supposed destination. As a consequence the "cloverleaf" has become our national flower

> and "wall-to-wall" concrete the ridiculous symbol of national affluence and technological status." (p. 247)

Mumford echoed the perspective of many of the other anti-freeway advocates, like Jane Jacob, who saw the "ordered complexity" of their communities being wiped off the map (Jacobs, 1961). This bottom-up movement gave rise to the "freeway revolts" of the 1960s and 1970s that had varied success in different cities across the country (Rose and Mohl, 2012, p. 116). By the 1970s, these local forces were able to influence the federal agencies and administrators that had first passed the Federal-Aid Highway Acts, and politicians began to respond to the plight of their constituents. Congress accordingly produced legislation aimed at mitigating the worse effects of urban freeway building with a new regulatory environment: the National Historic Preservation Act of 1966, the National Environmental Policy Act of 1970, the Clean Air Act of 1970, and many more (DiMento and Ellis, 2013). These laws had the effect of increasing construction costs and drawing out the timeline of new freeway projects (2013). Freeway revolts also became integrated into the civil rights movement of the 1960s. As freeways were widely used by city leaders to reinforce racial barriers, black residents decried the destruction of their homes with the mantra "white men's roads through black men's homes" (Jaffe, 2015; Archer, 2020). Due to the growing regulatory hurdles and cultural backlash against urban freeways, the state highway engineers, who had initially possessed the expertise and political power to create and construct highways without question, saw their influence diminishing in the late 1960s and early 1970s (Rose and Mohl, 2012, p. 116). Now in the 21st century, cities have entered into a new era of freeway removal (Khalaj *et al*., 2019). Although not widespread, the freeway removal movement is growing and discussed in more depth below.

Philadelphia and the Delaware Expressway

Philadelphia's history of freeway building demonstrates an interesting case study to examine the influence of federal transportation policies on a locality. By the mid-20th century, Philadelphia was facing the same issues as many other cities across the country. The process of decentralization was emptying the city of its tax base as residents resettled in the surrounding counties, leaving behind blighted neighborhoods that slowly eroded away the urban built environment. It was also experiencing insufferable traffic congestion. The relocation of residents to the suburbs meant more traffic than ever was flooding into the city's narrow streets, causing the downtown business elites to worry that frustrated shoppers would turn elsewhere. A report published by the Philadelphia Traffic Board in 1948 summed up the city's deep concern: "[Automobile congestion triggers] a deadly chain reaction…loss of downtown business…unemployment, property devaluation… a breakdown of municipal services… But the first and heaviest losers are those in the heart of the city; the merchants, industrialists, and business and professional men who make 'downtown' not only the nerve center but the most valuable section of Philadelphia" (Philadelphia Highway Traffic Board, 1948, p. 512). City leaders, anxious to reverse decentralization and the decline of the downtown, initiated a new chapter of policies and projects to bring about an urban renaissance in Philadelphia.

One of the leaders that emerged during this influential period in Philadelphia's history was Edmund Bacon, who served as the city's planning director from 1949 to 1970. Schooled in the Garden City planning philosophy, Bacon believed strongly in the power of urban design and the physical environment to have an impact on the social issues plaguing the city

(Heller, 2009, p. 23). Bacon's ideology of physical determinism led him and other decisionmakers to advocate for physical improvements to the built environment as a way to stem the tide of decentralization and blight (McKee, 2009, p. 61). Their policy prescription to save the city thus consisted of three objectives: housing, redevelopment, and freeways (Bauman, 1990). The Housing Acts of 1949 and 1954 granted the funds that allowed Philadelphia to pursue the first two of these goals. Often, these policies worked hand-in-glove with freeway-building as part of the overall campaign of urban renewal (Teaford, 1990). Housing funds could be used to clear blighted areas that helped make room for the freeways. It is important to note that Philadelphia stood out among its peers as avoiding the mass clearance that characterized other urban renewal movements in other cities during this era (Knowles, 2009). Under Bacon's influence, the city sought to preserve the social cohesiveness of communities and thus engaged in highly targeted blight clearance. Bacon seemed to understand the complications of removing deteriorating building stock, commenting in 1949 that "the very nature of urban blight itself is complex, elusive, difficult to define. The mere spending of money, clearance of areas or building of projects doesn't necessarily constitute a valid attack on urban blight…" (1949). However, this methodology of selective clearance did not carry over to the city's approach with its freeways.

When the Federal-Aid Highway Act of 1944 passed and established the national interstate system, Philadelphia had already developed a regional freeway plan to "save" its central business district (Bauman, 1991). Now, with the federal government promising to fund half of the cost of new freeways, the city's freeway building campaign began in earnest. After heavily lobbying the state's highway department in Harrisburg for Pennsylvania's allocation of funds, Philadelphia began construction on two major new highways: the Vine Street Expressway and the Schuylkill Expressway. The historical documents around these projects demonstrate Philadelphia's unquestionable commitment to the traffic-service focus

on urban freeways (Bauman, 1990, p. 51). In a report to City Council, Philadelphia's Department of Streets claimed the "future economic welfare and expansion of business in the central business district depends upon expediting the movement of vehicular traffic in and out of the district and encouraging more traffic to patronize the district." (1990, p. 50). While planners elsewhere advocated for a transportation system that integrated multi-modal facets and wove better into the urban fabric, Edmund Bacon's Planning Commission was in full agreement with the outlook of highway engineers to build freeways strictly for the car (Knowles, 2009). And yet, the city largely avoided controversy with these early freeway projects (Bauman, 1990). Although the Vine Street Expressway required the destruction of thousands of homes and the Schuylkill Expressway became known as the "Surekill" Expressway for its high accident rate, neither of these highways were as controversial as the Delaware Expressway (Bauman, 1990; Bauman, 1991).

With the unprecedented level of funding that the Federal-Aid Highway Act of 1956 provided, Philadelphia scrambled to secure its share of capital for its most ambitious highway yet: the Delaware Expressway (Kobrick, 2010). Also known as the section of Interstate 95 that runs through the city's boundary, planners had long envisioned a freeway that ran along the city's riverfront due to its industrial character (2010, p. 21). The Delaware River waterfront in Philadelphia represented the birthplace of the city. It was here that William Penn first landed in 1680 and established his "City of Brotherly Love". It quickly became an important city in the New World with an ideal geography as an inland seaport (Kyriakodis, 2011, p. 10). By the mid-20th century, however, the riverfront was no longer a pleasant area. The corridor adjacent to the river was dominated by industrial uses, and pollution and waste regularly spilled into the Delaware River. Commentators reported that the river was not even fit for ships: "acids and gases generated by decaying sewage eat the paint off their hulls, corrode their metal work, and, if they linger long enough, eventually eat holes in their

bottoms" (O'Neil, 1947, p. 62). As a result, this land was cheap and easy to clear for a freeway right-of-way. The location of the Delaware Expressway along the river was also thought to help stimulate the city's floundering industrial economy by acting as the "conveyor belt of Philadelphia", carrying goods throughout the region (Philadelphia City Planning Commission, 1950). The city also saw the Expressway as a vital component to the city's freeway plan that would help relieve the recently built but already congested Schuylkill and Vine Street expressways (Kobrick, 2010). Edmund Bacon's planning commission began preliminary plans for the freeway's routing in 1951 (2010, p. 70). Typical of the top-down nature of planning during this time, the public was neither consulted nor informed of the freeway until after studies and routes were already established (2010). Besides the industrial districts, the route was also projected to run straight through the Southwark neighborhood, a mostly white, working-class community in South Philadelphia. In contrast to the experience of many other cities, Philadelphia's freeways did not impact minority neighborhoods. However, as the waterfront represents the oldest section of the city, there was outrage over the potential destruction of historic structures. Concerning the Southwark community, a Pennsylvania Senator pleaded with the Federal Highway Administration to create a historical record of the area to be cleared, saying that "one of the great concerns of the people of Philadelphia about the Delaware Expressway is that the present plans will destroy over 131 certified historic homes in the Southwark area of the city. I profoundly wish that this highway could be located in such a way as not to make the destruction of these homes necessary" ("Anthony Garvan Collection", 1988). The Colonial Philadelphia Historical Society also criticized one of the projected routes of the Delaware Expressway saying its location on "Front Street between Elfreth's Alley and Old Swedes' Church would mean the greatest slaughter of early Philadelphia houses ever proposed" (Colonial Philadelphia Historical Society, 1956). A local reverend likewise wrote to the major, asking if he was "on the side of

human beings, or on the side of the engineers whose hearts are apparently made of the steel and concrete with which they would build a highway on the crushed homes of thousands of people and the ruins of six Catholic parishes" (Walsh, 1956). Outrage over the impending destruction of their communities caused many residents to furiously protest and resulted in ultimately delaying the construction of the highway by over a decade. Residents also anticipated the induced demand such a freeway would cause (Kobrick, 2010, p. 83). An interesting chapter of the Delaware Expressway saga that exposed the powerful connections of the city's elite is around its Society Hill segment. One of the wealthiest neighborhoods of the city, Society Hill residents were able to petition the freeway to be lowered adjacent to it (Knowles, 2009). Nevertheless, after a dizzying array of litigations, protests, and rallies, Philadelphia Delaware Expressway was finally completed after two decades.

Low Property Values and Lost Wealth

As noted in the Philadelphia history above, decisionmakers consistently cited the need to remove blighted slums with low property values to build freeways and save the city (Teaford, 1990). This thinking is repeated in the many reports, plans, and articles produced during this time to justify the construction of highways through densely populated urban areas. Indeed, this narrative might have significantly contributed to the narrative that led to the Federal-Aid Highways Act of 1944 and 1956. Lobbyists like the American Concrete Institute and the American Road Builders Association, who stood to gain much from the construction of a new interstate system, wrote that urban expressways could "contribute in a substantial manner to the elimination of slums and blighted areas" (Schwartz, 1976, p. 481). The Urban Land Institute also urged local governments to determine "the extent to which blighted areas may provide suitable highway routes" and positioned urban freeways as an

efficient approach to clearing "our nation's worst slums" (Scheuer, 1957). Redevelopers also saw the potential in a new downtown real estate landscape. A prominent developed wrote in 1959 that freeways were opening up previously blighted areas for "higher and better uses" (Rouse, 1963). As discussed earlier, the cheap urban land values in blighted areas were also used to justify freeways at the federal level. Thomas H. MacDonald, the Commissioner of the Public Roads Administration, wrote an article in 1947 called the "The Case for Urban Expressways" in which he states:

> "Admittedly, an expressway through a densely populated area does involve razing numerous buildings, including many dwellings. In most instances, routes selected for expressway as they approach the center of the city, pass through 'blighted' section where property values are low, and most of the buildings are of the type that should be torn down in any case to rid the city of its slums." (MacDonald, p. 92)

Other federal agencies also echoed this perspective. The Secretary of Agriculture reported that urban freeways could effectively remove the "unsightly and unsanitary districts where land values are constantly depreciating" (Rothstein, 2017, p. 127). Finally, in 1962 the Highway Research Board boasted the freeways were "eating out slums" and "reclaiming blighted areas" (2017, p. 128). In Philadelphia, Edmund Bacon attempted to put distance between the worrying succession of slum clearance and highway building, claiming that clearance was not the purpose of redevelopment (Knowles, 2009). Nevertheless, as outlined here, highway building often followed slum clearance. The historical record makes clear that the decisionmakers of the day believed that the areas of their cities with low property values represented the ideal location for new freeways. However, new studies have drawn into question the validity of this perspective.

Recent analysis of the areas targeted for slum clearance demonstrates that many of these neighborhoods were resilient and vibrant communities (Miller, 2018). Rothstein observes that terms such as "'slums' and 'blight' were widely understood euphemisms for African American neighborhoods" and that communities were targeted for their race more so than ease of land acquisition (2017, p. 127). Indeed, the creation of the interstate system allowed cities to accomplish what had been attempted for many years prior: to remove minority communities. Connerly takes this view, maintaining how urban highways were routed to reinforce racial boundaries rather than the removal of aging building stock (2002). Miller goes a step further in claiming that many of these demolished areas did not fit the definition of "slums" at all (2018). Through analyzing several cities that underwent slum clearance for highway rights-of-way, he reports that these "slums" actually outperformed adjacent areas with regards to property value and deteriorated housing units (2018). This finding suggests that the goal of at least some highway routing projects was not in actuality the removal of slums, but the targeting of specific communities. Furthermore, in historic cities like Philadelphia, these "blighted" neighborhoods now would be some of the choicest real estate in the city (Kyriakodis, 2011). Not only did the Delaware Expressway destroy historic building stock situated in now wealthy neighborhoods, but also cuts the city off from the recreational and commercial benefits generated from riverfront activities (Kraft-Klehm, 2015).

The literature also clearly demonstrates the economic benefits of these lost "blighted" neighborhoods. Studies have shown that traditional development patterns with high density and narrow streets continually prove to be the most financial productive regions when comparing tax revenues generated and cost of services (Burchell and Mukherji, 2003). In comparison, the sprawling development pattern enabled by urban freeways does not allow enough revenue to service itself (2003). Carruthers and Ulfarsson point out that there are

savings with higher densities. For example, such as how a police patrol that can provide protection to more people in a square mile than his/her counterpart in the suburbs (2003). This allows medium-to-high residential developments to pay for themselves. In Philadelphia, these lost riverfront neighborhoods today would be financial solvent communities situated in some of the desirable land in the whole city.

Currently, the literature contains many examples of the impact a freeway removal project has on the surrounding property values. An analysis on the removal of Harbor Drive along Portland's riverfront showed that opening land catalyzed downtown redevelopment and resulted in a tripling of surrounding property values between 1974 and 2002 (Seattle Urban Mobility Plan, 2008). Kang and Cervero used multilevel hedonic price models to analyze the replacement in South Korea of the Cheong Gye Cheon elevated freeway with a landscaped greenway in 2004 (2009). Their analysis demonstrated a premium on residential and non-residential property values within 500 meters of the new greenway (2009). They also found that while residents valued the proximity to freeway ramps, this value was offset by the noise, dust, fumes, and visual blight associated with the traffic volume (2009). One of the more famous freeway removal case studies is Boston's "Big Dig". In the 1980s, Boston began a process to bury their Central Artery freeway system in a series of tunnels and bridges. Tajima estimates that this lengthy and costly process created a $732 million increase in property values and that the projected parks would create $252 million in adjacent property values (2003). Iskandar challenges the underlying deeply held assumption that freeways positively contribute to the local economy (2014). In her study of 23 freeway removal case studies, she identifies an array of mixed results on the impact of cities, bringing into question the pervasive narrative about the straightforward value of urban freeways (2014). Although the literature is clear on the negative impacts of urban freeways at city or regional scale, there

exists a gap in understanding the lost wealth of American cities after the construction of postwar freeways with regards to property taxes.

This thesis seeks to understand the residential property taxes and the built environment that was lost due to the construction of the Delaware Expressway using historic maps from the Sanborn Map Company. Currently, the only other academic work in this area known to the author is the Center for Urban and Regional Analysis at the Ohio State University with the "Ghost Neighborhoods" project ("Center for Urban and Regional Analysis", n.d.). Through the use of GIS and Sanborn Maps, this research team has been able to digitally recreate the historic conditions of Columbus neighborhoods before the interstate system was built. This thesis seeks to build on this growing body of work with a focus on Philadelphia's waterfront neighborhoods.

Methodology

This chapter reintroduces the research questions stated at the beginning of this thesis and outlines the methodology used to conduct the research. The first question regards investigating what the current property and wage tax revenue of demolished residential units along the Delaware Expressway's route would be today. This fiscal analysis provides some insight into the wealth that Philadelphia lost during the construction of the national interstate program and opens the door for further research into cost-benefit analysis of urban freeways. The second question concerns what the built environment along this corridor once looked like. Using historic maps and geo-design techniques to digitally recreate the original built environment is vital to understanding the Delaware Expressway's impact on the urban fabric. Research into these dual questions of analysis and visualization were performed using quantitative data drawn from primary sources described below.

This thesis uses a simplified comparative sales method to determine the average property values of present-day single-family dwellings along the Delaware Expressway in order to estimate the values of the lost residential dwellings demolished for highway's construction if they still existed today. This approach makes two assumptions. First, since the primary source of this analysis are historic maps dating to the year 1950, it is assumed that the built environment was the same when the construction of the freeway began in 1959. Although this corridor no doubt underwent changes during this gap of nearly 10 years, it is reasonable to conclude that those changes are linked to the knowledge of the Expressway itself. Edmund Bacon's planning commission first began drawing up preliminary plans for the Delaware Expressway's route in 1951, and when the project was made public, it instigated a period of disinvestment in the area (Kobrick, 2012, p. 116). Businesses began to avoid renewing their lease, capital investments were forgone, and the real estate values were thrown into uncertainty (2012). Thus, even before construction began, the impending reality

of the Delaware Expressway's began to impact the built environment before the actual highway clearance took place. The year 1950, therefore, represents an ideal date to study this stretch of land. The second assumption made concerns the validity of interpolating current day property values onto non-existent properties. The literature is clear that urban freeways have a negative impact on nearby property values (Liang *et al.*, 2020; Conway *et al.,* 2010; Fonseca-Sarmiento *et al*., 2022). Thus, it can be reasoned that if the Delaware Expressway was never built, then the values of adjacent properties would no doubt be higher than they are today. However, calculating the delta between the higher values of this hypothetical situation and the current day values to correct for any impact the Expressway would have been outside the scope of this paper. Therefore, the lost property and wage tax revenue calculated for residential dwellings in this thesis can be viewed as a conservative figure.

As discussed in the previous chapter, much of the literature on this topic leverages difference-in-differences and hedonic models to analyze how certain events impact property values (Liang *et al.*, 2020; Conway *et al.,* 2010; Fonseca-Sarmiento *et al*., 2022). The difference-in-differences approach allows researchers to analyze the causal effect that a treatment (highway construction) has on a variable (property value) by contrasting the results of a treatment and control group (Fonseca-Sarmineto *et al*., 2022). Meanwhile, hedonic models use regression analysis to estimate the value a good or service based on its characteristics, such as proximity to greenspace, transportation, or other amenities effects property values (Conway *et al*., 2010). Since an analysis of the impact of the Delaware Expressway on nearby property values was outside of the scope of this research, as was an estimation of the environmental variables that impact property values, neither of these approaches were suitable for this study. The comparative sales method, on the other hand, allows researchers to quickly estimate the value of a property based on similar properties nearby (i.e., "comps") (Kim *et al.,* 2020). While other comparative sales approaches attempt

to calculate the similarity of properties in order to increase accuracy, these additional controls were not possible with this type of dataset (Indiana Department of Local Government Finance, 2022). The historic maps used to derive the demolished buildings do not contain some of the characteristics that can be factored into the comparative sales method (number of bathrooms, bedroom, square footage, etc.). Therefore, this thesis uses a simplified version of this method by finding the average assessed property value of current-day homes in each historic map's area and imputing the mean to the demolished residential properties.

Sanborn Map Company

The historical maps used as the core dataset for this research comes from the Sanborn Map Company. The Sanborn Map Company was established in 1867 and provided fire insurance companies with maps of cities throughout the United States, Mexico, and Canada. These hand-written maps contained detailed information on the variables an insurance firm would need to know to make an accurate assessment of fire risk. Such details included a building's use (residential, commercial, industrial, etc.), location of windows and doors, structural material, roof types, as well as block dimensions, width of streets, location of fire hydrants, fire stations, and more ("Library of Congress", n.d.-a). Although other fire insurance map companies did exist, the Sanborn Map Company had an essential monopoly on the market and produced nearly 700,00 maps over the course of their history (n.d.-a). Most of these maps are digitized and reside at the Library of Congress, where they are freely accessible to the public in digital formats ("Library of Congress", n.d.-b). Due to a commercial decline in demand for these detailed maps after World War II, Sanborn published its last catalog in 1961. Fortunately, this date represents an ideal timeframe to understand

historic conditions surrounding the landmark Federal-Aid Highway Act of 1956, which provided the funds for the new interstate system.

The Sanborn Map Company has a long history among geographers, city planners, and historians (Lamb, 1961). Dating back to 1949, Wrigley promoted the use of Sanborn maps as a valuable resource for contemporary city planners to understand the land use:

> "In the case of urban areas the most valuable source of land use information, other than field survey, is the fire insurance map made and published by the Sanborn Map Company. This map is used widely by city planning departments and by public and private organizations interested in details of urban land use. In fact, it is considered indispensable equipment in many offices." (p. 1)

Although not originally intended for historical analysis, these fire insurance maps provide a highly detailed snapshot of the historic conditions that allows for researchers to understand the physical development of urban areas across the country (Lamb, 1961). In his analysis of the Boston waterfront using Sanborn maps, Sauder claims that studying "geographies of the past" is vital to preservation: "uncovering links with the past emphasizes the need for increased participation by geographers in the preservation process" (Sauder, 1980, p. 212). While research leveraging Sanborn Maps do not have a strong presence in the geography literature, there is growing interest in using these resources to understand how freeways have impacted American cities (Center for Urban and Regional Analysis, n.d.). The specific maps used in this thesis were collected from the Library of Congress's digital catalog of Sanborn Maps ("Library of Congress", n.d.-a). Searching for Philadelphia in this collection yielded 44 different volumes. Since the focus was on collecting data nearest to the Federal-Aid Highway Act of 1956, the volumes that were dated to the year 1950 were

selected. Each volume contained a cover page demonstrating the area of the city the volume contained (Figure 1). For instance, the blue rectangle in the upper left side of the map area in the cover page in Figure 1 corresponds to the map on sheet 401 demonstrated in Figure 2.

Many of these Sanborn Maps also contained a "skeleton" map version that only contained the parcels and building footprint data (Figure 3). As will be discussed later, the "skeleton" map was needed for automating the digitizing process. To determine which specific maps were required for my analysis, I identified the ones that overlapped with the current route of the Delaware Expressway using ArcGIS Pro, a GIS technology software created by Esri. The geographic extent of my analysis stretched from Washington Avenue to the south and Susquehanna Avenue to the north. This four-mile stretch was chosen as the area of interest due to its central location along the Philadelphia waterfront and because of the limited availability of both colorized and skeleton maps for this extent (Figure 4). These maps were then downloaded as TIFF images from the Library of Congress – 22 colorized maps along with their corresponding skeleton maps.

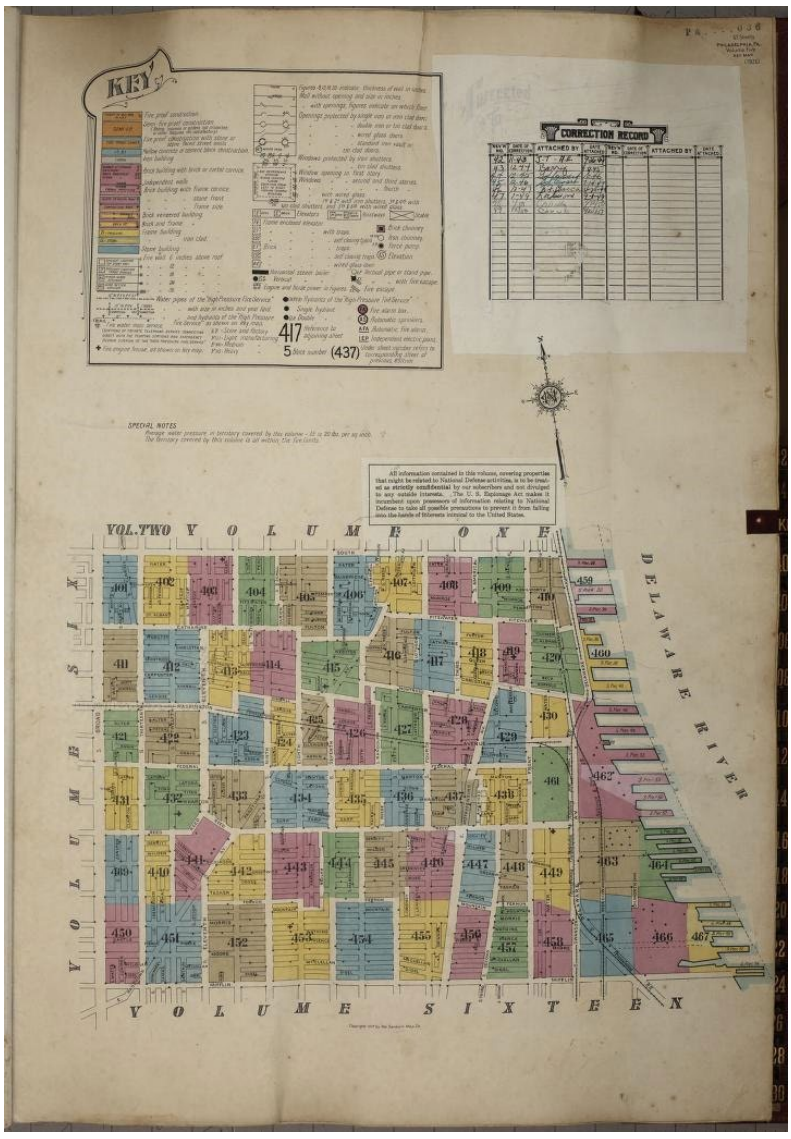

Figure 1. Example of Sanborn map volume cover page

Figure 2. Example of colorized Sanborn map showing built environment details

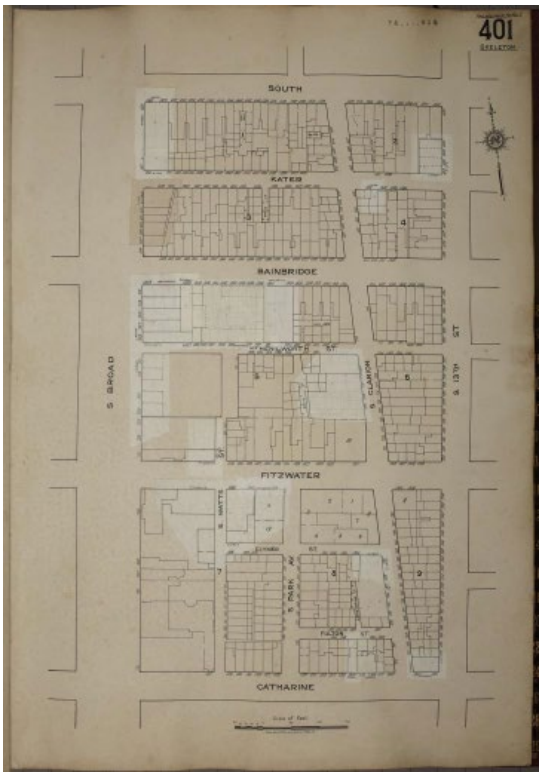

Figure 3. Example of "skeleton" Sanborn map showing only building footprints and parcel boundaries

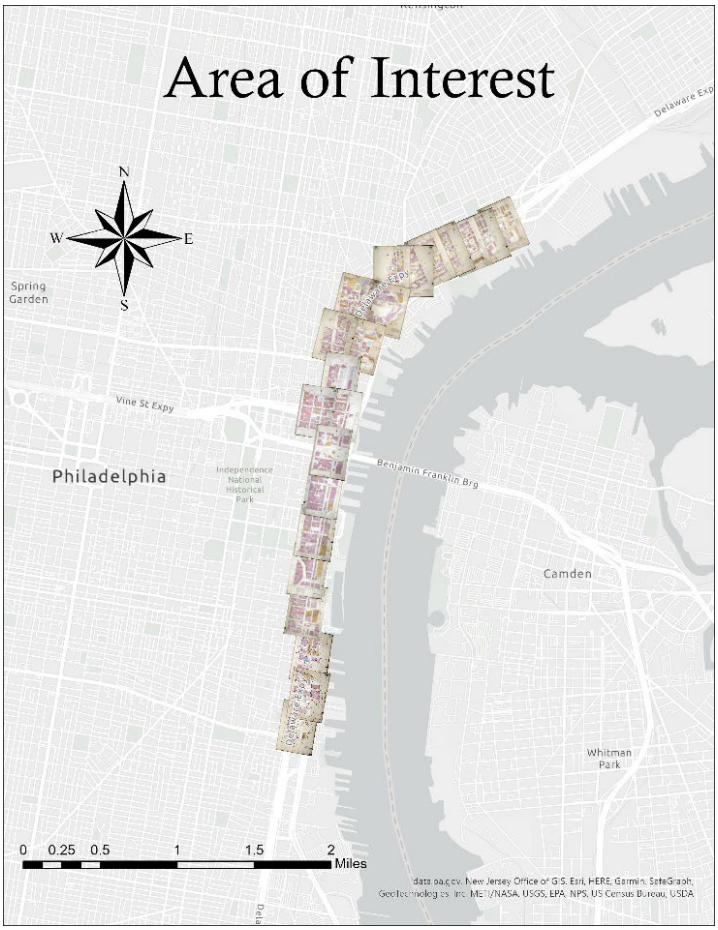

Figure 4. Map showing the study area and the Sanborn maps used for the study.

Two of the most southern colorized maps did not have a corresponding skeleton map – a deficiency that required manually digitizing the features on these maps in ArcGIS Pro. The images were imported into ArcGIS Pro, projected into the "WGS 1984 Web Mercator (auxiliary sphere)", and georeferenced using Esri's default basemaps and current parcel data as references.

Parcel and Assessment Data

Philadelphia's current parcel and property assessment data was required to help georeferenced the Sanborn map and also estimate property values. To obtain these data, I accessed and downloaded them from Open Data Philly ("Open Data Philly", n.p.; City of Philadelphia, n.p.-a). Once the parcel layer was imported into ArcGIS Pro, it was reprojected to "WGS 1984 Web Mercator (auxiliary sphere)" in order to maintain a common projection system for all layers within ArcGIS's suite of applications. Next came the georeferencing process. Georeferencing works best when there are easily identifiable common features on both the imported layer (Sanborn maps) and reference layer (parcels). Since the area represented on the Sanborn maps in 1950 appear radically different that the current built environment along this corridor, it was challenging to correctly georeference them. However, not all the parcels and buildings shown on the Sanborn maps were destroyed by the Delaware Expressway. In fact, many of the 1950 parcels and buildings outside of the Expressway's immediate right-of-way still exist today were vital for georeferencing the Sanborn maps. Thus, the first step was to identify the 1950 parcels on the Sanborn maps that survived the construction of the Expressway and place control points pinning them to the modern data parcel layer obtained from Open Data Philly. I first georeferenced all the skeleton maps since it was easier to identify parcels on, and then georeferenced the colorized version to that. It was important to ensure that the Sanborn maps were placed as accurately as possible since these raster layers would form the foundation of downstream 3D visualizations. Therefore, I

commonly placed up to 20+ control points on each skeleton Sanborn map and chose the "Spline" transformation type, which optimizes for local accuracy (Esri, n.p.-a).

The goal of georeferencing the Sanborn maps was so that when the parcels and buildings were digitized into polygon features, these features would be situated in their correct historic locations. Therefore, I created a model with ArcGIS Pro's Model Builder to automate the digitizing of the Sanborn maps. Model Builder allows users to string together a set of geospatial tools so that the same workflow can be run on different inputs. It should be noted that advancements in deep learning technologies have made type data extraction more feasible. Esri has made many of these deep learning packages freely available on their website (Esri, n.d.). However, since these pre-packaged deep learning approaches are trained on satellite or aerial imagery, they are not well-suited for the variability exhibited by hand-drawn maps.

To extract the parcels and buildings as a feature layer from the skeleton Sanborn maps, I leveraged ArcGIS Pro's Image Classification tools. The first step was to collect training samples from the map in order to train Esri's image classification tool on how to classify pixels in each skeleton map image. About 15 training samples were collected by drawing polygons around the pixels that correlated to each category. Once the training samples were collected as a feature class, they were used as the input for the "Train Support Vector Machine Classifier" to create an "Esri classifier definition file" (ecd), which contains all the information needed to classify the pixels of an image in ArcGIS Pro. Since all the Sanborn skeleton maps contain the same categories of pixels, the same ecd file derived from one skeleton map could be used to classify them all. Next, I used Model Builder feature to create a model that would automate the process to create a polygon feature class from the raster Sanborn map. A list of the tools used in this model can be found in Figure 5. Once the parcels and buildings features were digitized from the skeleton map, I needed to perform a

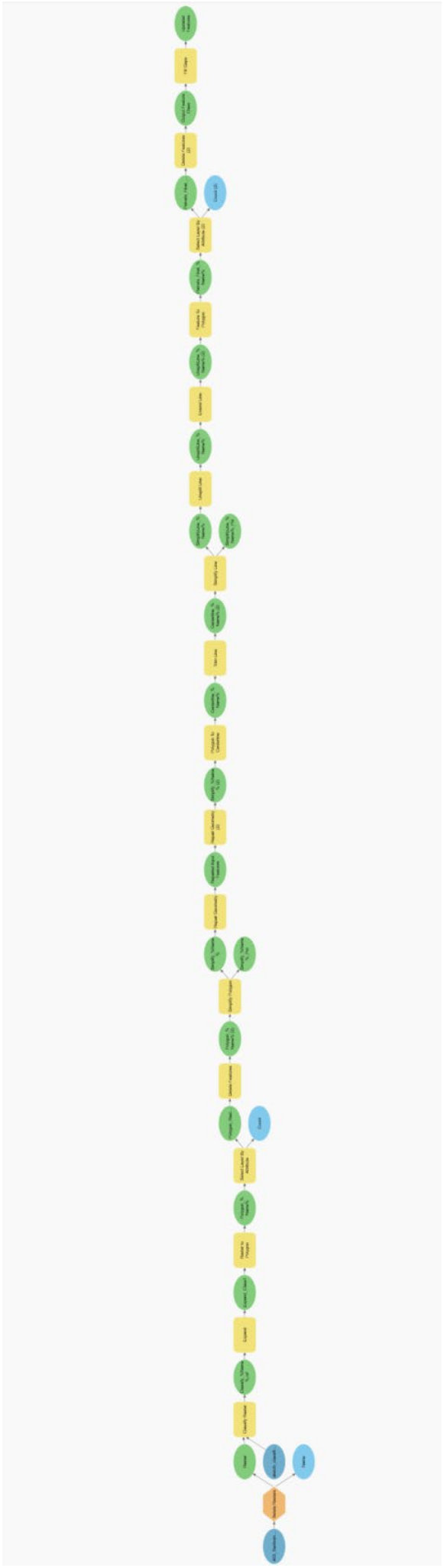

Figure 5. Model demonstrating the tools used to extract vector data from Sanborn skeleton map raster images

similar process for the colorized maps. The colorized Sanborn maps contain a multitude of information about the built environment that would be important for insurers to calculate fire risk. The mapmakers used a system of colors and symbols to represent this data in an easily digestible manner, shown in the Key in Figure 1. While most of this data was irrelevant for this study, some of characteristics were informative for my study. Since I was interested in calculating the residential property value, I needed to know the use type of each structure (dwelling, store, warehouse, etc.). This attribute was symbolized on Sanborn maps with a letter on top of each structure (Figure 6). I manually went through each Sanborn map to collect this data and attributed the buildings used for residential dwellings accordingly. Additionally, the colorized Sanborn maps have information about each structure's building material – an important factor in fire risk. This information is useful for accurately representing the facades of buildings in a 3D model. Therefore, I used the colorized Sanborn maps to derive the building materials attribute of each demolished structure. The buildings material attribute is symbolized on the maps with different colors: reddish/pink indicates brick or tile; yellow indicates frame or wood; olive green indicates fire resistance construction; gray indicates adobe construction or metal building materials (Library of Congress, n.d.-c). Sometimes a mix of colors was used to represent a mix of building materials (Figure 6). To simplify the portray of these buildings, I used brick in the facades any time a mix of brick and tile was present in a structure's construction materials. I also used Model Builder to

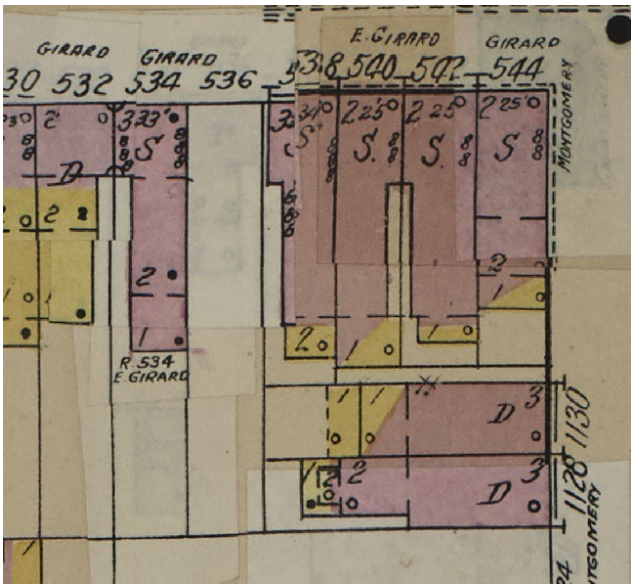

Figure 6. Colorized Sanborn maps showing use of building represented with letters (i.e., "S" = Store; "D" = Dwelling) and a mix of construction material in a single building.

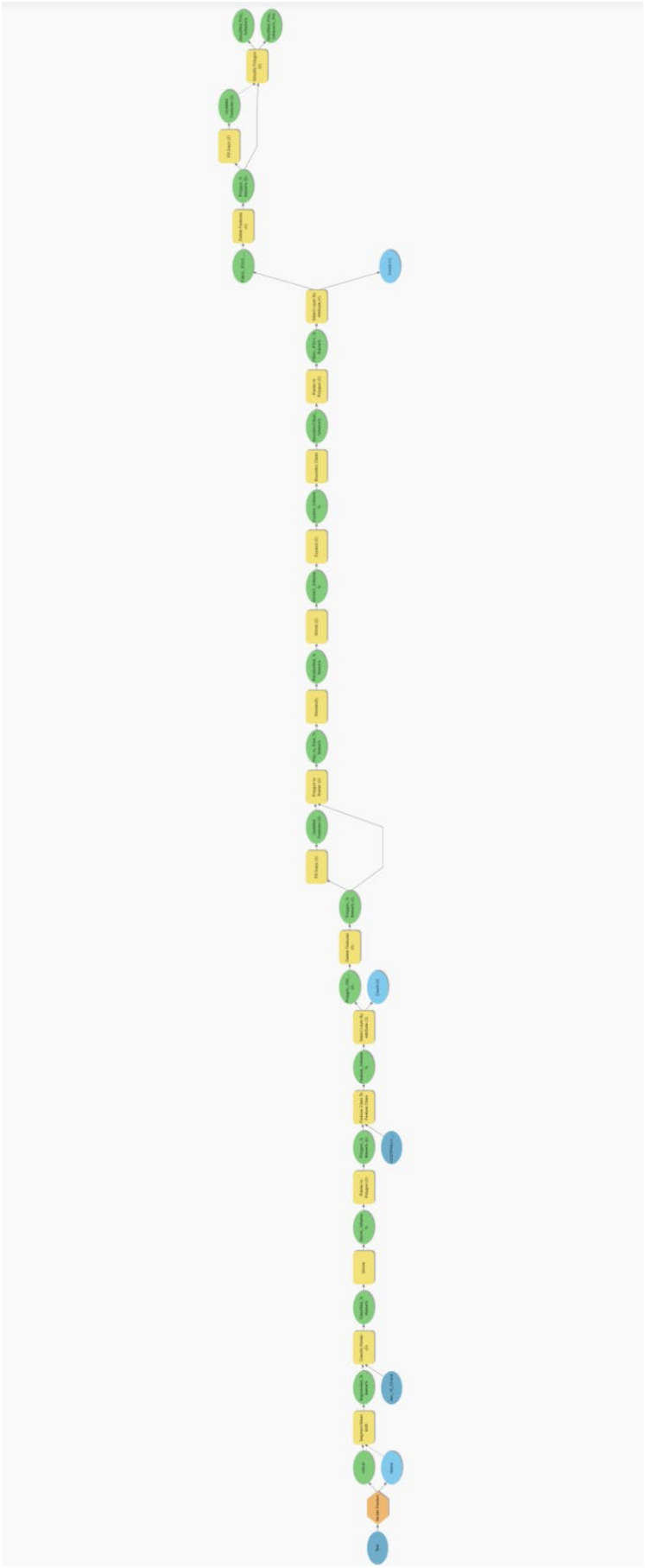

Figure 7. Model demonstrating the tools used to extract vector data from Sanborn colorized map raster images

automate the process of extracting building material details. Figure 7 outlines the process used to extract the pixel type from the colorized Sanborn map. After the model was completed, the Spatial Join tool was used to attribute the parcel and building polygon feature layer extracted from the skeleton. To ensure that these models performed well, and also to correct any difference between the skeleton and colorized maps, I manually went through the parcel and building feature layer to ensure the geometry was accurate.

Next, I needed to overlay the Sanborn-generated feature class with the current parcel layer from Open Data Philly to see which parcels and buildings still existed today. To do this, I first deleted out the parcels from the modern-day parcel layer that overlapped with the expressway, which represents areas underneath the elevated freeway or highways caps. These parcels were irrelevant to this study as they did not exist in 1950. A shapefile line layer of Interstate 95 was downloaded from PASDA and then a buffer of 20m was applied to each line of the dual divided highway, which roughly represents their width ("Pennsylvania Spatial Data Access", n.d.). Then, all the parcels that intersected this buffer were selected and deleted from the parcel fabric. Figure 8 portrays these parcels that overlap the Delaware Expressway

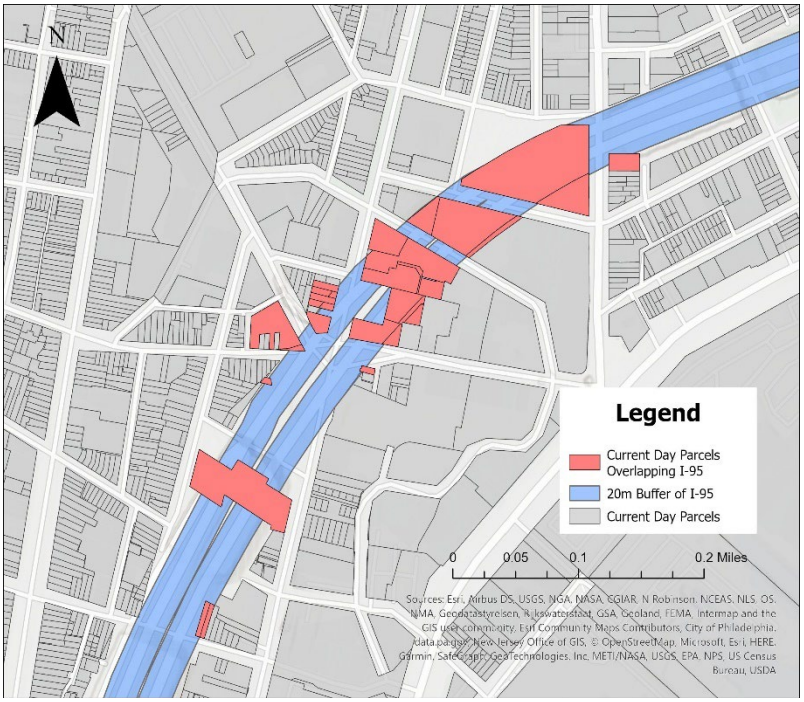

Figure 8. Example of parcels deleted out from Philadelphia's current day parcel fabric based on their intersection with the I-95 (i.e., Delaware Expressway).

in red. Combining these the current day Philadelphia parcel layer with the lost parcels from the Sanborn maps would digitally recreate the parcel fabric that existed before the construction of the freeway and provide the basis for further analysis and visualization.

The next step in understanding the tax value lost was to attribute each lost dwelling residential dwelling with the current property assessment of the existing buildings in the area. Using the property assessment data downloaded from Open Data Philly, I selected all the single-family dwelling units within a 500m distance of each Sanborn maps, using the street limits of each Sanborn map as the boundary for each calculation, and found the average assessment value for the single-family residential dwelling in that segment (Figure 9). The 500m distance was derived from the Kang and Cervero study of the Cheonggyecheon freeway removal in South Korea (2008). These values were then applied to the lost dwelling units in each respective Sanborn map and multiplied by Philadelphia's 2022 residential

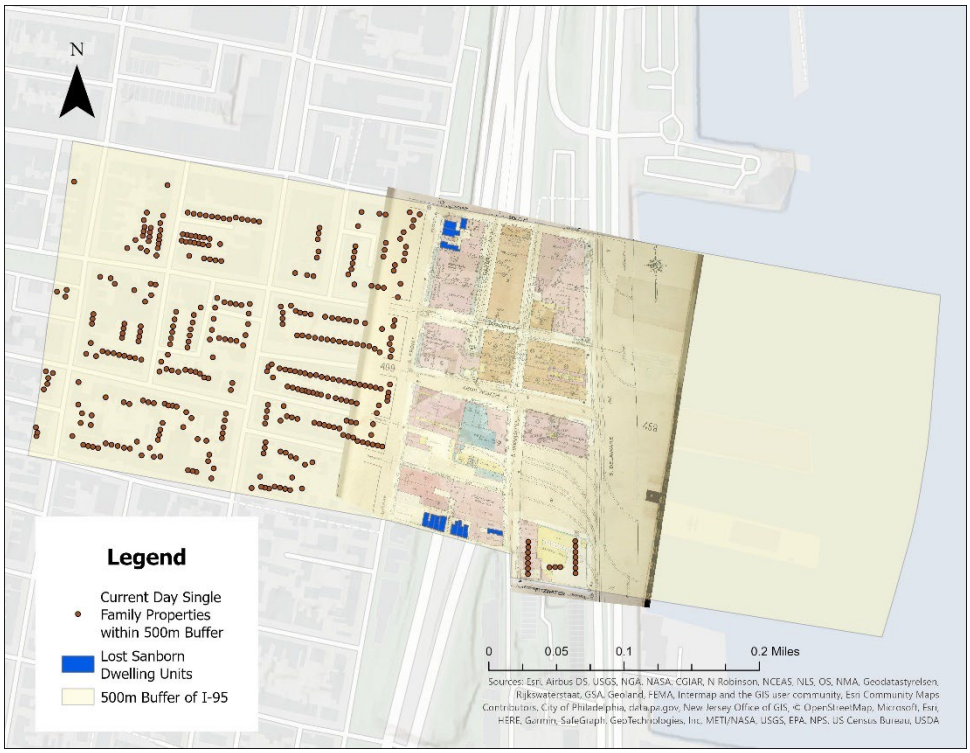

Figure 9. Cross section of 500m buffer with clipped, current day, single family properties used to calculate average assessment value.

property tax of 1.3998% to find their annual tax revenue to the city (Philadelphia, n.d.-b). Table 1 demonstrates the breakdown of the average assessment value for single-family

dwellings in the area defined by each Sanborn map along with other relevant statistics. Since the Sanborn map 218 did not have any single-family properties within its 500m buffer, its average value was calculated by averaging two of its adjacent segments, 208/209 and 226/227

Sanborn Map Number	Average Assessment Value	Standard Deviation	Number of Single Family Homes within 500m	Number of Dwellings Destroyed	Median Household Income
430	520,490	243,935	301	62	75,325
420	690,736	233,718	308	88	127,952
410	670,651	278,865	365	12	155,167
53	1,083,375	454,431	305	14	162,511
42	1,514,174	575,306	127	0	108,407
32	2,004,428	787,219	32	0	111,302
21	904,246	587,361	56	0	118,602
10	838,431	296,031	75	13	128,532
208/209	620,047	252,194	46	64	127,913
218	478,500	n/a	0	36	129,595
226/227	632,798	259,009	392	129	129,221
236/237	524,535	185,169	210	60	117,143
247/248	419,995	155,916	328	21	112,998
249	392,933	136,947	287	76	108,016
250	408,361	139,472	172	17	106,529
251	377,892	153,067	265	66	65,410
252	343,493	112,844	139	11	79,433
253	374,363	143,890	285	19	76,352

Table 1. Attributes of 500m buffer study area segments

After the property tax revenue was calculated, the next step was to calculate the wage tax revenue of each lost dwelling. Philadelphia's wage tax is one of the highest in the country at 3.79%, and accordingly, it makes up a significant portion of its annual budget. To find these values, the 2022 median household income was calculated for each Sanborn map segment of the 500m I-95 buffer by using Esri's "Enrich" function. Then, this value was multiplied by the tax rate and applied to the lost dwelling units. The 2022 median household income for each Sanborn map segment is shown in Table 1.

ArcGIS CityEngine

To fully understand the building stock destroyed by the construction of the Delaware Expressway and to demonstrate the original urban fabric along the Philadelphia waterfront, ArcGIS CityEngine was used to digitally recreate this corridor in 3D. CityEngine is a procedural modelling program that supports the creation of detailed, large-scale 3D models (Esri, n.d.-a). It relies on "computer generated architecture" (cga) rules that can be applied to building footprints or building masses to create realistic renderings of buildings and landscapes (n.d.-a).

The area I chose to recreate is the Southwark neighborhood in South Philadelphia. Described in the literature review, this neighborhood was arguably the most directly impacted from the construction of the Delaware Expressway. It lost dozens of homes, businesses, industries, and churches in the process. While creating a 3D model of the whole corridor would have been ideal, it would require manually attributing each individual structure's height. Since the time required to perform this was greater than what was available, I chose to focus my efforts on the Southwark neighborhood. The building footprints generated from the Sanborn maps in ArcGIS Pro for this area were imported into CityEngine. Then, using their building facades and height attributes, they were modeled in 3D using one of CityEngine's default cga rules "3D Transect". The Sanborn Maps themselves were also brought into CityEngine to help add context. Finally, the layers were exported from CityEngine to ArcGIS Online.

Results

Digitization Process

This section reviews the results of each process stated above, listed as figures and tables here. Due to the limited nature of this written format, only certain aspects of the results can be shown here. Figure 10 demonstrates the skeleton map and Figure 11 shows the results of the Model Builder's digitization process, represented with light teal polygons.

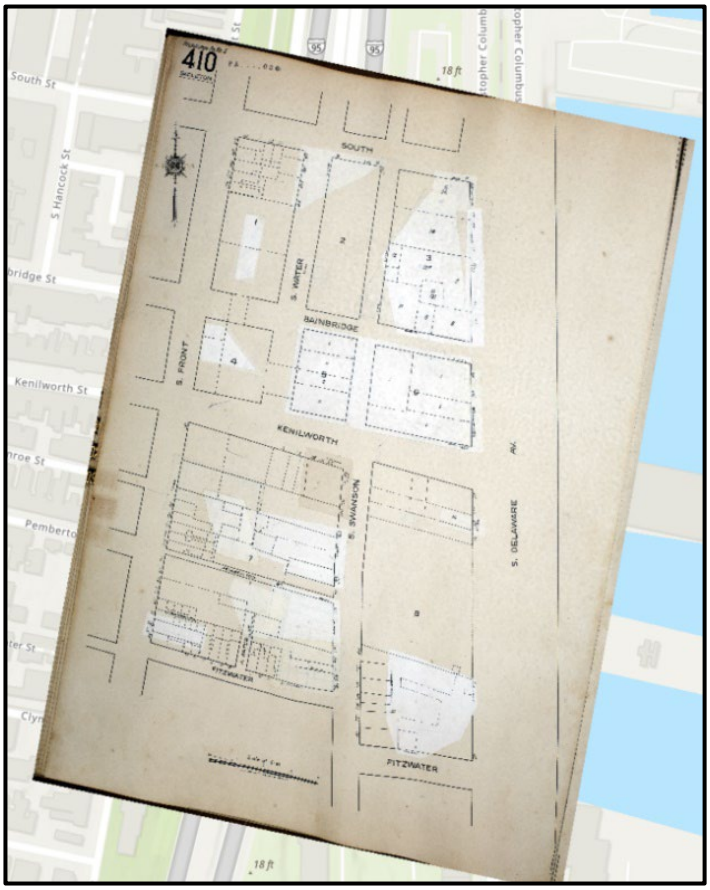

Figure 10. Skeleton Sanborn map used to extract the parcel and building footprint areas.

Figure 11. Results of the Model Builder extraction tools on the skeleton map show in Figure 10.

Once the parcel and building footprint boundaries were extracted from the Sanborn skeleton maps, the Model Builder tools for the colorized Sanborn maps were executed. Figures 12 and 13 demonstrate the results of this process. The polygons shown on Figure 13 represent the pixel classes derived from the raster image in Figure 12. These polygons were manually

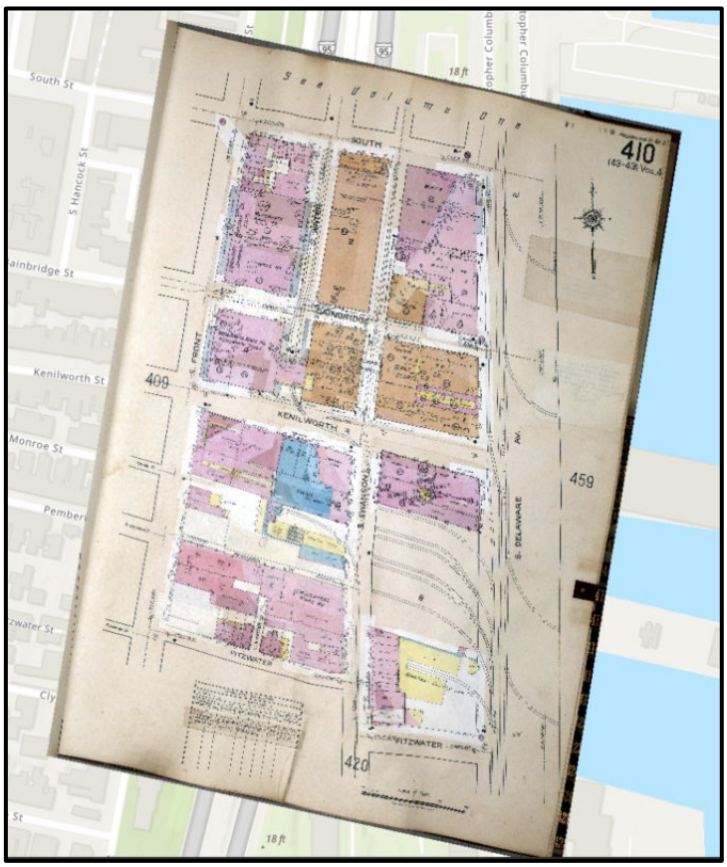

Figure 12. Colorized Sanborn map used to extract the building materials.

Figure 13. Results of the Model Builder tools on the colorized maps shown in Figure 12.

corrected to delete out the polygons that did not correlate with buildings. Figure 14 portrays the results after these two datasets were combined using Spatial Join. The results of this workflows yielded quantifiable insights into the impact to the built environment within this corridor in 1950. Table 2 lists the total number of structures destroyed, including the number of dwelling units lost, the total area of the building footprints lost, and the total developable land represented in the parcel area forfeited with the construction of the Expressway.

Figure 14. Map showing the final result of digitization process with the buildings and parcels accurately represented and symbolized according to building material.

Number of structures destroyed	Number of Dwellings Destroyed	Total Building Footprint Area Destroyed (acres)	Total Developable Area Destroyed (acres)
1697	687	95.73	133.52

Table 2. Total number of structures as well as dwellings destroyed. Also shows total acreage of building footprint and developable area destroyed by Delaware Expressway.

Tax Revenue Lost

After using the comparative sales method described in the last chapter to assign modern day property values to the demolished dwelling units and estimating the wage tax revenue from the median household incomes, the lost tax revenue was generated for each dwelling unit. Figure 15 demonstrates the total annual residential property and wage tax generated from the demolished dwelling units.

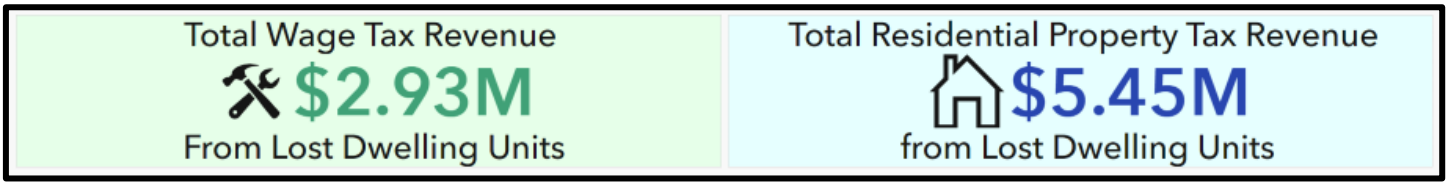

Figure 15. Annual wage and property tax revenue from destroyed residential dwellings units in 1950 if they existed today.

CityEngine Results

Finally, Figures 16-18 contains screenshots from recreating the Southwark neighborhood in CityEngine. OpenStreetMap 3D building features were used to add context to the scene, represented in the white buildings shown in the images below. Figure 16 shows

Figure 16. Overview of the lost structures from the 1950 Sanborn map overlaid on a current day imagery basemap with OpenStreetMap 3D buildings for context.

the Sanborn-generated features overlaid on a current day imagery basemap in which the Delaware Expressway is clearly visible. Figure 17 overlays these 3D structures on top of the historic Sanborn map from which they were derived. Finally, Figure 18 utilizes ArcGIS Online's Scene Viewer functionality to simulate weather events to demonstrate this neighborhood in a snow event. These web scenes can be viewed in further detail at the online companion to this thesis (Edmonds, 2023).

Figure 17. Demolished structures overlaid on Sanborn map from which they were derived along with OpenStreetMap

Figure 18. Lost structures shown in the midst of a simulated snow event in ArcGIS Online's Scene Viewer capability.

Discussion

Urban infrastructure projects, far from being a reality of the past, continue to shape and effect cities today. As local, state, and federal decisionmakers grapple with the legacy of urban freeways and their role in cities, it is crucial to understand their long-term impact on local economies and environments. This section discusses the two goals stated in the first chapter. First, this study sought to investigate the loss of tax revenue to the city of Philadelphia that accompanied the construction of the Delaware Expressway along the riverfront. Second, it sought to demonstrate how this lost corridor could be modelled in 3D to better understand the built environment. The results presented in the previous chapter have timely implications for the city of Philadelphia and the state of transportation planning at large.

Georeferencing and Model Builder Results

The georeferencing and digitization process performed by the Model Builder produced a geospatial feature layer of 1950 buildings and parcels that fit seamlessly into Philadelphia's existing parcel fabric (Figure 19). The combination of these Sanborn-generated parcels and the city's current day parcel layer reveals lost city blocks and road networks that existed before the Delaware Expressway cut through them. However, the feature layer results generated from the Model Builder tools still required manual corrections in order to account for differences between the skeleton Sanborn maps and the colorized Sanborn maps as well as errors in the extraction process. Additionally, this workflow required manually attributing which buildings were dwellings, which is a time-consuming process for large corridors such as this one. As mentioned in the previous chapter, further research into this topic might take advantage of the growing availability of deep learning tools to extract features and attributes

from historic maps more rapidly and with fewer errors (Al-Bakri and Fairbairn, 2021; Sun *et al.*, 2022).

Figure 19. Map of Fishtown neighborhood showing the original parcel fabric.

Several important insights can be derived from examining these georeferenced Sanborn maps. The urban fabric makes clear that the Delaware River was once widely accessible to neighboring communities. Out of the 60 alleys and streets that once crossed through the corridor where the Delaware Expressway is currently situated, only 24 have survived as bridges or underpasses. This drastic change reflects a significant decrease in the city's ability to the river. Not only does the Expressway represent an imposing barrier between the waterfront and the core of the city, but also makes those existing connector streets an intimidating and unenjoyable trek on foot. Pedestrians must either cross over the freeway via an overpass that exposes them to the deafening roar of highspeed traffic, or they must travel underneath through a dark and menacing underpass. These georeferenced maps portray the extent to which the city was connected to the waterfront and how these neighborhoods

facilitated the easy movement of people and goods to and from both (Gavin, 2012, p. 20). This connection also had economic and social significance. The riverfront provided residents with employment, recreation, social connectivity, and a deep connection to the city's heritage (Kyriakodis, 2011). Philadelphia's founder, William Penn, saw the riverfront as the heart of his newly established city and sought to maintain that connection as the riverfront began to develop (2011, p. 18). These georeferenced Sanborn maps provide the first step toward further research into the Philadelphia's geography of the past that may yield further insights into the Delaware Expressway's impact on the relationship between the city and the river.

These maps also vividly depict the type of land uses affected by the Delaware Expressway's path. While the highway was primarily routed through industrial land occupied by manufacturing buildings and warehouses, it also cuts directly through densely populated areas. Out of the roughly 1,697 structures that were demolished for the Expressway's right-of-way, about 687 were residential dwellings. The majority of these residences were located in the neighborhoods of Southwark (158), Northern Liberties (224), and Fishtown (210). These communities had strong ties to the river, which is exemplified in their historic trades in shipbuilding, ropemaking, and fishing (Delaware County Historical Society, 1902; Saffron, 2022). Now, they have become some of the most desirable real estate in the city (Taylor, 2018). While the tax revenue implications of their clearance are reviewed below, it is clear from the Sanborn maps that the Delaware Expressway disrupted the economic vitality and social cohesion that once existed among the homes, business, churches, and markets destroyed by the freeway. This phenomenon unfortunately fits a pattern experienced by every major city in the United States with the advent of the freeway building era (Rose and Mohl, 2012, p. 104).

Property Values

This thesis used a simplified approach of the comparative sales method to estimate the average property values of present-day single-family dwellings along the Delaware Expressway if they still existed today. This calculation does not take into account the impact that the Expressway had on property values, which is a well-documented effect of urban freeways (Allen *et al.*, 2015). According to this valuation theory, it can be reasonably concluded that if the Delaware Expressway was never built, the values of adjacent properties would be higher than they are today. However, calculating the delta between the higher values in this hypothetical situation and the current day values to correct for any impact the Expressway would have been outside the scope of this paper. Therefore, the lost property tax revenue calculated in the previous section is a conservative figure within the context of the hypothetical scenario this study investigates.

The results show that if the residential units that existed within the Delaware Expressway's right-of-way existed today, they would generate a roughly $5.45 million in property taxes and $2.93 million in wage taxes, for a total of approximately $8.28 million in tax revenue to the city of Philadelphia. For context, in fiscal year 2021 the city's property tax brought in $723 million while the city's wage tax brought in $2.004 billion (Caudell-Feagan and Haider, 2022). Interestingly, Philadelphia's reliance on the property tax is relatively low compared to peer cities, only accounting for 15.4% of its General Fund (2022). Thus, while the forfeited tax revenue calculated in this study represent mere fractions of the city's total tax revenue, they should be understood as significantly conservative estimates of the total wealth lost in this demolished corridor. The residential building footprints make up only 15% of the total building footprints destroyed in this corridor, which represent a small fraction of the corridor's total building potential. As can be observed from the Sanborn maps, the

majority of the other 85% of building footprint was occupied by non-residential uses (warehouses, manufacturing, commercial, etc.). Today, however, this area is dominated by high-value, high-density development such as the Pier 3 and Pier 5 Condominiums, One Water Street Apartments, and the Society Hill Towers. Undoubtably, this forfeited land would be similarly valued if it existed today. And as stated earlier in this chapter, the tax revenue results presented here are also affected by the presence of the Delaware Expressway itself. Not only does this highway negatively impact property values through noise and air pollution, but also by obstructing the adjacent neighborhoods from the river (Delaware River Waterfront Corporation, 2011). Increased access to the river and its amenities would result in a real estate premium valuation (Rigolon and Németh, 2018). Lastly, missing from this discussion is an analysis of the costs of the Delaware Expressway itself. While most cities could only afford to build these megastructures because of federal funding, further studies could seek to understand the long-term maintenance costs for local, state, and federal governments. This analysis offers some insight into the wealth lost in this corridor, but further research is needed to provide an in-depth calculation of tax revenue generated from the non-residential land ignored in this study.

ArcGIS CityEngine

The ArcGIS CityEngine model of the Southwark neighborhood provides a powerful visual of what was once a vibrant, working-class neighborhood (Figure 16-18). Combining this model with other 3D datasets, such as OpenStreetMap's 3D Buildings and Trees layers, provide important context of what this neighborhood might look like if it existed today. 3D models are increasing becoming an important resource for historic preservation that could help guide future city planning and architecture efforts (Ma, 2021; Deng and Gan, 2019).

There are some aspects of this 3D model that could be improved upon in future iterations. First, there is notable lack of architectural variety. Since the same CityEngine cga rule was applied to all building footprints, they exhibit similar designs and facades. This could be improved by creating cga rules that mimic the historic architectural designs of this neighborhood, either based on historic photography or by interpolating based on existing structures. Second, due to the manual input required to extract the necessary information from the Sanborn maps, only one neighborhood was built out. Future research equipped with better extraction tools could produce a detailed 3D model of the entire corridor instead of only one neighborhood. Lastly, to enhance this 3D model further, it could be brought into a game engine to add pedestrians, cars, trees, and more features to increase its realism. Game engines are increasingly used by city planning professionals to model complex environments for analysis and renderings (Buyuksalih *et al*., 2017).

Relevance

The results of this study bear relevance to Philadelphia's future planning and development around its freeways as well as to the current state of transportation planning at large. As of the writing of this paper, Philadelphia is over a decade into an extensive initiative to redevelop its riverfront. The project is being overseen by the Delaware River Waterfront Corporation (DRWC), a non-profit whose purpose is to "design, develop, and manage the central Delaware River waterfront in Philadelphia…[in order to transform it]… into a vibrant destination for recreational, cultural, and commercial activities for the residents and visitors of Philadelphia" (Delaware River Waterfront Corporation, 2023). In 2011, DRWC released a Master Plan for the Central Delaware that outlined a sweeping slate of projects aimed at fulfilling this mission, many of which have already been completed (Delaware River

Waterfront Corporation, 2011). Construction on a redevelopment of the Penn's Landing area, their milestone project, is slated to begin in a few months. During the Delaware Expressway's construction, highway engineers sunk it below grade at this section with the promise of constructing highways caps once funding was available. After several decades, the DRWC has established a plan to cap the Delaware Expressway in this area between Chestnut and Walnut streets in order to create a 11.5 acre park. There are also plans to develop two nearby parcels into mixed-use developments with a host of residential, hotel, retail, and dining space (Delaware River Waterfront Corporation, n.d.). According to estimates, the project is expected to generate $1.6 billion of new revenue for the Philadelphia, its School District, and the state of Pennsylvania (n.d.). This figure is another example of this area's real estate value, and thus the lost opportunity cost of constructing the Delaware Expressway. And while there is no indication that Sanborn maps were used to guide the design of these DRWC projects, they were leveraged for the historic analysis of future improvement projects surrounding the Delaware Expressway (Digging I-95, n.d.). The Penn's Landing project, and others like it, seek to mitigate the negative impacts of the Delaware Expressway and redevelop the industrial character of the riverfront so that the city can enjoy the benefits offered by one of its greatest assets.

The Vine Street Expressway is another Philadelphia freeway that has received renewed public attention recently. Crossing through the city from the Delaware River to the Schuylkill River, Vine Street was originally a busy thoroughfare lined with a mix of uses (Yee, 2015). As congestion became a greater problem, city leaders fervently lobbied to have the street developed into a freeway. Rhetoric from decisionmakers at the time perceived the Vine Street Expressway as a crucial component of Philadelphia's post-war prosperity (Bauman, 1991). With funding from the Federal-Aid Highway Act of 1956, the street was eventually redeveloped into a depressed, limited-access highway. This project required the

clearance of historic buildings and split Philadelphia's Chinatown neighborhood in two. Now, with the availability of federal funding in the Bipartisan Infrastructure Law of 2021, the city is looking to cap this highway and reconnect the two sides of this neighborhood (Gammage, 2023). As discussed in the Boston "Big Dig" example, new real estate made available from burying a freeway can generate significant economic benefits to the locality and the city at large (Tajima, 2003). Sanborn maps and 3D modelling software could be used to guide the future of redevelopment in this area and restitch the urban fabric in Chinatown to its original conditions.

These highway capping projects in Philadelphia reflect a larger national trend of cities reckoning with their freeways. Indeed, in contrast to the dominating narrative of the 20th century, many cities are removing their freeways altogether (Rose and Mohl, 2012). While there are many factors that involved in the removal of a freeway, a common justification is the financial solvency of such projects. The Highway Trust Fund, which is the main source of maintenance funding for highways, has steadily shrunk over the past several decades since revenue generated from fuel has decreased as cars have become more fuel-efficient. Furthermore, many of these infrastructure projects are nearing the end of their relatively short lifecycle, and in some cases are more affordable to tear down than rebuild (Rose and Mohl, 2012, p. 177; Billings *et al.,* 2013). And as mentioned earlier, case study cities have demonstrated the economic benefits of opening up valuable urban real estate for redevelopment (Tajima, 2003; Delaware River Waterfront Corporation, 2011). Yet, for all the momentum away from urban freeways and toward teardowns, Khalaj *et al*. argue that transportation planning has not yet experienced a true paradigm shift (2020). They claim that most policies aimed implementing alternative modes of transportation still coexist alongside freeways (2020). Moreover, there are powerful interest groups and constituencies who continue to lobby for new highway projects today (Mohl, 2012, p. 96). Instead of

constructing new routes, however, today's state departments are focused on expanding existing freeways with more lanes (Horrox, 2022). Many of these projects would require the demolition of buildings and the destruction of natural areas, mimicking the traffic-service priorities of state highway engineers during the post-war highway boom. Opponents of these projects argue that expansion projects induce demand and thus negates any increased traffic flow capacity (2022). Additionally, they point to the negative impacts these projects have historically had in cities, some of which are presented in this thesis (2022). The demolition of buildings and the displacement of residents is still happening in transportation planning today and understanding the significant loss urban freeways have wrought in the past may help to inform decisionmakers of the true cost of these projects.

Lastly, the $1.2 trillion Bipartisan Infrastructure Law passed in November 2021 has initiated another historic period of federal funding for transportation. However, this landmark bill demonstrates the dominance of conventional approaches to transportation planning. Out of the $550 billion the bill sets aside for new spending, only $1 billion is dedicated toward the funding the "Reconnecting Communities Program" (McKinsey & Company, 2021). This program seeks to address the harm that highways have historically caused communities by "removing, retrofitting, or mitigating transportation facilities like highways or rail lines that create barrier to mobility, access, or economic development through technical assistance and grand funding for planning and capital construction projects that reconnect communities and improve peoples' lives" (U.S. Department of Transportation, n.d.). Funding from this program is being used to study the capping of the Vine Street Expressway in Philadelphia and other important projects (Gammage, 2023). Leveraging historic resources such as the ones outlined in this thesis to demonstrate the impact of historic freeways projects might be useful for cities seeking to obtain funding for their own projects.

Conclusion

This research had two primary goals. First, it sought to identify the buildings destroyed by the construction of the Delaware Expressway in Philadelphia and investigate the current tax revenue potential of the lost dwelling units if they still existed today. After using the comparative sales method for median property values and household income, total tax revenue that would be generated from these dwellings if they existed today is approximately $8.38 million ($2.93 million in wage tax and $5.45 million in residential property tax). This study fills a gap in the literature concerning the wealth that urban freeways stripped from cities. Much of the research around urban freeways focus on the impact of the existing structures and current residents by using hedonic models and difference-in-differences analysis. This study presents a unique perspective in freeway research by taking up the counterfactual and calculating the value of a built environment that no longer exists using sales comparative method. However, there is much room to be improved upon. As stated in the previous chapter, the total area taken up by the footprint of these demolished dwelling buildings comprises just 15% of the total developable land that has been lost. This area, while ignored in this study, provides an opportunity for further research to investigate the total valuation of the corridor between Washington Avenue and Susquehanna Avenue along Philadelphia's waterfront. Based on the current development of high-density, high-value projects and the significant resources the city has invested in the waterfront area, the figures presented in this study are an underestimate of the true tax revenue potential.

Secondly, this thesis sought to digitally recreate the Southwark neighborhood in a 3D environment using ArcGIS CityEngine. The results of the georeferencing and digitization process provided the baseline to procedurally model this neighborhood in CityEngine with out-of-the-box cga rules to create realistic renderings of what this neighborhood would look

like if it existed today. The technical workflow from historic maps to 3D renderings is increasingly becoming a more feasible process which will undoubtably lead to greater research in this topic. Improved deep learning tools could help aid the extraction process and remove the need for manual attribution used in this study. Further research in this study area should build out the remaining neighborhoods in 3D to provide a digital twin of this lost corridor for historic preservation purposes as well as the basis for more in-depth analysis.

As demonstrated in the literature view of this thesis, the history of freeways is extensive and complicated. The narrative provided in this thesis has attempted to provide an informative overview of this history to portray the context that led to the construction of the Delaware Expressway in Philadelphia. Understanding this history is increasingly becoming more important considering recent events in transportation planning. The Bipartisan Infrastructure Law passed in 2021 has released an unprecedented level of funding that has the potential to reshape the landscape in the United States for the next half-century. While this law authorizes the funding of innovative new initiatives as such as the Reconnecting Communities program, it also funds much of the same conventional projects that resulted in the destruction of Philadelphia's waterfront. Although there are more regulatory safeguards in place today to protect people and property than when the Federal-Aid Highway Act of 1956 was passed, there are freeway projects in progress today that threaten to demolish homes, businesses, and institutions. Without understanding the true costs of urban freeways, decisionmakers lack a historical context with which to evaluate future highway projects. This thesis has sought to provide this historical context by recreating the built environment of the demolished neighborhoods along Philadelphia's waterfront.

These maps also provide an insight into how restitching the urban fabric could resurrect a walkable and human-centric development pattern. Before the interstate freeways tore through cities, there existed historic communities that developed around pedestrians,

horse-drawn carriages, and streetcars. In the case of the Philadelphia's waterfront, the Sanborn maps demonstrate the ease with which pedestrians could navigate this built environment. It also portrays a democratized riverfront that was widely accessible to city residents. This type of development was sacrificed for the car-centric transportation framework that has dominated the transportation planning for nearly a century. The mid-20th century Federal-Aid Highway Acts had a monumental role in establishing the car as the primary mode of transportation in the United States. As a result, this legislation completely reshaped the urban landscape and has led to the destruction of some of the most valuable real estate in cities. Many decades later, the negative impacts of freeways have been thoroughly established and yet, state highway departments continue to push similar projects and decisionmakers lack historic context to guide future development. By analyzing the geographies of the past, this thesis has sought to provide the field of transportation planning with a workflow to evaluate the costs of past freeways projects and an understanding of how historic conditions would lead to future prosperity for our cities.

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