The flexible urban grid: adaptation, expansion and evolution in Philadelphia's city block morphology

Title

The Flexible Urban Grid: Adaptation, expansion and evolution in Philadelphia city block morphology, 1683-1900

Abstract

This study examines the evolution of Philadelphia's city block morphology between 1683, when the city was planned by William Penn, and 1900, when new development abandoned the grid. The study uses both quantitative and qualitative assessment. The city grid underwent evolution during this time that resolved deficiencies of the original Penn plan, improving circulation and maximizing rowhouse development. The 1683 grid had large rectilinear blocks with irregular dimensions: it experienced two types of evolution. The first was adaptation through *infill*, as large 1683 blocks were subdivided by secondary through streets and tertiary streets. The second was adaptation through *expansion* of the grid, first irregular and "unplanned" grid, and later a regular, "planned" grid. Both reduced 1683 block depths to permit additional east-west circulation and to increase developable block frontage. Mean block depths of 666 feet in 1683 grid were reduced to 383 feet in the adapted 1683 grid, and were 328 ft (south) and 393 ft (north) in the unplanned expansion grid, and 422 feet (south) and 534 feet (north) in the planned expansion grid. In the expansion grid, tertiary streets and rowhouse dimensions and heights were systematized together with quaternary streets (pedestrian alleys), permitting high levels of housing density and diversity.

Key Words:

Philadelphia; urban grid; block morphology; diversity; American city

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Introduction

Many cities are designed with rectilinear blocks intersecting each other at right angles, or grids. Urban grids transcend time and culture; both ancient and contemporary cities utilize them, as do cities on all six inhabited continents. Grids are particularly widespread in the Americas. Spanish, French, and English colonial planners utilized grids in the planning of cities like Buenos Aires (Argentina), Cap-Haïtien (Haiti), or Savannah (Georgia, USA). These grids are diverse in form, reflecting their diverse conceptual origins, like the Laws of the Indies in Spanish colonies (Lejeune 2003, 39-41) or the vision of James Oglethorpe in Savannah, Georgia (Reps 1965, 195-99; Reinberger 1997, 839-40; Sears 1979, 34). In North America, the use of grids for urban plans was reinforced by the US National Survey, adopted in 1785. This survey platted a six-mile-square grid across North America during the 19C (Hubbard 2009, 193), shaping the grid of cities from Chicago to Los Angeles.

Urban grids experienced some disfavor in 20C urban planning as most cities in developed countries evolved from "dense, compact, and continuous" neighborhoods toward "diffuse, loose, and discontinuous" districts, typically in suburban areas (Levy 1999, 80). However, later trends like East Asia's rapid urbanization (Chow 2015) and a new emphasis on pedestrian-friendly neighborhoods (Haas 2008) have made the urban grid once again a "flexible and productive channel for urban transformation" (Busquets et. al. 2018, 684). Even in the United States, where "diffuse" settlement remains popular, the National Survey grid provides a certain structure for even low-density districts.

Many urban grids experience change or adaptation over time. Busquets et. al. (2018, 568-89) inventory several types of grid change, including "topography adaptation" and "downtown groupings", or redevelopment for high-density projects in growing cities. Declining cities like Detroit also experience adaptation of their grids. In Detroit, city blocks have progressively been combined and enlarged through highway construction, megaproject construction, and neighborhood clearance (redacted). Grids can be redeveloped to very high density levels. New York City's "greatest grid" (Ballon 2012) is renowned in part for its ability to accommodate almost any form of development, including tall towers (Koolhaas 1994).

If an initially designed grid has shortcomings, can its street and block pattern be altered? Over time grids may require adaptation or redesign. New York City's grid is notably resistant to redesign. Shortcomings like a lack of alleys and overly long and deep blocks have remained uncorrected, causing problems in refuse pickup, street circulation, and housing diversity (discussed again later in this manuscript). Some notable grids have also been abandoned because they were not adaptable. In Savannah Oglethorpe's 1733 city plan features small parks that inhibit traffic, constrain development, and occupy valuable real estate. These flaws doubtless led to the grid's abandonment in city expansions after 1856, as noted by Reps (1965, 201). New

Haven, CT, had an equally notable 1638 city plan that was constrained by topography (Brown 1976, 11-14) and by very large blocks. It was also abandoned in subsequent city expansions. These cases indicate that some urban grids may prove too inflexible to be adapted or too idiosyncratic to be utilized in city expansion.

Few studies exist of grids that have successfully evolved over time to serve new needs or to correct deficiencies. This study was undertaken as an examination of one such grid, that of Philadelphia, Pennsylvania, US. Well-known as one of the United States' early planned cities, Philadelphia is perhaps less well-known as an industrial city, the second-largest in the United States for much of the 19C. Throughout this era Philadelphia's growth was framed by a rectilinear grid, initiated with founder William Penn's original plan (1683) for the city (Reps 1965, 161) and then by subsequent extensions of the grid that have been little documented. Unique among American cities, Philadelphia's nineteenth-century grid was largely an extension of its seventeenth-century one. Given that few city grids are retained and expanded over such a long period, Philadelphia was a natural subject for a study examining urban grid evolution over time to accommodate changes in city form and development.

The study sought to address the following questions. How did Philadelphia's grid change during two hundred years of urban development, particularly as the city grew rapidly in the late 18C and 19C? Why did the city's grid evolve in the manner that it did? What urban development challenges, if any, were addressed by Philadelphia's city grid changes, and what were the morphological dimensions of these changes? Which particular qualities or elements of Philadelphia's grid were improved upon, or abandoned, during this period? Lastly, what lessons does Philadelphia's grid evolution hold for other cities with urban grids?

To investigate these questions, the study examined two aspects of evolution in Philadelphia's grid. First, it examined the original 1683 grid's *adaptations through infill* with urban development in the decades after 1683. Second, the study examined Philadelphia's *adaptations through expansions* beyond the 1683 grid as the city grew rapidly in the 18th and 19th centuries. The date 1900 was taken as a somewhat arbitrary ending date marking the near-total infill of the grid, and predating large-scale 20C alterations to the grid such as the Benjamin Franklin Parkway and Independence Mall (Wurman and Gallery 1972, 26-7; 50-3). The study finds that unlike many other urban grids, Philadelphia's grid was highly flexible, evolving substantially over time through infill and expansion adaptation while retaining the overall dimensions of William Penn's original grid from 1683.

The section of the study below describes the study method. Two subsequent sections then introduce the 1683 grid and explain its 18C and 19C adaptations, and the grid's 18C and 19C expansions. The study concludes by discussing the lessons of Philadelphia's flexible grid, implications for other cities with urban grids, and directions for future research.

Study method

To examine the evolution of Philadelphia's grid, the study utilized a mixed quantitative and qualitative methodology. This mixed method provided detailed measurements of Philadelphia's grid from contemporary data while also permitting analysis of information from historic data. The study additionally used qualitative methods to code different elements of the grid into types that could then be discussed analytically. The goal of this hybrid methodology was to comprehensively and empirically study Philadelphia's grid transformations in a way that permitted a clear conceptual and analytically informative understanding of the grid.

For a baseline digital map of Philadelphia's grid, the study utilized city street centerline data for 2022, available in GIS format (Philadelphia Streets Department 2022). All data was analyzed in QGIS software (qgis.org 2022). Prior to data analysis, data was cleaned to permit measurement as follows. Street segments categorized in the GIS as expressway, ramp, parkway, boulevard, and trail were removed from data because these types were 20C in date and did not constitute part of the city's pre 1900 grid. Other street types also not part of the pre-1900 grid were removed based on visual inspection, including short street segments such as driveways, internal roads for large buildings, railways, etc.

To analyze the 1683 grid, this area was first defined as extending from Vine Street (north) to South Street (south). These are the bounds of the initial Penn survey, shown in Figure 1. Data was coded as follows: Current (2022) streets remaining from the 1683 plan were coded as layer 1 (primary streets), while current (2022) streets that subdivided 1683 blocks were coded as layer 2 (secondary streets). Additional streets that did not fall into layers 1 or 2, including tertiary streets (alleys) were excluded from further quantitative analysis but were examined qualitatively. Lastly, streets within layers 1 and 2 that had been removed between 1900 and 2022, mostly by 20C redevelopment, were identified by examination of historic maps (UMI.com 2022). These 'removed streets' were manually recreated in GIS and were then coded as either layer 1 or 2.

To analyze the expansion of Philadelphia's grid beyond the bounds of the 1683 plan, streets were identified through visual inspection and comparison with historic maps (UMI.com 2022) and coded as either "preexisting" (i.e., roads that predated the grid extension); "expansion" (streets continuing north and south from the 1683 plan area); "extension" (east-west streets surveyed between 1683 and 1900); and "other" (mostly tertiary streets within blocks). Within the grid expansion area, only the neighborhoods known today as North and South Philadelphia were examined. Resource limitations did not permit examination of other areas of the city.

Once streets comprising the urban grid had been coded, block dimensions were measured using a measure tool in QGIS. Blocks were measured from street centerline to street centerline except in the case of sample blocks. As Philadelphia was originally surveyed in Imperial measurement units, these units are used in the manuscript. Metric equivalents are available in the

Appendix. A block measurement of 450 feet, for example, could comprise 400 feet of urban block and 50 feet of street (25 at either end of the block). Streets were manually tagged by name, orientation (i.e., N/S or E/W), and type (original/subdivided). In the study, we refer to streets as E-W or N-S, despite Philadelphia streets being about nine degrees 'off' the cardinal directions (Hidden City 2015). Streets within the original grid (e.g., 15th Street) were further coded to be distinguishable for analysis and measurement. E-W distance is referred to as "block width" in the study, while N-S distance is referred to as "block depth". Contemporary GIS shows small variations of between 1 to 3 ft between otherwise identical blocks, indicating initial or subsequent surveying errors or conversely, errors in the GIS. All block measurement figures are therefore +/- 1 to 3 feet. Further data filtering was undertaken to calculate average (mean) 1683 grid block dimensions before and after subdivision and to correct for exceptions such as intervening parks, etc. The findings of these analyses are discussed in the sections below.

Findings

Philadelphia's 1683 grid: secondary streets resolve deficiencies of the Penn plan

The initial plan of Philadelphia was surveyed by John Holme in 1682 and 1683 with input from William Penn (Reps 1965, 157-74; Roach 1968a, 1968b; Garvan 1963). The plan has a distinctive grid, with five symmetrically distributed parks and two wide streets running E-W and N-S. Holme's, or Penn's, plan has no direct precedents but may have been influenced by English military camps and planned cities in Ireland, by plans for the reconstruction of London in the 1660s, or by medieval or classical precedents in continental Europe (Reps 1965; Garvan 1963). Whatever its inspiration, the Penn plan was unique in British colonial North America. The grid spanned a flat peninsula between the Delaware and Schuylkill rivers, with a scale that was vast for the time. At nearly two miles by one mile, the Philadelphia grid was about the same size as contemporary London. The plan's significant scale connotes Penn's ambition for his New World settlement, but it also implied an expectation of tremendous growth for Philadelphia. Even though the city soon became the largest in British North America, it would not fully occupy the blocks defined by the Penn grid for nearly two centuries.

Holme's survey was followed with surprising fidelity and remains substantially intact today as the street grid of so-called "Center City" Philadelphia. Figure 1, showing the original survey, can be clearly traced against the area within the Penn grid today (Figure 2). The numerous post-1683 interventions are shown in Figure 2. Many aspects of the original plan are of interest and have been discussed by previous scholars, particularly the five parks surveyed by Holme that remain today in variously altered forms. Of particular interest regarding grid evolution, however, are post-1683 interventions, particularly the subdivided, or secondary streets in Figure 2.

[Figure 1, original 1683 Penn survey, here]

[Figure 2, diagram of Penn grid today, here]

The 1683 plan featured notable irregularities in its block dimensions that would substantially influence its evolution. Block dimensions for the Penn Grid are shown in Table 1. East-west block dimensions are quite consistent at 450 feet, except for three blocks of 540/625/550 feet that are respectively adjacent to the riverfronts and to the central square. There are also smaller variations elsewhere, noted in Table 1.

[Table 1, Penn grid block dimensions, here]

The 1683 grid has a higher level of variation in north-south block dimensions, easily visible in the original survey (Figure 2). What explains these irregularities? Talarcheck (1979, 168) argued that the different block depths were surveyed as such to "adjust to topography" such as bluffs along the riverbanks. Another related possibility is that the blocks were shifted to accommodate small water inlets visible in the 1683 plan (Figure 2). These adjusted E-W street terminations would have accommodated water inlets at mid-block instead of at street ends. These inlets are long gone today, but one located between Spruce and Walnut streets persisted into the 18C and was used for commerce (the "City Dock"). Notably, the block containing the former City Dock has the deepest N-S distance between primary streets. Overall, it seems likely that water played a role in shaping the Penn plan's irregular north-south block dimensions.

Table 1 shows that the N-S dimensions of blocks in the Penn grid were not only irregular, but deeper than the grid's E-W street dimensions. The mean block depth of the Penn grid is a substantial 666 feet. While E-W block dimensions were typically 450 feet wide, three N-S blocks were between 525 and 560 feet deep, and another five blocks were 675 feet or greater. The deepst block, containing the aforementioned City Dock, was nearly 875 feet in depth.
As it grew, Philadelphia was developed with dense rowhousing and commercial warehousing. Some 18C survivors of this development are still to be seen today near the Delaware waterfront (e.g., Teitelman and Longstreth 1974, 28-50). Rowhouse development was poorly accommodated by the grid's overly large blocks, which did not permit full utilization or development of block interiors. Nor did these blocks permit substantial east-west circulation to the westernmost blocks of the growing city. The evidence for this is discussed below.

Over a period of approximately 150 years after 1683, the Penn grid was subdivided both systemically, by the creation of secondary streets that bisected multiple blocks, and episodically, through the creation of tertiary streets (alleys) within blocks. Today (2022), secondary streets

running east-west, shown in red and yellow in Figure 2, subdivide six of the eight N-S blocks in the Penn plan. The block with the smallest depth, between Pine and Spruce Streets, lacks a secondary street, as does the deeper block between Race and Vine Streets. The remaining 1683 blocks are effectively halved by secondary streets, generating "new" subdivided blocks between 225 and 440 feet deep (Table 2). The resulting new block depth mean of 373 feet (excepting two unsubdivided blocks) is less than the typical E-W block width of 450 feet.

Most secondary streets run E-W, while one secondary street runs N-S, subdividing a large E-W 1683 grid block. Several additional N-S secondary streets exist west of the 1683 grid, which ends at 22nd Street. These streets were not present in the original Penn plan (Figure 1) and first appear to have been surveyed in 1794 (Figure 4). These "secondary blocks" share the new Penn grid block depths, but have an E-W mean width of 317 feet, substantially less than the typical Penn grid E-W block width of 450 feet.

[Table 2, subdivided Penn grid block dimensions, goes about here]

The eastern termini (or beginnings) of secondary streets within the Penn grid are irregular. One (Lombard Street) extends clear across the Penn grid, while the others begin respectively at 3rd (Cherry St), 6th (Sansom St), 4th (Locust St), 8th (Filbert St), and 16th (Ludlow St). What explains this irregular geography? Historic maps of Center City in 1762, 1794, and 1797, shown in Figures 3, 4, and 5, indicate the likely cause (Clarkson and Biddle 1762, Biddle 1794, Hills 1797). The 1762 and 1794 maps place the Delaware River at bottom, indicating the city's early dependence on this waterfront: maps would continue to use this orientation through at least 1824. Three of the six E-W secondary streets (Cherry, Locust, and Lombard Streets) already existed by 1762, and two more (Sansom and Filbert), existed by 1794. The westernmost, Ludlow St, is much shorter, extending for only five blocks. Its early form is visible in Figure 5 and the street was fully surveyed by the 1830s. Short in length and younger than other secondary streets, Ludlow arguably has a status between secondary and a tertiary streets.

[Figure 3, 1762 map, here]

[Figure 4, 1794 map, here]

[Figure 5, 1797 map, here]

The historic maps provide a convincing explanation for the eastern origin points of the secondary streets. All three show urban development was densest around the intersection of Market and Front Streets, and development decreasing both to the north and south. Given that the secondary streets had to be surveyed through existing property, it was likely easier to survey streets and to acquire necessary properties in less built-up or subdivided areas. This would

explain the origin points of Cherry and Lombard Streets at 3rd and Front Sts, respectively, and of Locust St at 4th. These streets were toward the northern and southern ends of the Penn grid and urban development was sparser there, permitting the streets to begin closer to the river. Conversely, denser development around Market Street might have inhibited the eastward extension of Filbert and Sansom Streets, which begin at 6th and 8th Streets respectively. The surveying of Ludlow Street was likely delayed by the presence of substantial properties between Market (also called High until the 19C) and Chestnut Streets.

Why were secondary streets created? Unlike the 1683 plan's primary streets, which balanced function while accommodating topography and ornamental squares (noted earlier), the Penn grid's secondary streets were purely functional. Pragmatically avoiding dense urban development, the secondary streets addressed circulation problems inherent in the primary streets' deep N-S blocks. The presence of E-W secondary streets substantially increased the westward street capacity of the Penn grid, even though both secondary and primary streets were only 50 feet wide. The secondary streets also provided additional frontage for residential development, and certain secondary streets, particularly Ludlow, Filbert, and N-S Juniper Street, provided service access to business activities along 100-foot-wide Market and Broad Streets. This service function would become increasingly important in the 19C as the central business district of Philadelphia expanded west to encompass the intersection of those two streets.

The historic maps show the Penn grid riddled with alleys. We may term these tertiary streets, as they occupied a functional status below that of primary and secondary streets. Almost every block in the Penn grid is subdivided by tertiary streets, including many blocks close to the Delaware riverfront that lack secondary streets. Tertiary streets in Figures 3, 4, and 5 are for the most part irregular and *episodic* in form and location. The form and location of these streets is distinct: they run both E-W and N-S, few run for more than one block, and they are quite narrow, often less than 20 feet in width. Tertiary streets are numerous and persistent within the Penn grid; Figure 2 shows that blocks with as many as five or six irregular tertiary streets survive even today.

Tertiary streets solved the challenge of residential development within Philadelphia's overly large blocks. Philadelphia's primary grid was far too large to efficiently house residential development, nor did secondary streets resolve this problem. Given that a rowhouse is rarely deeper than 50 feet, even subdivided city blocks, such as the 450 wide, 335 foot deep block between Pine Street (primary) and Lombard Street (secondary), were too deep. Tertiary streets solved this issue. They were narrow enough to access all of the developable land within a block. At the same time they had limited traffic utility, an advantage for residential privacy but a disadvantage for circulation.

The Penn grid's tertiary streets changed in form and location as the city developed in the 19C. The city blocks east of Broad Street possessed a large number of episodic tertiary streets,

indicating a piecemeal, gradual subdivision and development process of these streets. Those to the west, of Broad Street, however, particularly around Rittenhouse Square (Figure 2) show tertiary streets that subdivide blocks in an organized, *systemic* manner. Like episodic tertiary streets, systemic tertiary streets are not through streets. They are typically narrow and are inconsistent in location from block to block, discouraging through vehicle passage. Seclusion can connote privilege: some systemic tertiary streets in the Penn grid house prestigious residential development, including Delancey Place, one of central Philadelphia's most imposing streets.

Systemic tertiary streets provided new opportunity for diverse development within the Penn grid. Sometimes as many as three, running E-W, subdivide already subdivided Penn grid blocks. For example, the subdivided block bounded by Lombard (secondary), South (primary), 21st and 22nd Streets has a depth of 370 ft. This block is further subdivided by *three* systemic tertiary streets, creating four narrow blocks with a mean depth of only 93 feet. These narrow blocks nevertheless house a mix of rowhouses on two sides: both 'typical' rowhouses about 40 feet deep, and tiny rowhouses only 20 to 25 feet deep each. The tiny rowhouses have only one room per floor: they are common in Center City and are known as "trinities", because they only have three rooms.

Systemic tertiary streets permit development within a city block in a more organized, replicable manner than do episodic tertiary streets. They provide Center City Philadelphia with an efficient and close to maximum utilization of block space for a range of single-family rowhousing types, from the grandeur of Delancey Place to the tiny streets of trinities. In the 19C, before the advent of apartment buildings, Philadelphia's flexible grid of primary, secondary, and tertiary streets provided a wide range of single-family housing types and options. Today they give Center City Philadelphia a diverse range of streets and blocks, and a rich experiential quality. As Philadelphia continued to grow, systemic tertiary streets would persist, ultimately dominating as the morphological solution to access to and development of block interiors. As we will see below, tertiary streets play a critical role in organizing Philadelphia's expansion grid beyond the bounds of the 1683 plan.

Philadelphia's expansion grid, part 1: the unplanned grid corrects errors but introduces distortions

The Penn plan of 1683 was expansive, but it did not fully foresee, nor did it fully shape, the direction of the city's future growth. As early as 1762 (Figure 3), urban development had expanded north and south along the Delaware River into what were known as the city's "Liberty Lands". The resulting development and streets were not shaped by the Penn grid and were therefore less constrained. By 1794 (Figure 4), this "unplanned grid" had extended six or seven blocks north and south of the Penn grid. The city would continue to grow within the unplanned

grid until the surveyed or planned grid, discussed in further detail in the following section, was established around the turn of the 19C.

What form did Philadelphia's unplanned grid take? Figures 6 (South Philadelphia) and 7 (North Philadelphia) show the unplanned grid today. This grid has numerous qualities that differentiate it from the Penn grid.

[Figure 6, diagram of South Philadelphia, here]

[Figure 7, diagram of North Philadelphia, here]

First, the grid's E-W streets near the Delaware river are not parallel to the Penn grid streets. Instead, many of unplanned grid's streets diverge from the Penn grid orientation and also from each other, creating trapezoidal blocks with shifting depths. This irregularity is visible in the 1794 map. The cause appears to be agricultural property boundaries, clearly seen south of South Street in Figure 5, as well as topography, such as streams north of Vine Street and the irregular Delaware River shoreline, both of which are also visible in Figure 5.

Second, numerous preexisting streets, shown in Figures 6 and 7, cut across the unplanned grid in both North and South Philadelphia. These were originally rural roads that traversed open countryside to access other settlements or Philadelphia's growing numbers of country houses, which had come into existence simultaneously with the city (Reinberger and McLean 2015, 51-73). Visible in Figure 5 are two preexisting roads (Moyamensing and Passyunk) in South Philadelphia, and three (Ridge Road and two "roads to Germantown") in north Philadelphia. Passyunk, Ridge, and the western Germantown roads begin at Vine and South Streets near Ninth and Fifth Streets, respectively, while Moyamensing and the eastern Germantown "roads" begin nearer to the waterfront. Existing development may have led to the origin points of preexisting roads close to the river being within the unplanned grid, while those farther away begin at the Penn grid.

The Penn grid's north-south streets are part of the unplanned grid. In South Philadelphia, the primary N-S streets of the Penn grid continue without interruption and with little deviation through the unplanned grid (Table 3). The single secondary N-S street in the Penn grid (Juniper St), does not continue into the unplanned grid. However, in North Philadelphia the preexisting streets both distort and are distorted by the unplanned grid. N-S streets in this part of the city are substantially more irregular, as shown in Table 3 and visible in Figure 7. This is less the result of topography than of the presence of preexisting streets and property lines. Figure 5 shows that primary streets could ignore topography: two N-S primary streets (Second and Third) extend as far north as the eastern Germantown Road, and two others (Fourth and Sixth) are apparently in the process of being extended north. An 1811 map (Figure 8) (Paxton 1811) shows the new Sixth

and Eighth Streets with additional distortions, plus distortions in Seventh, Eighth, and Ninth Streets to the north. Property lines are not shown in the 1811 map, but it is possible that these streets were skewed to align with properties located along the outer Germantown Road, labelled Old York Road in 1811, or to avoid a watercourse west of that road. Today (Figure 7) all N-S streets east of Ninth Street are skewed, creating trapezoidal blocks within the unplanned grid that do not parallel the Penn grid along any of their sides.

[Table 3, unplanned grid measurements, here]

[Figure 8, 1811 map, here]

The subdivision of the Penn grid with secondary streets demonstrated the need for shallower blocks in that grid. Unplanned grid block depths are consistent with the subdivided Penn grid (Table 3). The mean depth of subdivided Penn grid blocks is 373 feet; unplanned grid mean block depths in North Philadelphia are 393 feet, similar to the Penn grid, and 328 feet in South Philadelphia, shallower than the Penn grid. As in the Penn grid, tertiary streets further subdivide blocks in the unplanned grid to permit additional rowhouse development.

The unplanned grid is a vernacular extension of the Philadelphia grid. It extends the Penn grid beyond its original bounds, correcting the deficiency of that initial grid's overly deep blocks in a manner similar to the Penn grid's secondary streets. But the unplanned grid lacks a differentiation between primary and secondary streets; it was not platted and then subdivided in the same manner, and its block depths are shallow enough to suffice for east-west traffic. In other words, the unplanned grid evolved incrementally in a manner designed to address the needs of circulation and development. At the same time, the unplanned grid has its own deficiencies, especially the irregularities resulting from preexisting streets and property lines. These deficiencies distort the grid's E-W streets and many N-S streets, creating irregularly sized and shaped blocks.

Unlike the Penn grid, the morphology of Philadelphia's unplanned grid has functional, but not formal interest. Nor is it unique: many cities with a planned grid have irregular grids beyond that grid's borders, such as Savannah, with irregular grids both east and west side of the 1733 Oglethorpe grid (Colton 1865). But Philadelphia's unplanned grid is of great interest nevertheless, not only in the way in which it functionally improves upon the Penn grid, but in the role that these functional improvements would play in the next stage of Philadelphia's grid development. During the early and mid 19C, Philadelphia would develop a third grid that incorporates additional functional and formal improvements to the previous two generations of grids. This "expansion grid" is discussed below.

Philadelphia's expansion grid, part 2: the planned grid balances circulation and development

Philadelphia's urban growth during the nineteenth century was rapid. In 1800, the population within today's city limits was 81,009 and by 1860 the city population had multiplied sixfold to 565,529. This population doubled again by 1900 to 1,293,697 people. The city's rapid demographic expansion was mirrored by its physical expansion. As a resident commented in 1828, "Below South Street, east of Broad, has recently sprung up a new town. Where last summer the boys played, there are now solid blocks of brick buildings, grocery stores and taverns [and the] clitter clatter of the weavers' shuttle" (Wiegley 1982, 281). In 1830 over 5,000 houses were being erected within the city each year.

Philadelphia accommodated its rapid growth with a surveyed, or "planned" expansion grid. This appears to have been fully surveyed by 1836 and is of substantial morphological interest. Interestingly, the historical origin of the planned grid has been little documented. An incremental process is indicated by the historical maps in Figures 5, 8, 9, and 10. The first two, discussed previously, show the city in 1797 and 1811, while the latter two show the city in 1824 and 1836 (Carey 1824, Tanner 1836). A planned, though irregular, grid began to appear as early as 1797. Blocks showing E-W surveyed streets parallel with the existing Penn grid are visible in Figure 5 to the south of the city's built-up area around Christian Street. The surveyed streets extend west to the border of the then-municipality of Southwark, indicating a potential municipal role in the survey. These blocks have inconsistent N-S depths as a result of the unplanned grid.

By 1811 (Figure 8), N-S streets extending south from the Penn grid had been surveyed as far west as Broad Street, but no E-W streets are shown beyond those extant in 1797. Another survey of E-W streets is present in Figure 8 in North Philadelphia along the Schuylkill riverfront. This grid is more regular, with one wide and two smaller E-W streets with different depths. The wide street appears intended to connect to a bridge, constructed on this site in 1812 (Griggs 2004). This grid extends eastward to "Fourth Street", today's 19th St.

The 1824 map (Figure 9) shows extension of E-W surveyed streets west of the 1811 survey in South Philadelphia, and east of the 1811 survey in North Philadelphia. In South Philadelphia, E-W streets are surveyed west of the unplanned grid to the border of the then-municipality of Moyamensing, marked as "M" on the map. Some of these surveyed E-W streets are skewed to accommodate the trapezoidal blocks of the unplanned grid. However as these streets cross Broad Street all become parallel with the Penn grid, reconciling the unplanned grid's skewed streets with a surveyed, planned grid parallel with the Penn grid. In North Philadelphia the surveyed grid of 1824 extends eastward to connect with the existing informal grid in Northern Liberties (marked "NL" on the map). The surveyed grid fills the bounds of Spring Garden municipality (marked "SG"), indicating a potential municipal role in the survey.

[Figure 9, 1824 map, here]

The surveyed grids of 1797, 1811 and 1824 show streets whose form and alignment represent a compromise between the irregular blocks of the informal grid and the regularity of a surveyed grid. The Penn grid had already achieved some regularity in 1683, and additional regularity was clearly desirable within the rapidly expanding Philadelphia of the 19th century. A fully surveyed grid would permit not only rapid land sales of similar or identical parcels, but rapid development of similar or identical houses. An ideal survey would balance the need for sufficient E-W circulation and the need to fully access block interiors for residential development. In its final form, Philadelphia's planned grid provided a successful solution to these conjoined problems, demonstrated in this grid's being replicated in nearly identical form across much of South and North Philadelphia (Figures 6 and 7).

By 1836 Philadelphia possessed a surveyed, "planned" grid extending to, and likely beyond, the bounds of the map shown in Figure 10. This grid has two key features. First, it has regular block depths (Table 4). Compared to the unplanned grid, block depths of both North and South Philadelphia planned grids are nearly invariant. South Philadelphia blocks are typically square at 400 feet on each side, while North Philadelphia blocks are typically deeper (500 to 525 feet) than they are wide (400 foot).

[Table 4, planned grid block dimensions, here]

[Figure 10, 1836 map, here]

The planned grid's block depths of 400 and 525 feet are shallower than the unsubdivided Penn grid (Table 1), but deeper than the subdivided Penn and unplanned grids (Tables 2 and 3). North Philadelphia's deeper 525 foot blocks are 140 feet shallower than the original Penn grid mean of 666 feet, while South Philadelphia's 400 foot deep blocks are deeper than the subdivided Penn grid mean depth of 373 feet. We can argue the planned grid's block dimensions to achieve three goals. The first is sufficient east-west circulation. The depths of the planned grid were apparently sufficient for through traffic, as no further subdivision or alteration for traffic occurred until the 20C advent of the automobile. The planned grid's tertiary streets, as we will see, permit residential development while discouraging traffic. Preexisting streets such as Ridge and Germantown Avenues in North Philadelphia may also have reduced the need for additional east-west circulation within the planned grid, and perhaps explaining the deeper blocks there.

A second goal of the planned grid, achieved only in South Philadelphia at any scale, is the creation of a perfectly square city block. Square blocks have been a feature of urban grids since at least Timgad, but the planned grid marks the first appearance of a square block in Philadelphia. A perfect square has little functional importance for traffic circulation, but it does provide a visually pleasing appearance on a map and may enhance subdivision and sale of land,

as in the US National survey (Hubbard 2009, 193-214). It may also have functional purpose if each side of a block is developed symmetrically, as was proposed for the Barcelona grid (Busquets 2014, 130-31). In fact South Philadelphia's square blocks do show some evidence of symmetrical development on each side despite block subdivision, explained further below.

Perhaps the most important goal of the planned expansion grid was to permit the easy subdivision of city blocks for residential development. While commercial, industrial and institutional uses also existed within Philadelphia's grid, the grid as constructed is primarily residential, and its subdivision seems clearly intended for easy residential development. Nearly the entirety of Philadelphia's planned grid, except for the farthest reaches of the northern grid (Figure 7), would be developed with rowhouses, as were many areas of the city beyond the extension of the Penn grid (i.e., other grids that do not align with the Penn grid, as in the Kensington neighborhood of Northeast Philadelphia). The systemic quality of the planned expansion grid is accompanied by its equally systemic subdivision with tertiary streets. Examples of subdivided planned grid blocks ("sample blocks") are shown in Figures 11 (North Philadelphia, Blocks 1 and 2) and 12 (South Philadelphia, Blocks 3 and 4). These examples were selected to represent surviving complete examples of planned grid blocks. Although many blocks within the planned grid are today deteriorating from housing abandonment and demolition, a random sample would likely show similar results to the selected examples.

The sample blocks illustrate three morphological features found throughout the planned grid. The first is subdivision of the larger block into multiple "sub blocks" by comparatively wide tertiary streets; second is subdivision of each sub block by "families" of identical parcels of varying widths and depths; and third is separation of parcel families within the block by "micro alleys" only 3 feet wide. Beyond the sample blocks, the study's qualitative analysis indicates that these features comprise the typical morphology of the expansion grid. Each of these three block features is analyzed below.

[Figure 11 here]

[Figure 12 here]

Block subdivision with tertiary streets

The four sample blocks in Figures 11 and 12 are subdivided by two tertiary streets each, 30 or 35 feet in width. Two tertiary streets are the norm except in North Philadelphia where deeper, 525 foot blocks permit three tertiary streets (Figure 13) Today, this subdivision permits a one-way street with cars parked on one side of the street (50-foot primary streets are typically one-way in the expansion grid, with cars parked on both sides of the street). In the sample blocks, tertiary streets subdivide the block symmetrically in an "A B A" arrangement, creating

two slightly deeper blocks (A) on the 'outside' of the block, and a slightly shallower block (B) on the inside. The ratio of block depths is 6:5 or close to it, e.g., 120 feet to 100 feet or 115 feet to 100 feet. The ABA hierarchy of sub blocks, with deeper sub blocks 'outside' and a narrower sub block 'inside', implies a hierarchy of housing development as well, confirmed below. [Figure 13 here]

The directionality of block subdivisions varies. In North Philadelphia between North Jefferson and Tioga Streets, the study measured 68% of tertiary streets running north-south and only 31% running E-W, while a smaller 56% of tertiary streets in South Philadelphia run E-W, and 40% run E-W. A small percentage of blocks in both North and South have tertiary streets running in both directions. N-S and E-W subdivided blocks are seemingly located randomly, which seems to indicate no overall plan or survey for tertiary streets, or that block subdivision directionality may have been determined by developers. The shifting directionality of tertiary streets interferes with through traffic: typically, one cannot drive on tertiary streets between blocks for more than a few blocks before arriving at a block where tertiary streets are oriented to the other direction. However, North Philadelphia's easternmost expansion grid is an exception, where 90% of tertiary streets run N-S. This orientation may have occurred to increase N-S traffic capacity, but narrow E-W block dimensions, shaped by the skewed primary streets discussed earlier, likely encouraged this subdivision directionality.

Sub block subdivision with parcel families

Within the sub blocks, parcel dimensions often vary depending on a parcel's position within the sub block, and on its position within the larger block. The four sample blocks show similar parcel subdivision morphology. Block 1 in North Philadelphia is a long (530 foot) N-S subdivided block with the most regular and least complex parcel subdivision pattern of the sample blocks. It has two parcel families, shown as I and II in Table 5, and two sub block types, shown as A and B: I has 65-foot deep parcels on sub blocks A facing the two N-S exterior primary streets, while II has 48-foot deep parcels facing the two interior tertiary streets, on one side of sub blocks A, and both faces of sub block B. Parcels run from block end to block end, and all parcels face N-S running streets, meaning that E-W primary streets are faced by rowhouse sides. The two parcel families have different widths as well as depths: I is 15.5 feet wide and II is 14.27 feet. The difference between 15.5 and 14.27 feet is not great, but 1.25 feet makes a substantial difference inside a narrow rowhouse, and a smaller rowhouse is both cheaper to construct and to purchase. Block 1's parcel subdivision demonstrates the planned grid's placement of more expensive rowhouses on primary streets and less expensive rowhouses on tertiary streets. This contrasts with the subdivided Penn grid, where larger rowhouses may also be found on tertiary streets like Delancey Place.

[Table 5 of parcel families for sample blocks here]

This same parcel subdivision pattern is found with variations on the other three sample blocks, but with more complex subdivision morphology and a larger number of parcel families on each block. Blocks 2, 3 and 4 are square 400 by 400 foot blocks, each with two tertiary streets running either N-S or E-W. The three blocks have different directionalities but very similar parcel subdivisions. In Block 1, two of the four primary streets are faced by rowhouse sides, but Blocks 2,3, and 4 perimeters all have deeper parcels facing the primary street, giving them a symmetrical parcelization on their four equal sides, broken only by the tertiary streets. The "exterior" large parcels of Blocks 2, 3, and 4 confine smaller parcels to tertiary streets.
In each sample block 2, 3, and 4, deeper "exterior" parcels are also wider than shallower "interior" parcels. The parcel families are also more diverse: Block 1 has only two parcel families, but Blocks 2, 3, and 4 have between four and five parcel families each (Table 5). Block 4, for example, has two exterior parcel families (16 by 66 and 16 by 64 feet) and two interior parcel families (15 by 49 and 15 by 46 feet), whereas Block 3 has five parcel families, and Block 2 four.

Large parcels are both wider and deeper than smaller parcels, and the rowhouses constructed on those parcels differ in size as well. Figures 14 and 15 provide street views of two facades within Block 3. Figure 14 shows two-story rowhouses on 14.5 foot wide, 50 foot deep parcels along South Hicks Street, one of two tertiary streets in Block 3, and Figure 15 shows three-story rowhouses on 16.5 foot wide, 68 foot deep parcels along South 15th Street, the easternmost primary street of Block 3. The addition of a third floor makes a primary street rowhouse substantially larger than its tertiary street neighbor. If we estimate the Hicks Street rowhouse to be 35 feet deep and the 15th Street rowhouse to be 50 feet deep, the floor area of the three-story rowhouse is approximately 2.5 times that of the two-story one.

This three-story, two-story relationship between primary and tertiary streets is also present in Blocks 1 and 2, where all primary streets have three-story rowhouses and tertiary streets have two stories, but not in Block 4, where primary and tertiary streets have only two-story rowhouses. Block 3 demonstrates a hybrid condition where three of the primary streets have three-story rowhouses and the fourth has two-story. The reason for these height differentials is likely economic, and the two-story houses on narrower streets also permit additional light and air to reach these narrow (30 to 35 foot wide) thoroughfares.

[Figure 14 street view of Hicks St rowhouses, here]

[Figure 15 street view of 15th St rowhouses, here]

The expansion grid's parcel subdivisions and rowhouse distinctions, present in slightly different iterations in the four sample blocks, demonstrate the high variability in housing morphology made possible by the expansion grid's morphology. Philadelphia's flexible grid permitted developers to adjust the width and depth of parcels within a hierarchy of primary and tertiary streets. The result was a wide range of rowhouse dimensions. Sample Block 3 accommodates five parcel families and rowhouse models, and a block with three sub blocks could conceivably house as many as eight different parcel families and rowhouse models. All these variations are possible within the confines of a 400-foot wide, 400 to 525 foot depth block.

Micro alleys further subdivide sub blocks

The four sample blocks possess an additional morphological feature: what we may term "micro alleys". These tiny passages, visible in Figures 11 and 12, adjoin the rear boundary of residential parcels, separating one face of a sub block from the other. These alleys are only three to four feet wide, indicating that they were only for pedestrian access. Micro alley morphology varies between the sample blocks. In Block 1, micro alleys terminate at the two E-W primary streets just as do the tertiary streets and housing. In Blocks 2, 3, and 4, however, nine of 12 micro alleys have egress only on the tertiary street. These nine micro alleys terminate two parcels short of the primary street. In this alley morphology, corner parcels have no access to micro alleys while the four adjacent parcels access alleys at the lot rear corner, at the stub end of the micro alley. This elegant arrangement permits nearly all parcels on these blocks access to micro alleys without the alleys having to exit onto primary streets, thereby conserving primary street frontage for rowhouses.

Micro alleys are a fourth circulatory type within the Philadelphia grid, differing from streets in that they do not permit auto access. While this is also true of some narrow tertiary streets in the Penn grid, micro alleys differ from these episodic tertiary streets in two ways. First, micro alleys are systemic; they were clearly designed as part of the parcel subdivision and rowhouse development process of each block. Their designed nature is manifested in their identical dimensions, similar form, and ubiquitous presence within the four sample blocks. Second, micro alleys always perform a service function; rowhouses never face them, unlike the Penn grid's tertiary streets.

The ubiquity of micro alleys in a densely developed urban fabric indicate that they played a critical function within the expansion grid. Given their 19C origins, micro alleys were presumably intended for waste removal from the rear of properties and possibly also for coal delivery to rear yards. These functions were likely significant before universal sanitation, water delivery, and electricity, but micro alleys appear little used today. A qualitative review of Google street view images shows these alleys to be gated and locked, with vegetation and debris often visible beyond the gates. The city appears to neither own nor maintain them. Regarding alleys in

Center City, one city official was quoted as saying "pedestrian alleys" "are not public ways and are the responsibility of the abutting owners" (Beisart 2014). The same is likely true for the derelict micro alleys of the expansion grid, made obsolete by changing technology. Within the expansion grid and perhaps in other parts of Philadelphia, micro alleys are omnipresent yet nearly invisible: they are a cryptic and curious feature of Philadelphia's grid morphology.

Discussion/Conclusion:

While Philadelphia's 1683 Penn grid has been widely studied by historians, the nature of the grid's evolution has been much less so. This study found that the Penn grid's overly large scale and consequent inadequate circulation were shortcomings that were overcome through two hundred years of subsequent evolution, both through subdivision with secondary streets and through construction of episodic, and later systemic, tertiary streets. All of these additional streets rectified the grid's original flaws and permitted denser development and sufficient circulation for surface traffic.

The study also finds that the expansion of the Penn grid both north and south of Center City are of substantial morphological interest. The unplanned expansion grid, created over the course of the 18C, lacked regularity and predictability, but had smaller blocks and more east-west circulation and development frontage. The planned expansion grid surveyed in the early 19C adopted features of the two previous grids and introduced important innovations of its own. It was even more regular than the Penn grid, with smaller 400 by 400 to 525 foot blocks that became the basic urban fabric for much of Philadelphia. Even more important was the expansion grid's rationalization of block subdivision with systemic tertiary streets, providing an organized, hierarchical system of parcelization and of rowhouse scale that provided a high level of development diversity within a single block.

The planned expansion grid of Philadelphia is a significant achievement in urban form that has been little recognized by scholars. Notably, it represents a harmonious reconciliation between the city's unplanned eighteenth-century grid and the seventeenth-century grid planned by William Penn, while providing a predictable framework for rowhouse development in a manner that provided to be scalable and replicable throughout much of Philadelphia. The diversity possible within the bounds of the expansion grid block is also notable. Unlike the subdivided Penn grid, the morphological diversity of housing in the expansion grid is provided by systemic and predictable street and parcel subdivisions. Although the scope of the study did not permit further investigation of housing diversity, the expansion grid doubtless provided nineteenth-century buyers, and buyers today, with a range of different housing options possible within just a single block of the urban fabric. Few other urban grids have achieved this level of housing diversity. The variability possible within Philadelphia's expansion grid contrasts

strongly with that of New York City, for example, where an invariable 200-foot-deep block permits neither further subdivision by tertiary streets, resulting in much wasted space within blocks, nor any possibility of diversity in rowhouse models apart from differing widths.

The Philadelphia grid is far from perfect. Housing density is high, resulting in little green space and tight lots. The resulting housing has proven to be undesirable for large households, particularly in low-income, ethnically and racially segregated areas. Much of Philadelphia's grid is subject to disinvestment and abandonment. This is not necessarily the fault of the city's urban morphology, however, but of social and economic factors beyond the scope of this study. Further study might examine the morphological dimensions of housing with relationship to parcelization and the performance of different housing or morphological features (e.g., micro alleys) with respect to contemporary functional needs.

Despite imperfections, the advantages of the Philadelphia grid hold many lessons for other cities that are considering grids for their own urban expansion. The narrow streets of Philadelphia provide abundant on street parking and even bicycle lanes, confining auto traffic to a slow speed. The tertiary streets protect many houses from through traffic and noise. Pedestrian movement within the Philadelphia grid is both pleasurable and secure as a result. The blocks themselves provide abundant space for mixed uses and both larger and smaller residential properties. The rowhouse model gives opportunity for very high homeownership and a small amount of outdoor private space, for every homeowner on the block. And the fractal quality of the streetscape provided by the tertiary streets give Philadelphia a varied and pleasurable experiential quality. Many better-known grids, such as New York or Barcelona, provide some of these advantages, but only Philadelphia provides all of them, giving the city a unique and privileged place among urban grids. Identification of other such grids with equivalent or parallel histories of experimentation and achievement of diversity is an important direction for future morphological research, as is the development of urban design strategies for contemporary cities using lessons from the Philadelphia grid.

The development of Philadelphia's flexible grid occurred, as far as we can tell, without the regulatory oversight of government or the influence of professional city planners or designers. This is testament to the unconscious logic of continued experimentation undertaken by vernacular surveyors and developers in the period between 1683 and 1900. This experimentation was made possible by persistent retention of the Penn grid in tandem with persistent evolution of its dimensions, subdivision with secondary and tertiary streets, diverse parcelization, and diverse development with housing. This flexible grid provides a robust and in many ways ideal framework for urban growth and development.

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Table 1.
Block Lengths, Original Grid

Start	End	Average Length (feet)
SOUTH	PINE	707
PINE	SPRUCE	524
SPRUCE	WALNUT	872
WALNUT	CHESTNUT	562
CHESTNUT	MARKET	547
MARKET	ARCH	763
ARCH	RACE	678
RACE	VINE	679
Average		666

Block Widths, Original Grid

Start	End	Average Width (feet)
22ND	21ST	452
21ST	20TH	541
20TH	19TH	420
19TH	18TH	479
18TH	17TH	447
17TH	16TH	451
16TH	15TH	444
15TH	BROAD	462
BROAD	13TH	626
13TH	12TH	447
12TH	11TH	447
11TH	10TH	447
10TH	9TH	447
9TH	8TH	449
8TH	7TH	414

7TH	6TH	488
6TH	5TH	432
5TH	4TH	460
4TH	3RD	447
3RD	2ND	550
2ND	FRONT	474
Average		468

Table 2.
Block Lengths, Subdivided Grid

Start	End	Average Length (feet)
SOUTH	LOMBARD	371
LOMBARD	PINE	336
PINE	SPRUCE	523
SPRUCE	LOCUST	433
LOCUST	WALNUT	440
WALNUT	SANSOM	278
SANSOM	CHESTNUT	284
CHESTNUT	LUDLOW	333
LUDLOW	MARKET	226
MARKET	FILBERT	405
FILBERT	ARCH	376
ARCH	CHERRY	342
CHERRY	RACE	336
RACE	VINE	683
Average		383

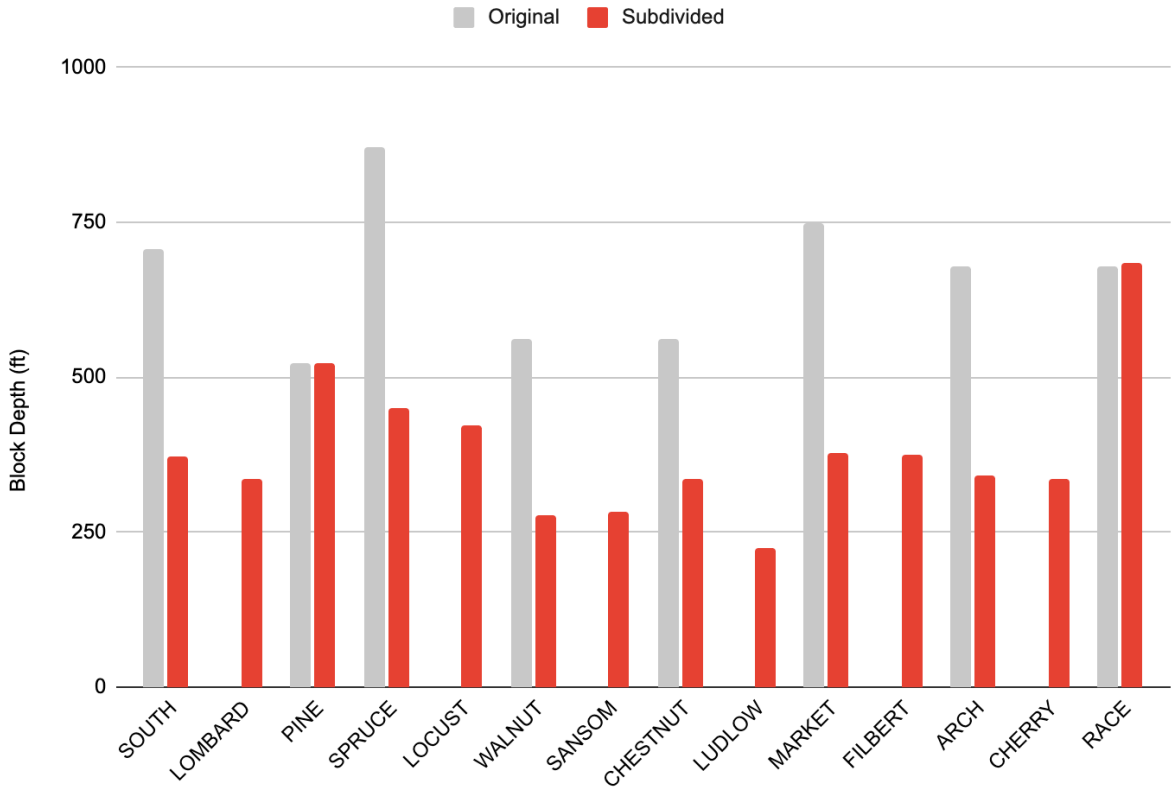
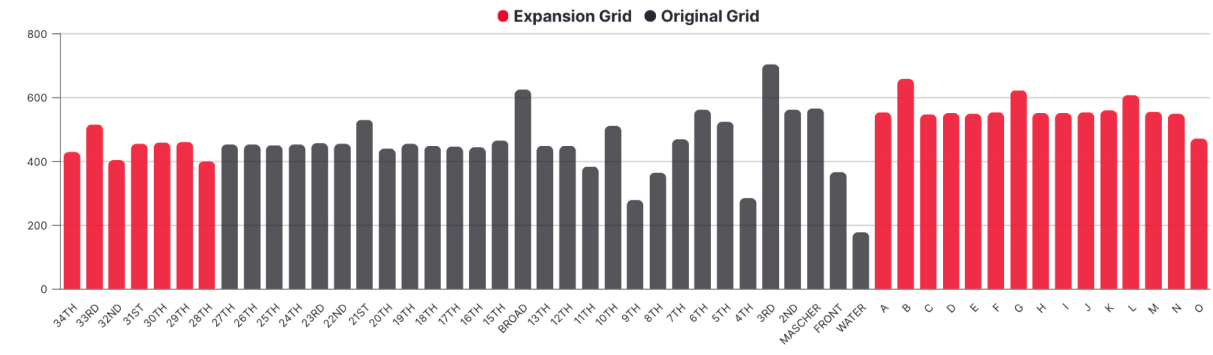


Table 3.
North Grid

	Original or Unplanned Grid	Expansion Grid
Average Block Width (feet)	474	486
Average Block Depth (feet)	393	534

Block Width (feet)



Block Depth (feet)

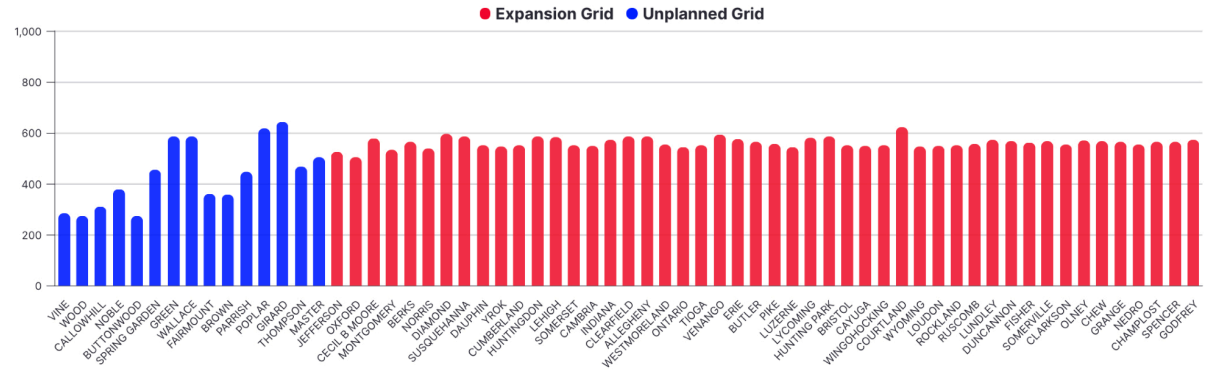
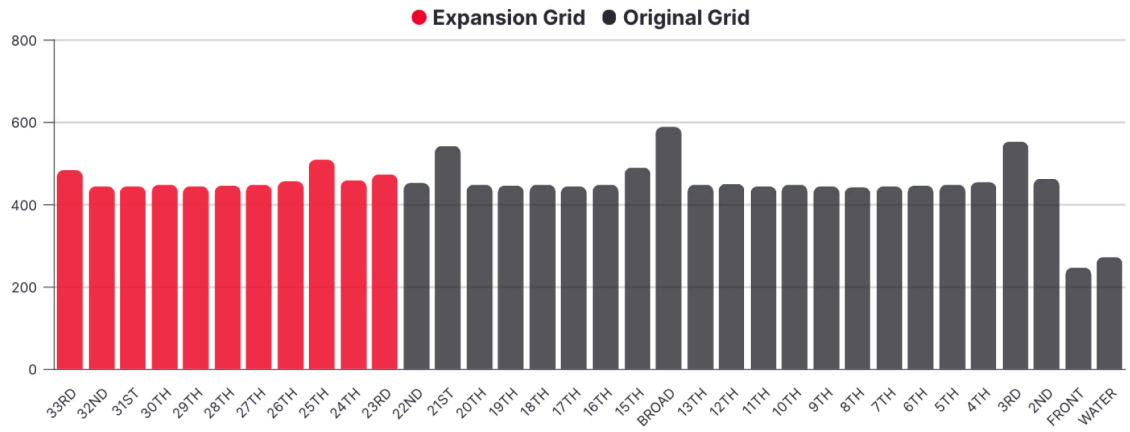


Table 4.
South Grid

	Original or Unplanned Grid	Expansion Grid
Average Block Width (feet)	467	453
Average Block Depth (feet)	328	422

Block Width (feet)



Block Depth (feet)

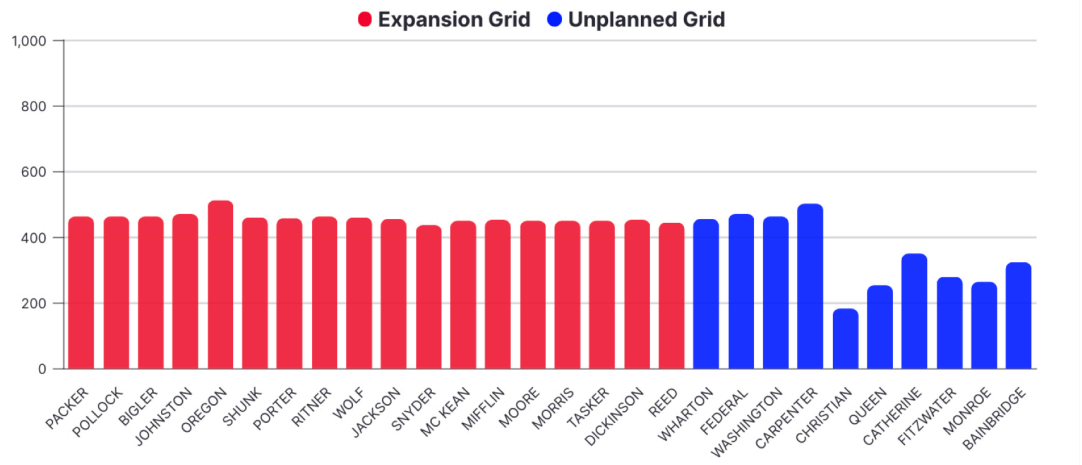


Table 5.

Parcel Families, Sample Blocks

Block	Family	Mean Width (feet)	Mean Depth (feet)	Mean Parcel area (sq ft)	Street facing	Parcel count
1	A	15.5	65	1007.5	primary	68
	B	14.3	48	686.4	tertiary	148
2	A	16.8	75	1260	primary	48
	B	15.2	71	1079.2	primary	18
	C	16.7	71	1185.7	primary	6
	D	14.1	50	705	tertiary	36
	E	14.2	42	596.4	tertiary	36
3	A	14.6	72	1051.2	primary	48
	B	15.9	68	1081.2	primary	16
	C	14.1	65	916.5	primary	18
	D	14.1	50	705	tertiary	54
	E	14.1	43	606.3	tertiary	18
4	A	15.4	63	970.2	primary	34

	B	16.4	66	1082.4	primary	40
	C	14.1	49	690.9	tertiary	36
	D	14.1	46	648.6	tertiary	36

Figure 1.
The well-known Penn survey of Philadelphia from 1683.

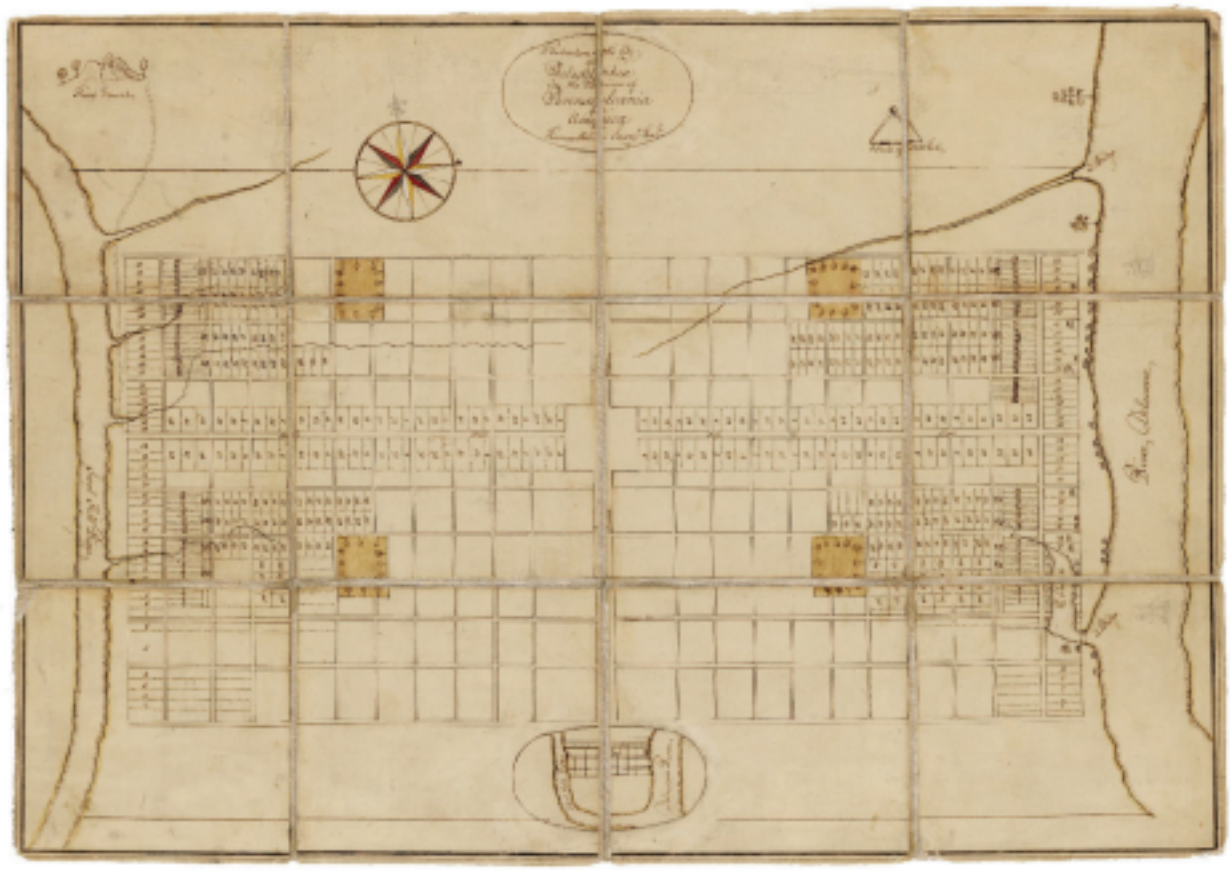


Figure 2.
Analytical map of Penn grid in 2022, showing primary 1683 survey streets, east-west secondary streets, numerous tertiary streets, and 20C highways and boulevards.

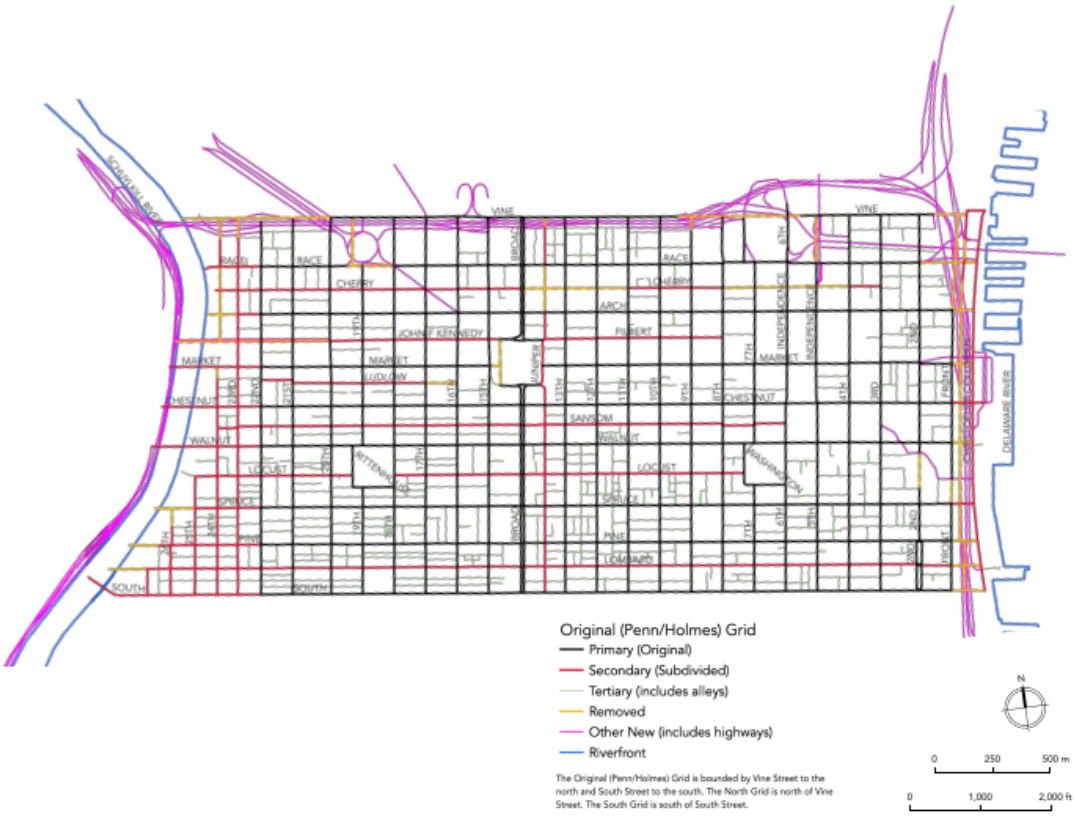


Figure 3.
The Clarkson and Biddle map of 1763 shows Philadelphia already expanding beyond the Penn grid and the beginning of secondary street construction.

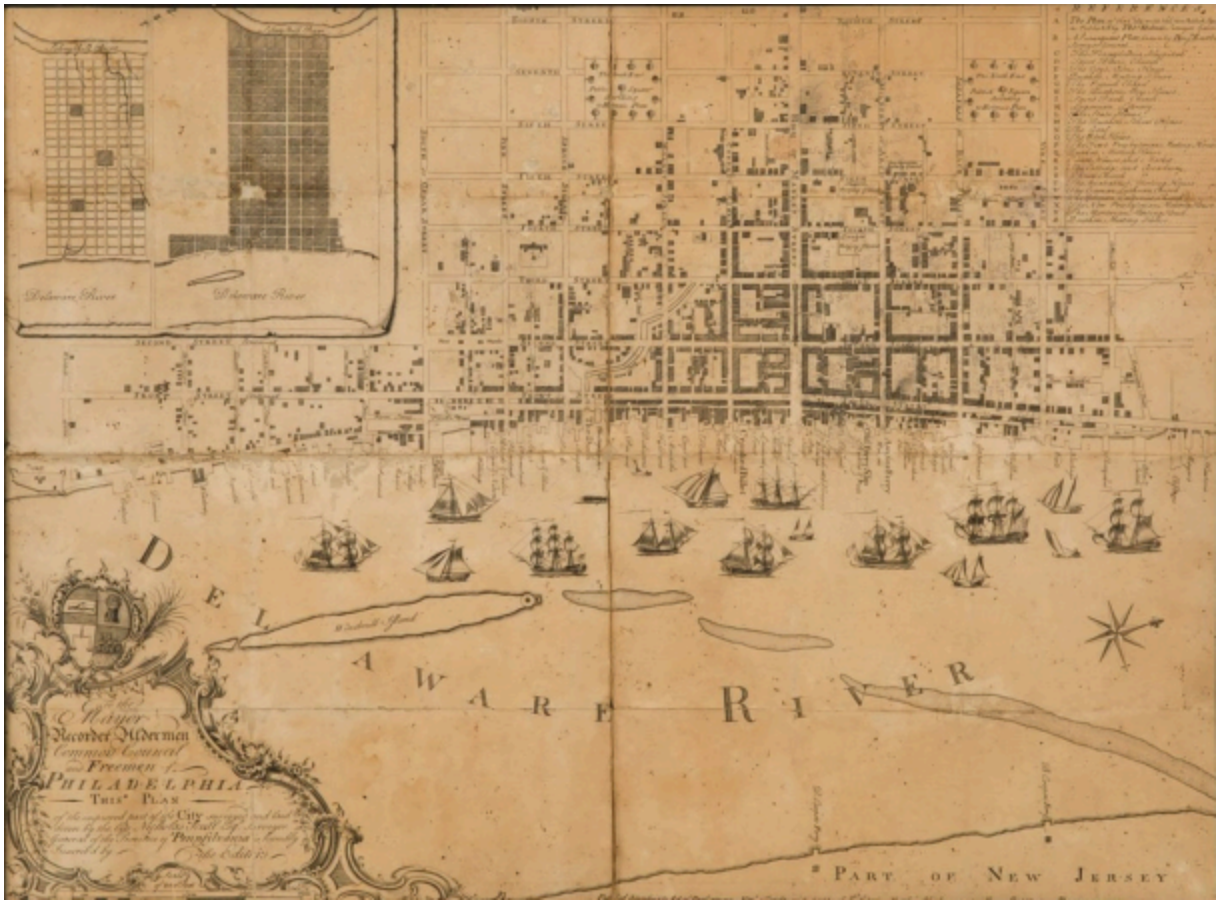


Figure 4.
This 1794 map shows secondary streets surveyed across the Penn grid and much development within the unplanned grid.

Figure 5.
In the Hills map of 1797, beginnings of a surveyed grid are visible in the southern area of Southwark municipality.


This Plan of the City of Philadelphia
to the MAYOR, ALDERMEN and CITIZENS thereof,
REFERENCE
PART OF THE NORTHERN LIBERTIES
SCHUYLKILL RIVER
DELAWARE RIVER
PART OF PASSYUNK
SOUTHWARK

Figure 6.
Analytical map of North Philadelphia unplanned and expansion grid in 2022, together with tertiary streets, pre-existing roads, and 20C highways.

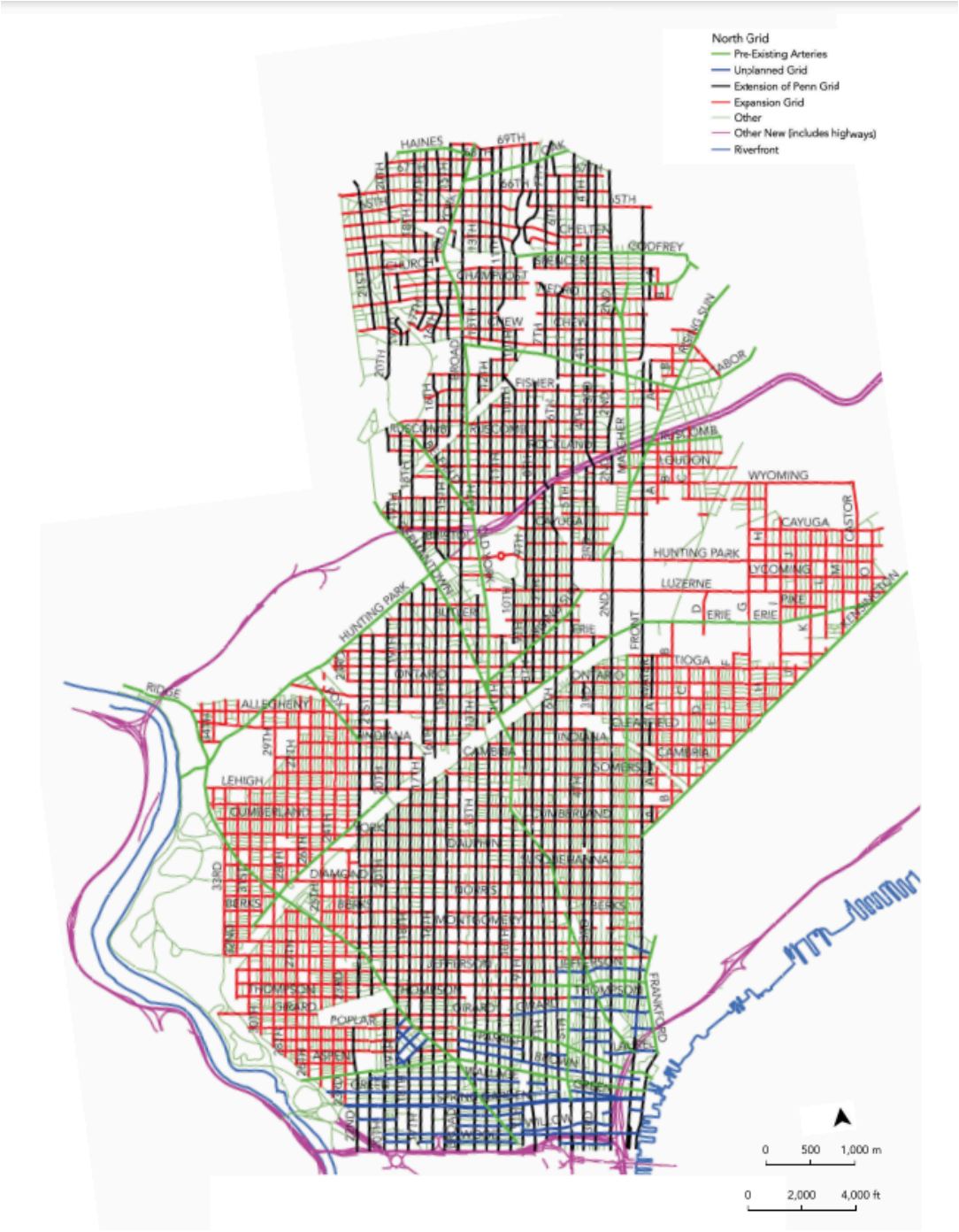


Figure 7.
Analytical map of South Philadelphia unplanned and expansion grid in 2022, together with tertiary streets, pre-existing roads, and 20C highways.

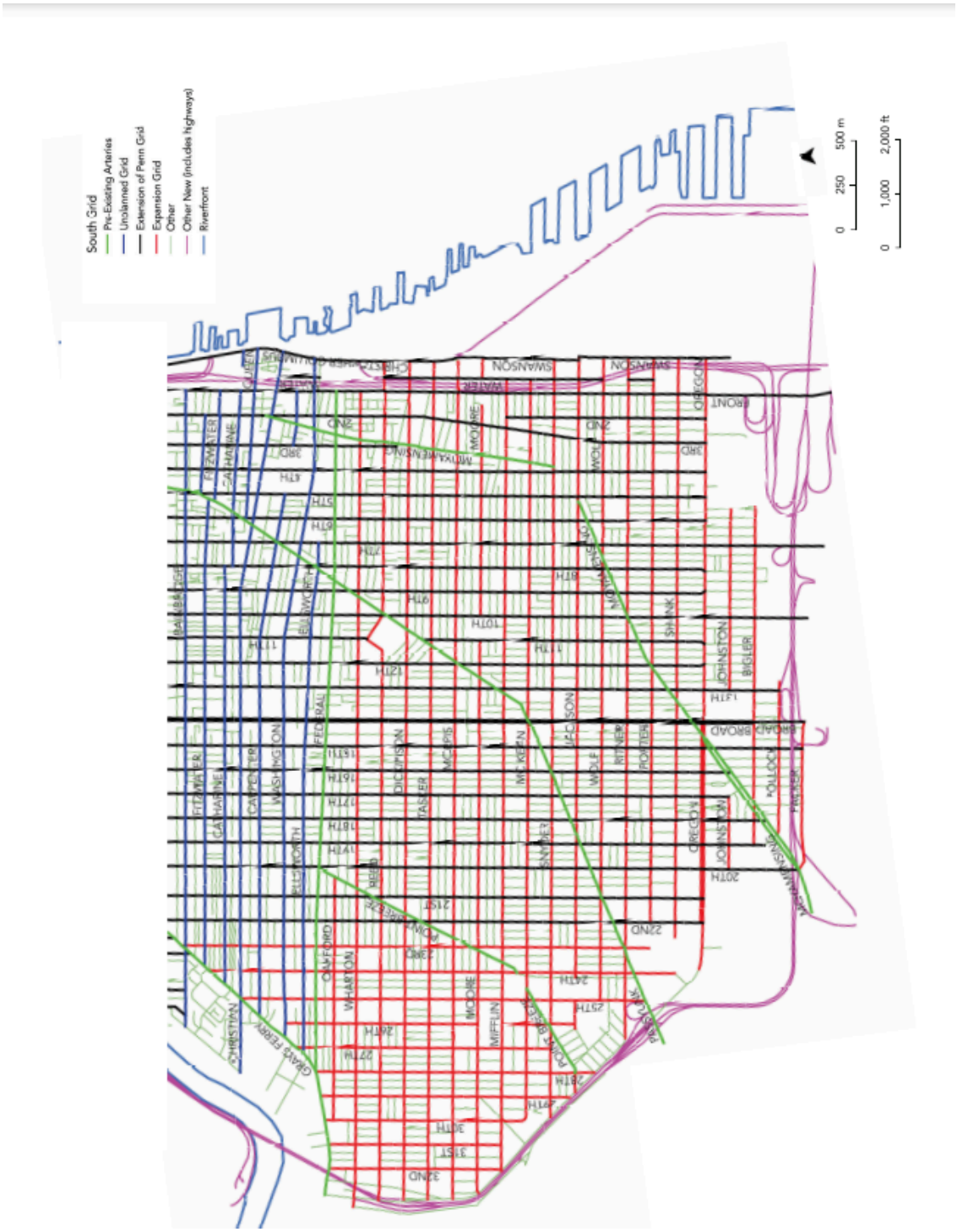


Figure 8.
Additional surveyed streets are visible in North Philadelphia in this 1811 map.

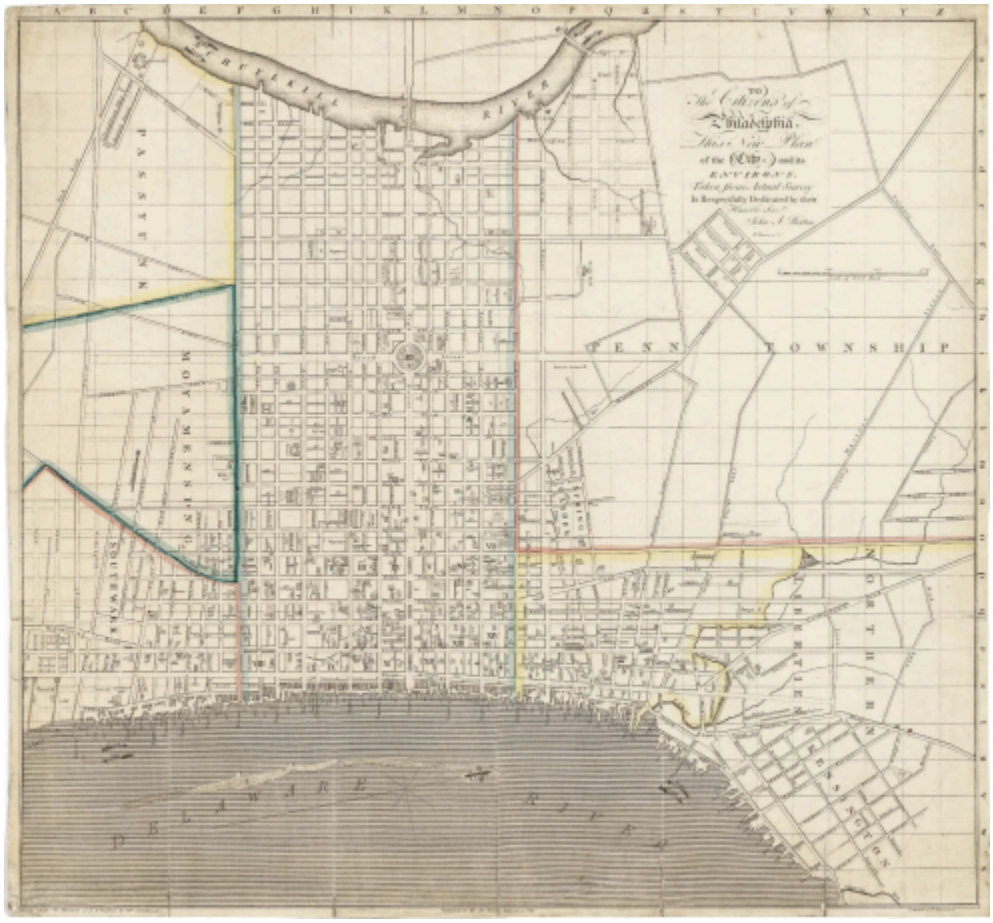


Figure 9.
Drayton's 1824 map shows a surveyed expansion grid adjacent to the unplanned grid in both North and South Philadelphia.

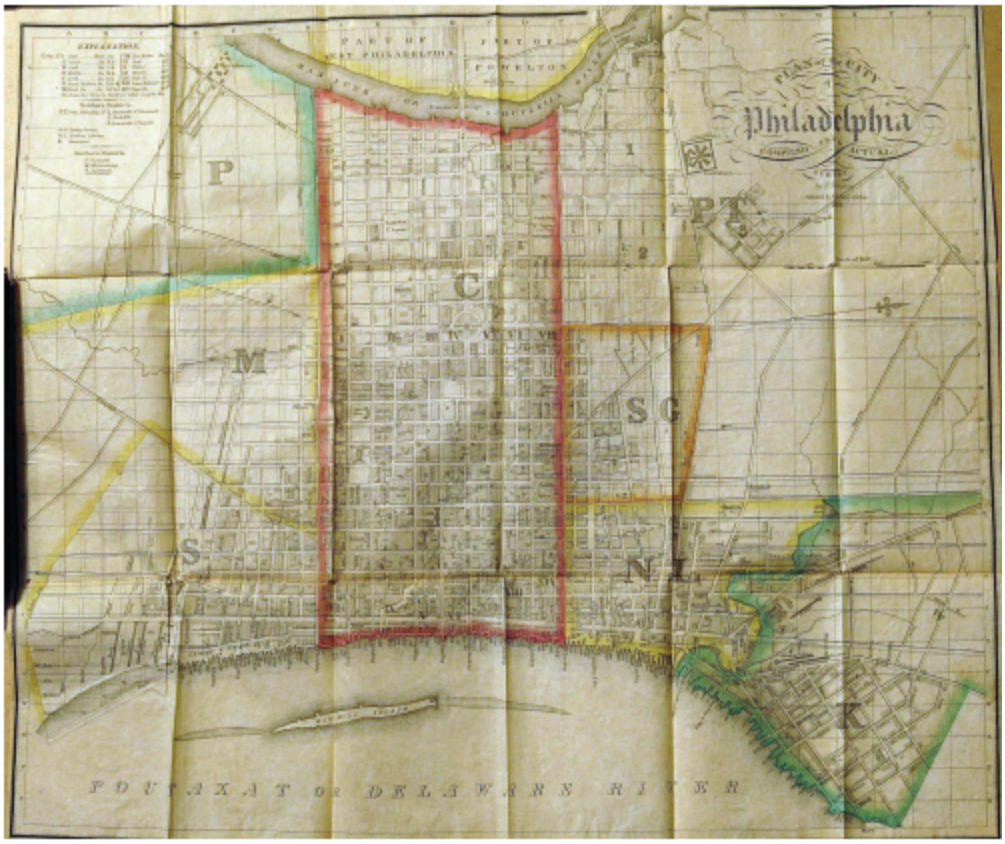


Figure 10.
Between 1824 and 1835 the expansion grid was surveyed across the entirety of the lands visible in this map from Tanner's atlas. Much of the 19C growth of Philadelphia would be framed by this grid.

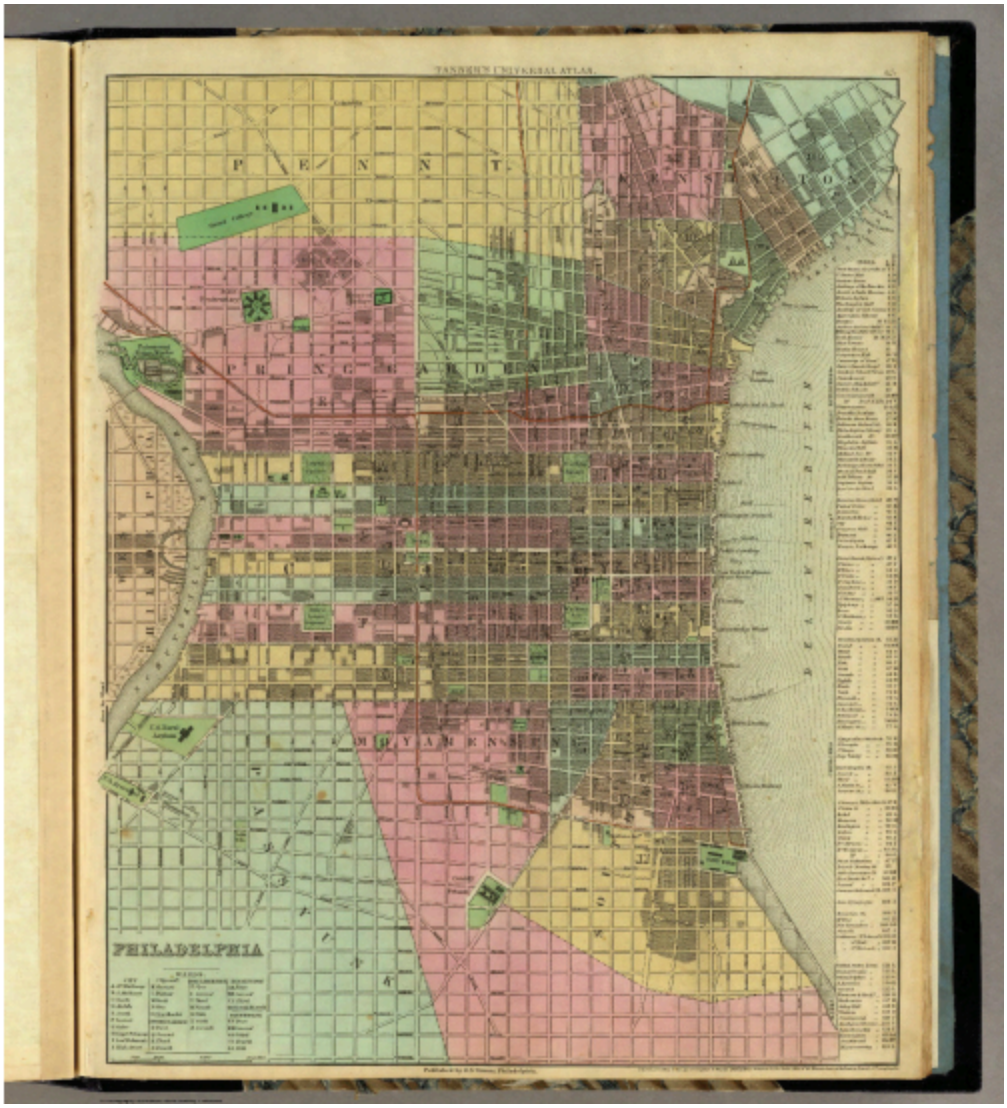

PENN
DELAWARE
PHILADELPHIA

Figure 11.
Plan of sample blocks 1 and 2 in North Philadelphia expansion grid, with locations shown in subsets. Systemic tertiary streets, parcel families, and micro alleys are present in different configurations. Note that one block is deeper than it is long, while the other is square.

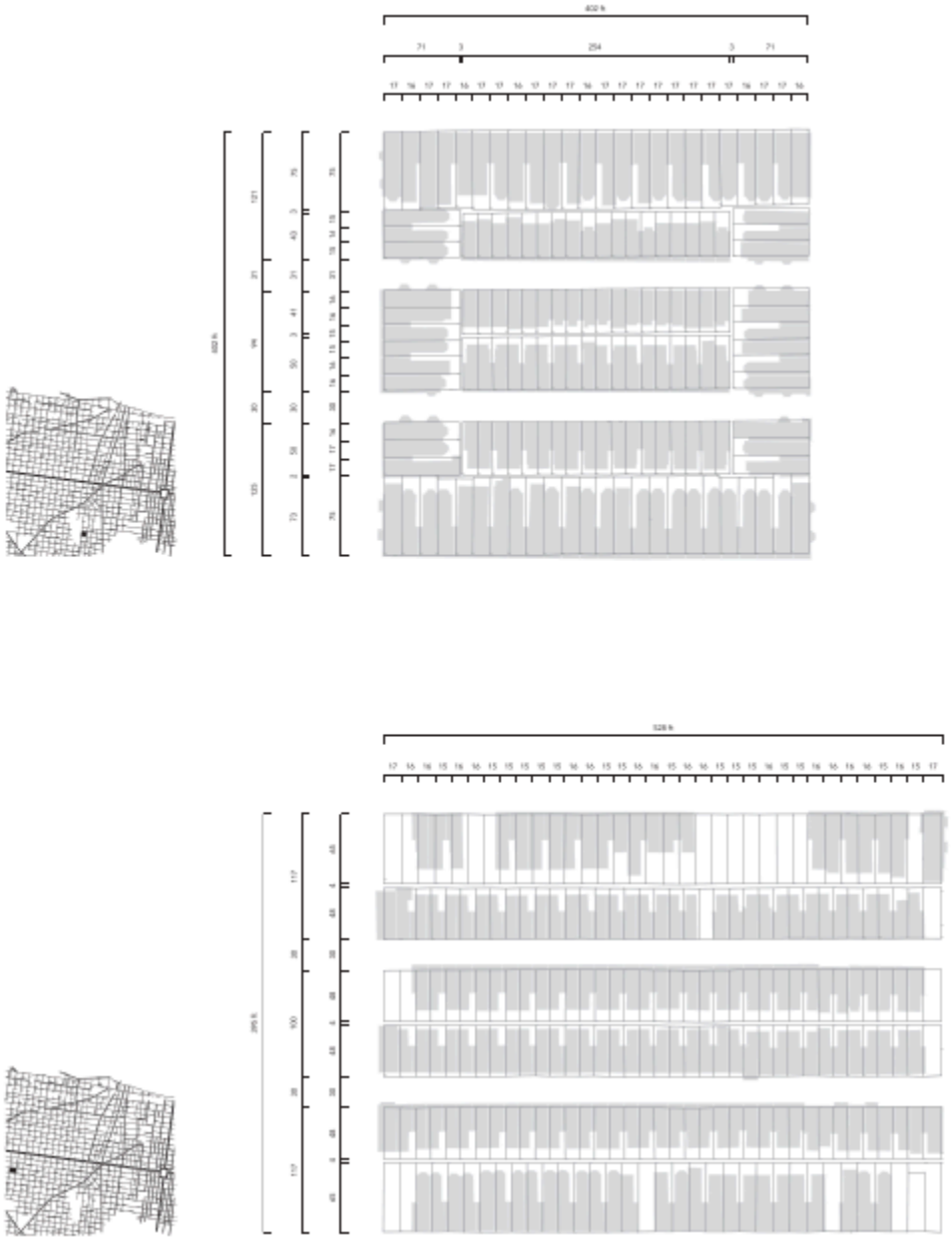


Figure 12.
Plan of sample blocks 3 and 4 in South Philadelphia expansion grid, with locations shown in subsets. Systemic tertiary streets, parcel families, and micro alleys are present in different configurations. Note that both blocks are square.

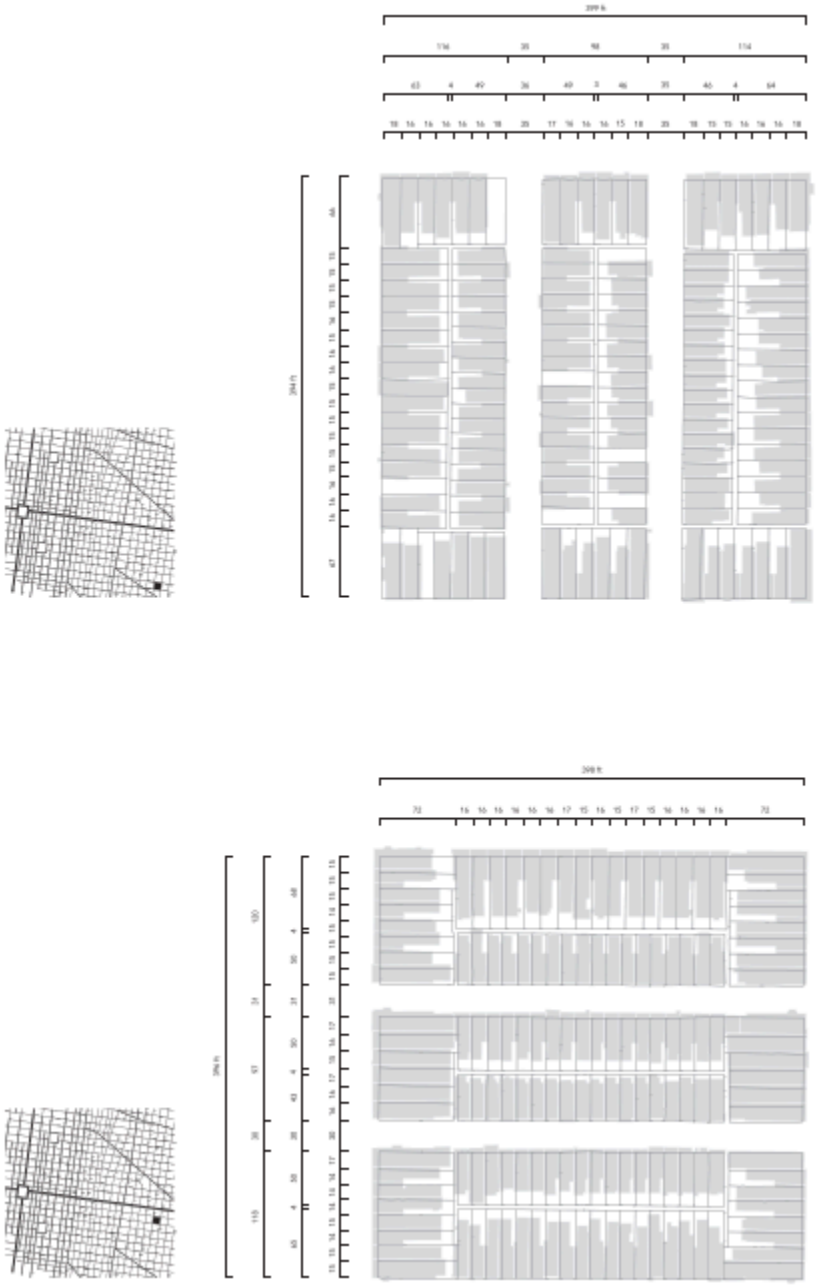


Figure 13.
In North Philadelphia, deeper blocks permit block subdivision with three E-W tertiary streets (left block) or two N-S tertiary streets (right block). Blocks shown are between Somerset (N) and Lehigh (S) Streets, and 26th and 24th Streets. Image source: Google Maps.

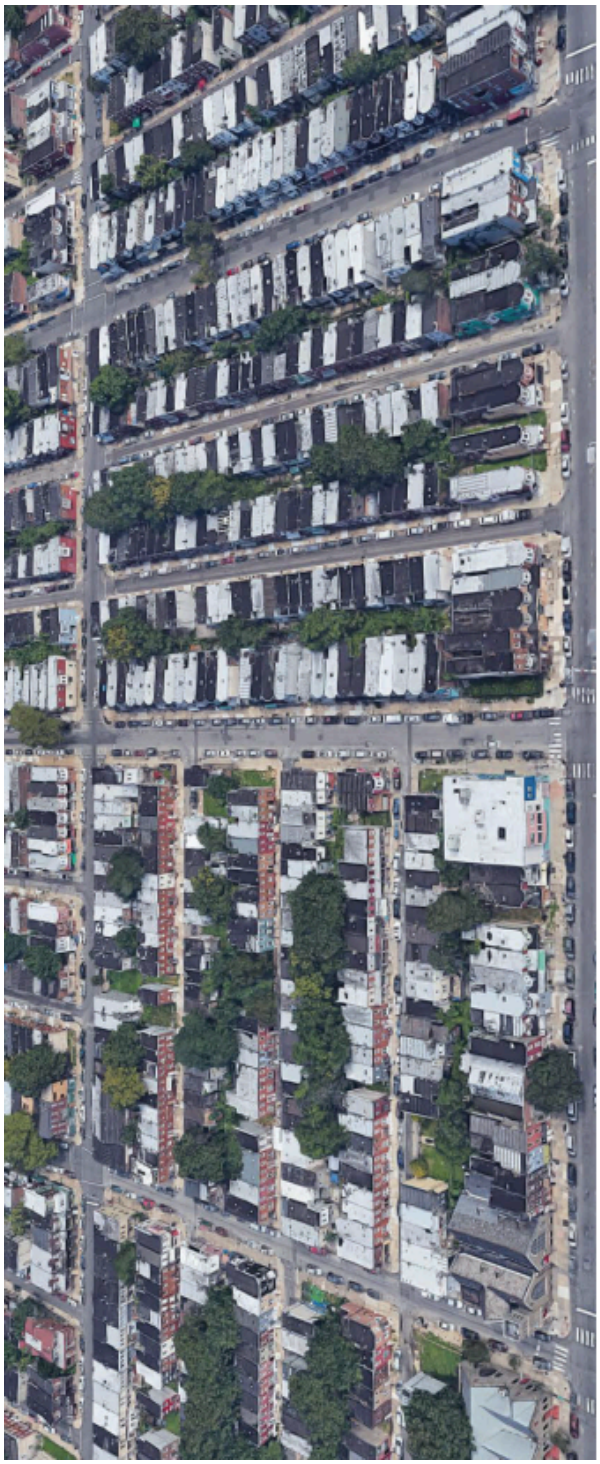


Figure 14.
Tertiary expansion grid streets such as Hicks St, one of the interior streets in sample block 4, had two-story rowhouses with comparatively modest dimensions and floor areas.

Figure 15.
Many primary expansion grid streets such 16th St, one of the exterior streets in sample block 4, had three-story rowhouses. These dwellings are both wider and deeper than those on the adjoining tertiary street.