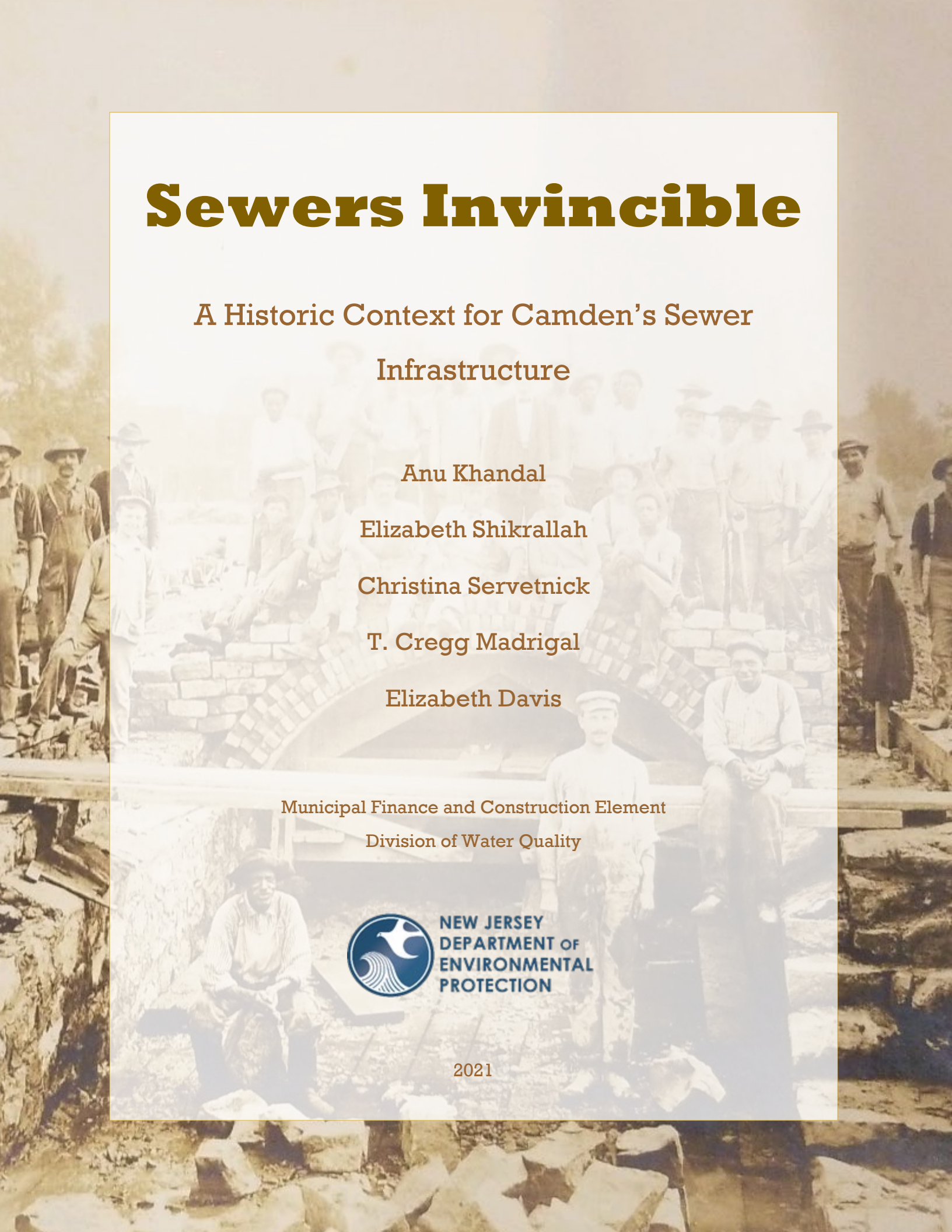

Sewers Invincible

A Historic Context for Camden's Sewer Infrastructure

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Municipal Finance and Construction Element

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NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION

2021

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Front cover image: *Newton Creek Line Ditch, Image No. 5017,* courtesy of Camden County Historical Society.

Copy of *Sewers Invincible: A Historic Context for Camden's Sewer Infrastructure* available at the New Jersey State Library; Municipal Finance and Construction Element, Division of Water Quality, New Jersey Department of Environmental Protection; and the Historic Preservation Office, New Jersey Department of Environmental Protection.

Acknowledgements

Since the early 1980s, the New Jersey Department of Environmental Protection's Municipal Finance and Construction Element has provided financing for water and wastewater infrastructure projects. The cultural resource unit reviews every project for its potential to affect historic and archaeological properties. At first, most involved construction of new facilities such as treatment plants, collection systems, and outfalls. As the program matured, more projects involved improvement of existing facilities, including the repair of original components such as brick sewers. We realized we needed a proper historic context to better inform our management recommendations for New Jersey's oldest sanitation utilities. Numerous surveys conducted for projects in the City of Camden have identified brick sewers, many of which are over one hundred years old. Therefore, because of the abundance of documentation and continuing rehabilitation work, we chose the brick sewers of Camden as our pilot research project.

Eugene Chebra, Assistant Director of the Municipal Finance and Construction Element, was interested in this research from the start and recognized its historical value as well as the value to the program. Our present and former bureau chiefs, Charles Jenkins and Gautam Patel, and our Section Chief Karen Cole, have also been ardent supporters of this project.

Craig Coutros, Geographic Information System Specialist at the NJDEP, shared his GIS data layer of Camden's sewers, which supplemented the data we mapped from the Camden Sewer Notebooks. The librarians at the Special Collections and University Archives at the Archibald S. Alexander Library at Rutgers University and at the NJDEP Environmental Research Library, particularly Tonia Wu, have been generous with their time, and led us to resources we might not have otherwise found.

We are particularly grateful to the Division of Capital Improvements and Project Management in the Department of Planning and Development in the City of Camden for sharing the Camden Sewer Notebooks, which has been a significant resource for our research. The Camden County Historical Society was an incredible repository for all things Camden. Librarian Bonny Beth Elwell helped us access historical images, including photographs of Aaron Ward on site at the Line Ditch Sewer. Phil Cohen's website, dvrbs.com, was another invaluable source for Camden history. Adam Levine, Historical Consultant for the Philadelphia Water Department and Webmaster for phillyh2o.org, has built an immense database of sewer history, which we found very useful.

Alexandra Tarantino, architectural historian with the Delaware Department of Transportation, reviewed the report, provided feedback, and asked thought-provoking questions. Her review was invaluable and is greatly appreciated.

As most research does, this work has raised new questions. We hope to expand this work to include other components of water infrastructure, such as water and wastewater treatment plants, and to contribute to the story of the growth and development of New Jersey.

Abstract

American cities in the 1850s were crowded, lacked clean water and adequate waste removal, and suffered from epidemics of cholera and other deadly diseases. To combat this, the City of Camden began building a municipal sewer system in 1863. Designed to carry both sanitary waste and stormwater in a combined system, the sewers were constructed mainly of brick.

Today, 86% of the original sewers are still in service, and many need to be repaired or replaced. Because of its association with improving public health and fostering the growth of cities, sewer infrastructure in Newark, Trenton, and around the world is recognized as historically significant. The Municipal Finance & Construction Element is required to consider impacts to cultural and historical resources during construction and is therefore addressing questions about the history and status of Camden's sewers while also developing a framework to streamline the review of sewer repair projects in the city.

This context includes a history of sanitation in the United States, as well as sewage conveyance technologies, materials, and construction methods, along with a historical context of the City of Camden and its sewage infrastructure. It also includes a synthesis of archaeological research on early sewer systems in Camden. As part of our discussion on the sewers' historical significance, a summary of other sewers and sanitary infrastructure listed on or eligible for the New Jersey and/or National Registers of Historic Places, and specific criteria for significance and eligibility are provided.

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List of Acronyms

BOH/NJBOH	Board of Health / New Jersey Board of Health
CCMUA	Camden County Municipal Utilities Authority
CIPP	Cured-in-place pipe
CSO	Combined Sewer Overflow
DCIPM	Division of Capital Improvements and Project Management
DRBC	Delaware River Basin Commission
EFC	Emergency Fleet Corporation
EPA	Environmental Protection Agency
GIS	Geographic Information System
INCODEL	Interstate Commission on the Delaware River Basin
MFCE	Municipal Finance & Construction Element
MPS	Multiple Property Submission
MRA	Multiple Resource Area
NJDEP	New Jersey Department of Environmental Protection
NJDOH	New Jersey Department of Health
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
PSC	Public Service Corporation
PVC	Polyvinyl Chloride
PVSC	Passaic Valley Sewerage Commission
SHPO/NJHPO	State Historic Preservation Office / New Jersey Historic Preservation Office
SRF	State Revolving Fund
USHC	U.S. Housing Corporation
WPA	Works Progress Administration
WPCP	Water Pollution Control Plant

1. Introduction

"I dream'd in a dream, I saw a city invincible"

-Walt Whitman

Wastewater infrastructure was vital to the health and development of cities in the United States. Early cities had no systematic plans for dealing with sewage and stormwater. Human waste was deposited in privies or cesspits while rudimentary, uncoordinated, and often ineffectual drainage systems were built by property owners to reduce flooding from rainstorms. By the mid-nineteenth century, American cities were overcrowded and polluted, largely without clean water or adequate waste removal, and subject to repeated epidemics of deadly diseases like cholera.

The Sanitation Movement arose in response to the devastating epidemics and the growing awareness that disease and filth were linked.[1] Waterworks projects, such as the Croton Aqueduct system in New York City and the Fairmount Waterworks in Philadelphia, provided clean drinking water. By increasing the amount of water being brought into homes and businesses, the amount of wastewater that had to be disposed also increased. The reform movement gradually resulted in local and state governments taking responsibility for sanitary infrastructure by regulating and financing comprehensive city-wide sanitary sewer systems. The earliest planned municipal sewer systems in the United States were built in the 1850s in Newark, Jersey City, Brooklyn, Chicago, and elsewhere, resulting in marked improvements in health and mortality rates. In 1879, the mortality rate in New Jersey was 20.03 per 1,000 people, with 15% of the

[1] David L. Cowen, *Medicine and Health in New Jersey: A History*, Vol. 16 (Princeton: D. Van Nostrand Company, 1964), 82.

deaths from typhoid fever, diarrheal diseases, and intestinal diseases.[2] By 1930, New Jersey's mortality rate had dropped to 12.16 per 1,000 inhabitants.[3]

Statement of Purpose

The City of Camden, in Camden County, New Jersey, began work on their municipal sewer system, which carries both sanitary waste and stormwater in a combined system, in the 1860s. Of the sewers built prior to the 1930s, most of which are made with brick, a majority are still carrying wastewater and stormwater.[4] It is a testament to the craftsmanship of nineteenth century sewer engineers and contractors that many of their pipes are still in use, but after more than a century, they are in need of repair or replacement.

To address the problems of an aging sewer system, the City of Camden and the Camden County Municipal Utilities Authority (CCMUA) have applied to the New Jersey State Revolving Fund (SRF) program for loans to repair and replace existing pipes. The Municipal Finance & Construction Element (MFCE) of the New Jersey Department of Environmental Protection (NJDEP), through a delegation agreement with Region II of the United States Environmental Protection Agency (EPA), is responsible for the administration of the SRF program, which includes conducting Section 106 reviews under the National Historic Preservation Act of 1966.[5]

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[2] New Jersey Board of Health, *Third Annual Report of the Board of Health of the State of New Jersey, 1879*, (Camden: Sinnickson Chew., 1879), 201.
[3] New Jersey Department of Health, *Fifty-Third Annual Report of the Department of Health of the State of New Jersey, 1930*, (Trenton: MacCrellish & Quigley Co., 1931), 153.
[4] Division of Capital Improvements and Project Management, "Camden Sewer Notebooks," Camden: Department of Planning and Development, n.d.
[5] For general information on water infrastructure problems, see Halsey's *Washington Post* article from 2012. Transforming the combined sewer system is a recent focus of CCMUA, which acknowledges that the CSOs pollute the Delaware River and result in flooding when backed-up. The CCMUA has been working with the EPA and educational institutions, including Rowan University, to brainstorm how to mitigate the pollution without requiring an overhaul of the historic sewer system.

Due to the importance of early sewer systems in improving public health and fostering the growth of cities, sewer-related infrastructure in several states has been listed on the National Register of Historic Places (NRHP) (Table 1) and in New Jersey sewer-related infrastructure has been determined eligible for the National Register of Historic Places (Table 2). This historic context report provides guidance to the MFCE, the City of Camden, and the CCMUA for evaluating the potential historical significance of Camden sewer infrastructure and streamlining the review of projects. It provides a history of sewer infrastructure, describes types of sewers that may be present, identifies areas where additional research is necessary, begins to evaluate the potential National and State Register eligibility of sewer infrastructure, and discusses actions that may be necessary to preserve or record historic sewers during future projects.

Table 1. Sewage Infrastructure Listed on the National Register of Historic Places

Date Listed	*Resource*	*Location*	*NRHP Reference Number*
1982	Arboretum Sewer Trestle	Seattle, Washington	NRHP82004229
1989	Ernest Street Sewage Pumping Station	Providence, Rhode Island	NRHP88003103
1989	Fields Point Sewage Treatment Plant	Providence, Rhode Island	NRHP88003104-NRHP88003106
1989	Washington Park Sewage Pumping Station	Providence, Rhode Island	NRHP88003107
1989	Reservoir Avenue Sewage Pumping Station	Providence, Rhode Island	NRHP88003108
1990	Alcantarilla Pluvial sobre la Quebrada Manzanares/Los Tuneles de San German	San German, Puerto Rico	NRHP 90000552
2004	Willow Street Pump Station/City Street Cleaning and Sewage Pumping Station	Houston, Texas	NRHP 04000547
2012	Main Sewerage Pumping Station/ DC Water Main Pumping Station	Washington, DC	NRHP 12000297

Table 2. Reports Submitted to SHPO with Determinations of Eligibility of Sewers[6]

County	*City*	*Resource Name*	*Description*	*Sources*
Camden	Camden, Gloucester City	Camden and Gloucester City Combined Sewer Outfalls (CSOs)	Nineteenth century wood and brick sewers	Pennington and Schopp, 1998
	Gloucester City	Gloucester City Sewers	Nineteenth century brick sewers	Howson, 1996
Essex	Newark	Newark Sewers	1854 brick sewers	McEachen et al., 2000
	Newark	Newark Sewers	1854 brick sewers	McEachen and Modica, 2003
Hudson	Hoboken	Grand Street Sewer	Wood sewers	Cushman et al., 2015
	Hoboken	Hoboken Sewers	Pine wood sewers	Cushman et al., 2015
	Hoboken, Union City	Hoboken, Union City Sewers	Twentieth century brick sewers	Modica and Walker, 2004
	Jersey City	Jersey City Sewers	Sewers on Brown Pl., Princeton Ave., Linden Ave., were likely built 1887-1898	Grossman-Bailey, 2011
	Jersey City	Jersey City Sewers	Brick sewers part of the 1853 Sewerage Plan	Lembo and Diker, 2018
	Union City	Kerrigan Avenue Sewer	Brick sewer constructed between 1900 and 1920	Scharfenberger, 2006
Mercer	Trenton	Lamberton Interceptor	1891/1892 circular brick sewer	Israel, 1976
Middlesex	New Brunswick	New Brunswick Sewers	Nineteenth century brick sewers	Yost and Modica, 2003

[6] Though our paper follows Chicago style for both formatting and citations, we have opted not to follow Chicago style for this table. As each resource has its own citation, we wanted to make it easier for you, the reader, to connect each resource to the respective cultural resources survey.

Parameters

Geographic and Temporal Parameters

This context discusses the sewer system built within the modern boundaries of the City of Camden, Camden County, New Jersey, between approximately 1860 and 1942. It focuses specifically on wastewater conveyance systems, that is, how sewage and stormwater is transported from buildings and ground surfaces to a wastewater treatment plant (if present), and then to a final discharge point. These conveyance systems take the form of diverse types of pipes (brick, concrete, iron, and other materials) and associated structures (such as manholes, outfalls, and catch basins).

To place the Camden sewer system into context, the history of sanitation and sewer infrastructure in New Jersey and the rest of the United States is summarized. The earliest municipal sewers in Camden were constructed in the 1860s, but property owners and businesses may have constructed ad hoc, localized sewer or drainage systems earlier. The last great expansion of the sewer system was in the 1920s as part of the Greater Camden Movement, which sought to consolidate the city with the surrounding municipalities to create an industrial and commercial powerhouse. In the 1930s, Camden, along with the rest of the United States, grappled with the economic and social consequences of the Great Depression. By the time the country entered World War II at the end of 1941, sewer infrastructure was in place throughout most of Camden and municipal sewer systems were a common and well-established fixture of most American cities.

Material Parameters

An assortment of materials were used in the construction of the sewer system, including brick, cast iron, concrete, vitrified clay, and wood. However, considering the temporal period this context is focusing on, the brick sewers are generally the oldest and most likely to need replacement. The other materials were also used at the time but were not as prevalent during the period of study of this context.

Methods

The research for this historic context included review of historic and contemporary maps, government documents, cultural resource management reports, National Register documents, historical and social overviews of sanitation history, contemporary engineering texts and articles, and local histories of the City of Camden. New Jersey Board of Health (NJBOH) reports were issued every year starting with its founding in 1877. Through 1915, the reports included information on water and sewerage throughout the state. Online resources, including archive.org, sewerhistory.org, and phillyH2o.org, were useful for finding sources and historic images. Archival research was conducted at the Special Collections and University Archives, Archibald S. Alexander Library, Rutgers University and the Camden County Historical Society.

The Division of Capital Improvements and Project Management (DCIPM), in the Department of Planning and Development in the City of Camden, maintains the Camden Sewer Notebooks, which are handwritten lists of sewers throughout the city, organized by street name, which include year constructed, contractor, cost, size, length, material, side of street, number of manholes, inlets, and house connections, and repair efforts. The notebooks appear to have been started in the late 1910s or 1920s, but they include sewers constructed as early as 1863 and as late as 1970. As far as our research has shown, there were no earlier sewers that were municipally

owned, but construction and repair has certainly taken place since 1970. It is also unclear if this is a comprehensive list of all sewer construction, both municipal and private. Comparison of the mapped sewers in the Camden Sewer Notebooks and the modern Camden street network demonstrates that not all streets have sewers listed in the Camden Sewer Notebooks. There may be additional sewers that do not follow modern roadways. The Camden Sewer Notebooks also do not contain data about construction techniques beyond the material of the sewers themselves, and so it is unknown what types of fill and foundation material may have been used.

Data from the Camden Sewer Notebooks was imported into an Excel spreadsheet and mapped in ArcGIS 10.4. The Geographic Information System (GIS) map derived from the Camden Sewer Notebooks was compared with a separate GIS map that had been digitized by NJDEP Bureau of GIS from sewer maps maintained by the city. This latter map layer complements the map derived from the Camden Sewer Notebooks but has limited associated data, and there are some discrepancies between the two sources of data.

We compared the GIS layer created from the Camden Sewer Notebooks with the GIS layer derived from the City's Sewer Maps (digitized by Craig Coutros), but there are inconsistencies we are unable to rectify. Several locations did not have the same material type, size, and/or shape in both layers, and multiple sewer segments appear in one layer but not the other. The Sewer Maps layer also did not have other historical information the Camden Sewer Notebooks provided, like contractor or year of construction. Other archival and historical documents would serve to verify information from the Camden Sewer Notebooks. Additional research into Camden's archives is necessary to find any extant documents related to the sewers.

2. Sanitation and Sewer History

In the early nineteenth century, New Jersey, like most of the United States, was still largely rural. In 1830, only 6% of the state's 320,000 residents lived in cities.[7] Urban sewer infrastructure, if present at all, was limited to gutters or open channels in streets that were built to reduce stormwater flooding and to remove water from basements and cellars.[8] Sewers like these, such as the Peddie Street Ditch in Newark and the Albany Street sewer in New Brunswick, although sometimes mandated by local government, were paid for by property owners.[9] Households were responsible for disposing of human waste by using privies, cesspits, and chamber pots, which had to be emptied regularly. Many cities explicitly forbade the disposal of human waste into sewers, although such laws were frequently ignored or unenforceable.[10]

The concern with human waste in sewers was that it was malodorous, resulting in illness-causing miasma. Miasma theory was predated by, and evolved from, the theory of humoral concepts and the theory of epidemic constitutions. The theory of humoral concepts emerged during the fifth century BCE with Hippocrates who believed that there were four basic humors (bodily substances): black bile, blood, phlegm, and yellow bile. An imbalance, or corruption, of one or more of these humors would result in illness. Unfortunately, the theory of humoral concepts was unable to explain why and how epidemic diseases appeared, which led to the development of the theory of epidemic constitutions. In the seventeenth century, English

[7] Martin V. Melosi, *The Sanitary City*, (Baltimore & London: Johns Hopkins University Press, 2001), 315-316.
[8] Steven J. Burian et al., "Urban Wastewater Management in the United States: Past, Present, and Future," *Journal of Urban Technology* 7, no. 3 (2000): 34; Melosi, *The Sanitary City*, 22.
[9] Paul McEachen et al., *Cultural Resources Investigation, City of Newark, New Jersey, Department of Engineering, Phase III/IV Brick Sewer Evaluation and Environmental Assessment, Appendix A to Volume 3*, (Richard Grubb and Associates, Inc., 2000), 7-14; Betty J. Cosans, "Archeological Investigations of a Proposed Urban Redevelopment Site, New Brunswick, New Jersey," 1983.
[10] Jean Howson, "The Archaeology of 19th- Century Health and Hygiene at the Sullivan Street Site, New York City," *Northeast Historical Archaeology* 22, no. 10 (1993): 140-142; Rudolph Hering, "Sewerage Work; a Twenty-Five Years' Review," *The Engineering Record Building Record and Sanitary Engineer* 47 (1903): 21.

physician Thomas Sydenham theorized that the climate and environment had a significant role in causing illness. Sydenham believed that effluvia or miasmas, which arose from "the bowels of the earth" were responsible for the changes in atmospheric conditions, which led to epidemic diseases. Since miasma or effluvia could not be seen but could be smelled, the connection to putrefying substances releasing noxious gases that led to the spread of disease supported the notion that sickness and filth, typically found in poorer parts of town, were interconnected.[11]

In 1720, Cadwallader Colden, a Scottish physician working in New York, postulated that the recurring yellow fever epidemics in New York were connected to the poor water supply of the city. Two decades later, Colden furthered his theory to state that filthy water and the respective putrefying substances found within the water were producing unique miasmas, and each unique miasma was responsible for a specific disease. Accordingly, Colden suggested that the only way to prevent epidemic diseases was to clean the city, which would result in the removal of the disease-causing miasmas. Unlike Sydenham, who suggested that miasma was indirectly responsible for the spread of disease, Colden's miasma theory held miasma directly responsible for the spread of disease.[12]

Miasma theory judged water for scent, taste, and clarity, none of which are definitive indicators that the water was safe to consume and would not spread epidemic diseases.[13] The theory that microorganisms, both in the water and out, were responsible for the spread of disease would be developed in germ theory. Germ theory is attributed to the work of Louis Pasteur, a French chemist and microbiologist, Joseph Lister, an English surgeon, and Robert Koch, a German physician. As early as the sixteenth century, people had postulated that microorganisms

[11] John Duffy, *The Sanitarians, A History of American Public Health,* (Urbana: University of Chicago, 1990), 20.
[12] Ibid., 21-22.
[13] Alice Outwater, *Water, A Natural History,* (New York: Basic Books, 1996), 141.

had caused disease; however, it was not until the invention of the achromatic microscope in the 1830s and the identification of fungi and parasites in the 1840s that this theory was proven.[14] In 1849, John Snow in his *On the Mode of Communication of Cholera* postulated that the emptying of sewers into the drinking water connected to a water pump in SoHo was responsible for an outbreak of cholera in London.[15] Wide acceptance of germ theory allowed for the identification of specific organisms that were responsible for disease.

Pure drinking water was essential to community health; and as we learned with the development of germ theory, contaminated water was a major vector of disease and was responsible for the spread of cholera, typhoid fever, and other contagions. Drinking water was obtained from wells or directly from rivers or streams. As both populations and industrial activity increased in urban areas across the United States, water sources became contaminated or insufficient to meet the needs of their population. Cities began to construct systems to provide cleaner drinking water to houses. In New Jersey, the Morris Aqueduct Company began to serve Morristown customers in 1799 in the wake of a drought that left wells in the town dry.[16] The private Trenton Water Works was chartered in 1804, switched from spring water to water from the Delaware River in 1852, and was purchased by the city in 1859.[17] The Camden Water Works Company was incorporated in 1845 and relied on river water, not fully switching to artesian wells until 1899.[18] Hoboken began laying water mains as early as 1857.[19] The Newark Aqueduct

[14] Duffy, *The Sanitarians*, 193.
[15] John Snow, *On the Mode of Communication of Cholera*, (London: Wilson and Ogilvy, 1849), 11.
[16] Arthur Mierisch, The Morris Aqueduct Company: New Jersey's First Water Company, Part I: 1798-1869, *Garden State* Legacy, GSL18, 2012.
[17] Morris A. Pierce, "Trenton," *Documentary History of American Water-Works,* 2015.
[18] Charles S. Boyer, *The Public Utilities in Camden, New Jersey, Annals of Camden No. 2*, (Privately printed, 1921), 4-6.
[19] Laura Cushman and Paul McEachen, *Northwest Resiliency Park, Block 103, Lots 7-26, Block 107, Lot 1, and Block 113, Lot 1, City of Hoboken, Hudson County, New Jersey*, (Cranbury: Richard Grubb & Associates, 2015), 3-7.

Company, chartered in 1800, was taken over by the city in 1860 and Newark's municipal waterworks was completed in 1870.[20]

By the mid-nineteenth century, half of US cities had a waterworks, but this resulted in new problems. Access to running water in houses led to a dramatic increase in the amount of water used, which was then discharged to privies and cesspits, causing them to overflow and further contaminate the surrounding soil. To address this situation, cities began to allow the disposal of human waste into the existing sewers. Boston changed their regulations in 1833; Greenwich Village, Manhattan, which had sewers as early as the 1820s, did not permit house connections until 1845; and Philadelphia allowed human waste in sewers in 1850.[21] Yet the existing sewer systems, which had been constructed piecemeal and with little or no municipal oversight, could not handle the increased load. They were often poorly designed, ineffective, and did little to prevent the contamination of water supplies.[22]

Beginning in the 1850s, the inadequacy of existing systems, combined with a growing awareness of the role of water systems in spreading cholera and other deadly diseases, spurred municipal governments to plan and build comprehensive sewer systems designed to address the needs of the city as a whole. American systems were influenced by and paralleled European sewer systems, and engineers on both continents debated the best way to design sewers.[23] While some cities experimented with novel technologies, such as pneumatic systems, the water-carriage

[20] Frank John Urquhart, *A History of the City of Newark, New Jersey, Embracing Practically Two and a Half Centuries, 1666-1913*, Vol. 2, 3 vols, (New York: The Lewis Historical Publishing Company, 1913).
[21] Howson, "The Archaeology of 19th- Century Health and Hygiene at the Sullivan Street Site, New York City," 140-142.
[22] Burian et al., "Urban Wastewater Management," 36-37; Joanne Abel Goldman, *Building New York's Sewers*, (West Lafayette: Purdue University Press, 1997); Jon C. Schladweiler, "The New American 'Roots'," *Sewer History*, 2004.
[23] Ellis S. Chesbrough, *Chicago Sewerage: Report of the Results of Examinations Made in Relation to Sewerage in Several European Cities, in the Winter of 1856-7*, (Chicago: Board of Sewerage Commissioners, 1858); Rudolph Hering, *Report on a System of Sewerage for the City of Binghamton, N.Y.,* (Binghamton: Daily Leader, 1882).

system, which relied on piped-in water and stormwater to convey waste, emerged as a consensus choice.

In Europe, Hamburg built a sewer system in 1842 as part of the reconstruction of the city after a great fire, Paris greatly improved and enlarged its sewers in 1857, even adding electric lights to the system, and following the Great Stink of 1858, London undertook construction of a modern sewer system between 1859 and 1865. It was not until after another deadly outbreak of cholera in the 1860s that many other European cities constructed sewer systems: Frankfurt in 1867, Berlin in 1873, and Munich in 1881.[24]

In the United States, in 1853, Jersey City was the first to plan a comprehensive water system that both provided clean drinking water and removed stormwater and sewage; the sewage system was designed by William Scollay Whitwell, who had previously worked for the city of Boston. His design consisted of

> …sewer mains of brick and laterals made of either brick or vitrified clay, depending upon the anticipated volume and rate of flow…the main sewers would vary in size from 24 to 36 inches in diameter. Intermediate and cross-streets would drain into the main sewers through 12 or 9-inch vitrified clay pipes…Whitwell altered the shapes of the brick mains and laterals to suit the unique drainage challenges and needs of each section of Jersey City, with circular, egg, and oval being the most common configuration recommended.[25]

Whitwell returned to Boston before construction began and was replaced in 1854 by George H. Bailey. In the summer of 1855, the first segment of Jersey City's sewer system was opened beneath Essex Street, and construction continued into the twentieth century as the city expanded. The sewer network was supposed to have a tidal canal flush it out to keep it clean, but the canal

[24] Javier Abellán, "Water supply and sanitation services in modern Europe: developments in 19th-20th centuries," *XII International Congress of the Spanish Association of Economic History – University of Salamanca,* (Salamanca: Universidad de Salamanca, 2017), 1-17.
[25] Lauren Lembo and Elizabeth Diker, *Stage IA Cultural Resource Survey, Jersey City Municipal Utilities Authority Sewer Phases 1-2 Sewer Rehabilitation, City of Jersey City, Hudson County, New Jersey (JCMUA Project No. S340928-24)*, (Prepared by RGA, Inc., 2018), 4-40.

was never built. Therefore, the city had issues keeping the sewers adequately clean and instead hired sewer cleaning squads to keep the sewers clean.[26]

Meanwhile, the first underground brick sewer in Newark was built in 1854. Julius W. Adams began constructing Brooklyn's sewer system in 1857, while a sanitation conditions report in Philadelphia sparked the construction of a sewer system in that city. In 1858, Chicago began work on a comprehensive system designed by E. S. Chesbrough that included raising existing buildings by several feet so that sewers could be laid on the ground surface and then covered over with fill. While New York City's government had regulated sewer construction for many years, it was not until 1865 that it began a systematic effort to design and build a city-wide sewer system.[27]

Neither the Civil War nor an economic depression in the 1870s could slow the growth in New Jersey. The population surged from around 500,000 people in 1850 to almost 2,000,000 by 1900, half of whom lived in cities. In 1866, the year of a major cholera epidemic, the New Jersey Medical Board, arguing that only governmental authorities would be able to take the necessary measures to prevent the spread of disease, created the Sanitary Commission to recommend prevention and mitigation measures. In 1877, the NJBOH was created out of the commission, although its powers were very limited at first. In 1880, a state law was passed requiring every New Jersey municipality to have its own board of health, which were soon given the power to pass ordinances and impose penalties in areas of hygiene and sanitation. In 1882, the state legislature

[26] Lembo and Diker, *Stage IA Cultural Resource Survey*.
[27] Goldman, *Building New York's Sewers*; Hayden et al., *Cultural Resources Investigation: Delancey Street Corridor Improvements, City of Newark, Essex County, New Jersey*, (Cranbury: Richard Grubb & Associates, Inc., 2010); Joel A. Tarr et al., "Water and Wastes: A Retrospective Assessment of Wastewater Technology in the United States, 1800-1932," *Technology and Culture* 25, no. 2 (1984): 242.

passed "An Act to authorize cities to construct sewers and drains and to provide for the cost thereof," providing municipalities with the legislative framework to build sewer systems.[28]

Rudolph Hering was a Philadelphia-born engineer, educated in Germany, who began working on sewer systems in 1875. In 1880 he was sent by the National Board of Health to Europe to study their sanitation systems, resulting in an influential monograph on sewerage and drainage practice that was accepted across the country for twenty-five years. Hering advocated a "rational engineering model" based on local conditions and cost. For large cities in the eastern United States, this meant a combined sewer system. This part of the country had enough stormwater to flush sewers, as well as numerous large streams and rivers in which to dilute wastewater, which made sewage treatment a less immediate concern. Smaller cities and cities with less rainfall could build systems meant solely for waste disposal and rely on surface-level drainage of stormwater. Hering went on to design or consult on water and sewer systems in Trenton and many other cities throughout the United States.[29]

Some cities did choose to construct separate systems, the first being Memphis, Tennessee, which installed a patented system designed by George E. Waring, Jr., in 1880, after epidemics of cholera and yellow fever hit the city (Figure 1).[30]

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[28] Cowen, *Medicine and Health in New Jersey*, 84; Stuart Galishoff, *Newark: The Nation's Unhealthiest City, 1832-1895,* (New Brunswick: Rutgers University Press, 1988).

[29] Rudolph Hering, *Report on a System of Sewerage for the City of Binghamton, N.Y.*, (Binghamton: Daily Leader, 1882); Leonard Metcalf and Harrison P. Eddy, *American Sewerage Practice, Volume I: Design of Sewers,* (New York: McGraw-Hill, 1914), 28; Tarr et al., "Water and Wastes," 154.
Hering also worked on Montgomery, Alabama; Los Angeles, California; San Francisco, California; Atlanta, Georgia; Chicago, Illinois; Indianapolis, Indiana; New Orleans, Louisiana; Baltimore, Maryland; Trenton, New Jersey; Binghamton, New York; Cleveland, Ohio; Columbus, Ohio; and Washington, D.C.

[30] Jon C. Schladweiler, "Design Choices and Philosophies," *Sewer History*, 2004; George E. Waring, Jr., *Concerning Mr. Rudolph Hering's Project for the Sewerage of Binghamton, N.Y.*, (Newport: Marshall & Flynn, Printers, 1883), 4.
Waring's patented separate system was also constructed in Birmingham, Alabama; Little Rock, Arkansas; Pittsfield, Massachusetts; Kalamazoo, Michigan; Omaha, Nebraska; Keene, New Hampshire; Wilkes-Barre, Pennsylvania; and Norfolk, Virginia.

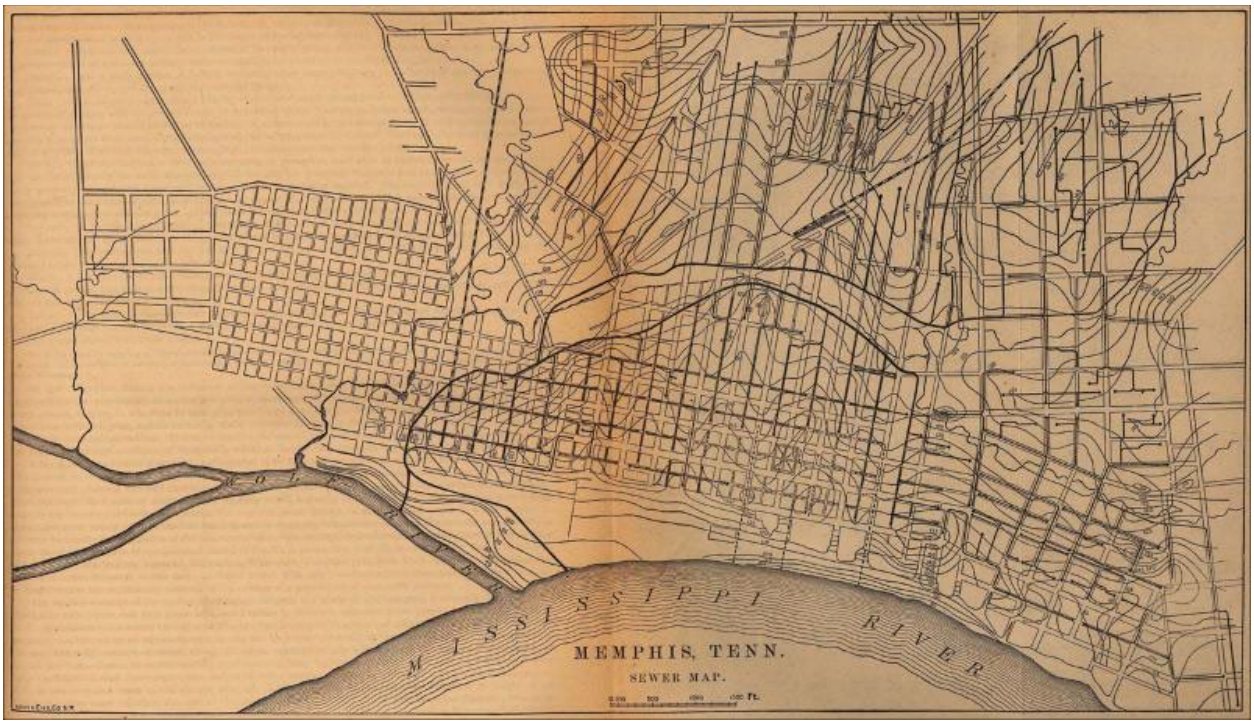

Figure 1. Map of Memphis' Sewer System
Source: Memphis Sewer Map 1880, Memphis Public Library. http://hdl.handle.net/10267/31162

Despite these efforts, infrastructure often could not keep up with the growth of New Jersey's and the nation's industry and population, even as demand for adequate sanitation increased. In 1880, Trenton was called the dirtiest city in the country and, in 1890, Newark was the deadliest city in the nation, thanks to the prevalence of disease.[31] Even in cities that had sewer systems, privies would remain in use until the end of the nineteenth century, or even into the twentieth century. For example, in the Covert-Larch neighborhood of Jersey City, sewer lines were not installed until 1891-1903, and some privies remained in use until the 1920s.[32]

Regardless of whether a city had a separate or combined sewer system, attempts to deal with sewage and garbage generally involved moving the waste out of populated areas and into bodies of water. It was thought that the best way of handling waste was by diluting it in rivers and

[31] Cowen, *Medicine and Health in New Jersey*, 81-82.
[32] Jean Howson and Leonard G. Bianchi, *Covert Larch: Archaeology of a Jersey City Neighborhood. Data Recovery for the Route 1 & 9T (25) St. Paul's Viaduct Replacement Project Jersey City, Hudson County, NJ,* (Cultural Resource Survey, Cultural Resource Unit, the RBA Group, 2014).

oceans. Both health officials and conservationists began to question the practice of dilution by the 1890s. Techniques for filtration and chemical precipitation of wastewater were developed as early as 1894. In the wake of the acceptance of germ theory, biological treatment processes were invented as well. In conjunction with this, combined systems fell out of favor and separate systems, in which stormwater could still be conveyed directly to rivers but sewage would be treated, became the standard.[33]

Laws addressing water pollution were enacted piecemeal at first, and regulation was largely left up to the states. The State of New Jersey gradually expanded its role in protecting its citizens' health, and, in 1899, enacted a law prohibiting the pollution of any water bodies used as a public water supply.[34] A state sewerage commission with the authority to approve new sewer construction and to inspect sewers throughout the state was also created in 1899.[35] Inspections were slow to start as money was not set aside for the purpose, but by 1905 regular testing of the water supplies of twenty-two towns was conducted.[36] Deaths from typhoid fever, already in decline, fell further over the next two decades.[37]

During the Great Depression, the Works Progress Administration (WPA) funded sewer projects throughout the United States (Figure 2).

[33] Melosi, *The Sanitary City*, 164; George W. Rafter and Moses Nelson Baker, *Sewage Disposal in the United States,* (New York: D. Van Nostrand Company, 1894), v-vi.
[34] New Jersey Board of Health, *Twenty-Third Annual Report of the Board of Health of the State of New Jersey, 1899*, (Trenton: MacCrellish & Quigley, 1900), 29.
[35] Cowen, *Medicine and Health in New Jersey*, 164.
[36] New Jersey Board of Health, *Twenty-Ninth Annual Report of the Board of Health of the State of New Jersey, 1905*, (Trenton: John L. Murphy Publishing, 1906), 55-57.
[37] New Jersey Department of Health, *Fifty-Third Annual Report of the Department of Health of the State of New Jersey, 1930*, (Trenton: MacCrellish & Quigley Co., 1931), 164.

Figure 2. WPA Storm Drain Project in Hackensack, NJ
Source: New Jersey WPA, Lincoln St. Storm Drain (The Dawn, September 1936), 6.
https://livingnewdeal.org/projects/fairmount-storm-sewers-hackensack-nj/

In 1948, the Federal Water Pollution Control Act authorized financing for water pollution control facilities and empowered the federal government to participate in addressing interstate water pollution issues with the affected states' consent. Despite some public opposition to giving the federal government more control, grant programs for water pollution persisted throughout the 1950s.[38]

In the 1960s, the environmental movement grew, thanks in part to the 1962 publication of Rachel Carson's *Silent Spring.* In 1970, New Jersey became the third state to consolidate its environmental programs into a single Department of Environmental Protection (NJDEP). The

[38] Melosi, *The Sanitary City*, 315-316.

growing awareness of the problems of pollution, especially industrial pollution, led to several federal laws and regulations that increased federal involvement. Finally, in 1972, the Federal Water Pollution Control Act, now the Clean Water Act, gave the federal government a central role in addressing water quality. A standard, country-wide water quality goal was put into place, and permits were required for all point-source pollution discharges. The Act was amended in 1977, giving more control to states, modifying deadlines, and increasing the funding for projects using innovative technologies.[39] In 1983, the NJDEP was delegated the authority to regulate and issue permits for the National Pollution Discharge Elimination System program under the Clean Water Act.

[39] Melosi, *The Sanitary City*, 387-389.

3. Sewage Systems

A sewer is a conduit for transporting sewage (liquid waste from both domestic and industrial sources, including houses and businesses). Sewers in the nineteenth century were built out of a variety of materials, including brick, clay, concrete, stone, and wood. Cradles or other support systems were sometimes used, generally contingent on the substrate in which the sewer pipe was laid.

Other features associated with sewer pipes include catch basins, flush tanks, fresh air inlets, lampholes, manholes and manhole covers, pump stations and lift stations, siphons, stormwater overflows and regulators, valves, and wastewater treatment plants. These are outside the scope of this context report, but in general, can be built out of the same materials as sewer pipes.

Sewage Conveyance Technologies and Associated Property Types

Privies, Cesspits, and Septic Systems

Prior to the advent of centralized water carriage sewer systems in cities, privies and cesspits (or cesspools) were used to manage household waste in a dry carriage system. A privy or outhouse is a small structure, usually constructed in the backyard of a property, with a vault or a pail underneath for collecting human waste. The earliest privies were unregulated, but as populations increased in urban areas, sanitation problems, including the contamination of drinking water sources, led to government regulation. However, cities often had a limited ability to make sure residents followed the law.[40]

[40] Stephen W.Yost and Glenn R. Modica, *Stage IA Cultural Resources Survey, Remsen Avenue Storm Sewer Improvements, City of New Brunswick, Middlesex County, New Jersey*, (Cranbury: Richard Grubb & Associates, 2003), 4-5.

A privy vault could be a simple unlined hole dug into the earth, a buried wooden barrel, or a more formal pit lined with wood, stone, brick, or concrete.[41] As early as 1863, some cities required that privy vaults be at least 8 feet deep, lined with brick or stone, and at least 10 feet from any public street, but in Newark, many privies were still lined with wood as late as 1885 (Figure 3).[42]

Figure 3. Excavated Privies with a Variety of Linings.
Source: Jean Howson and Leonard G. Bianchi, Covert Larch: Archaeology of a Jersey City Neighborhood. Data Recovery for the Route 1 & 9T (25) St. Paul's Viaduct Replacement Project Jersey City, Hudson County, NJ, (Trenton: the RBA Group, 2014), 352.

[41] Howson and Bianchi, *Covert Larch*, i-iv.
[42] Yost and Modica, *Stage IA Cultural Resources*, 4-5; Galishoff, *Newark*, 108.

A pail is a smaller, removable container that had to be emptied regularly. Dry loam was used as a deodorizer and absorbent in the pails, and any liquid wastewater was scattered on the ground.

A cesspit differs from a privy vault in that pipes transport waste from the house into the cesspit. This may include both kitchen waste and human waste from water closets. Some cesspits were unlined and allowed waste to percolate into the surrounding soils, but others were water-tight, sometimes at the bottom or entirely. Privy vaults could be converted into cesspits by connecting a pipe to the vault. A single large cesspit could be linked to two or more buildings.[43]

The privies and cesspits needed to be emptied as they became full. This might be done nightly for smaller vaults, or a few times each year for larger ones. Cities regulated this process and contracted the job out to people called scavengers, who used a long handle dipper and shovel to manually remove the waste, euphemistically called night soil, which was then put in airtight containers and either dumped elsewhere or sold as fertilizer (Figure 4).

Figure 4. Night Soil Barrel
Source: Charles V. Chapin, Municipal Sanitation in the United States, (Providence: Providence Press, 1900), 745.

[43] A. Prescott Folwell, *Sewerage, The Designing, Construction, and Maintenance of Sewerage Systems,* 6th, (New York: John Wiley & Sons, 1910), 3; Anson Marston, *Sewers and Drains*, (Chicago: American School of Correspondence, 1908); Giusy Lofrano and Jeanette Brown, "Wastewater management through the ages: A history of mankind," *Science of the Total Environment* 408, no. 22 (2010): 5256.

In some cities, the waste could not be carried through any public markets or other public spaces, and the scavenger's horse was not allowed to travel faster than a walk. In Hoboken, the containers could be removed only between 11:00 p.m. and 3:00 a.m., but in Newark, the scavengers could work during the day. By the late nineteenth century, some cities used wagon-mounted pumps to suction waste out of the privies, but Newark continued to rely on manual labor, while Camden only required the use of pumps in the summer. As cities constructed sewer systems, privies often remained in use, and in some cases, pipes were added to cesspits and privies to drain them into the sewage system.[44]

Septic systems were first patented in France in 1881 and introduced to the United States in 1883 but were not widely used until after World War II. Because they were more economical for slowly developing areas, septic tanks were favored in rural areas. Septic systems were an improvement on cesspits because they separate out and treat the more harmful components of wastewater. A buried concrete, fiberglass, or plastic septic tank collects household wastewater through a single drainage pipe. Solids settled to the bottom of the tank and oils and grease floated on the surface. The remaining wastewater was discharged through perforated pipes into a drainage field where the water percolated into the soil.[45]

Combined Sewer Systems

In the mid-nineteenth century, cities began developing sewers based on the water-carriage system. There are two types of sewer systems, combined and separate (Figure 5). The combined

[44] Galishoff, *Newark*, 109; Marston, *Sewers and Drains*; Glenn R. Modica and Jesse O. Walker, *Stage IA Cultural Resources Survey, North Hudson Sewerage Authority, System-Wide Combined Sewer Overflow Improvements Program, Cities of Hoboken and Union City and Township of Weehawken, Hudson County, New* Jersey, (Richard Grubb & Associates, Inc., 2004), 4-12; Rafter and Baker, *Sewage Disposal in the United States*, 352-353; Charles V. Chapin, *Municipal Sanitation in the United States*, (Providence: The Providence Press: Snow & Farnham, 1900), 746; Howson and Bianchi, *Covert Larch*, 351.
[45] Melosi, *The Sanitary City*, 170-171, 193.

sewer system receives domestic sewage, industrial wastewater, and stormwater. When the system is working at maximum capacity, the untreated sewage and stormwater is discharged into bodies of water from the outfall point. This system, particularly during wet weather conditions, results in the pollution of water bodies, negatively impacting health. In a separate system, the sanitary and stormwater pipes are separate and convey sewage via a closed system into a treatment plant.

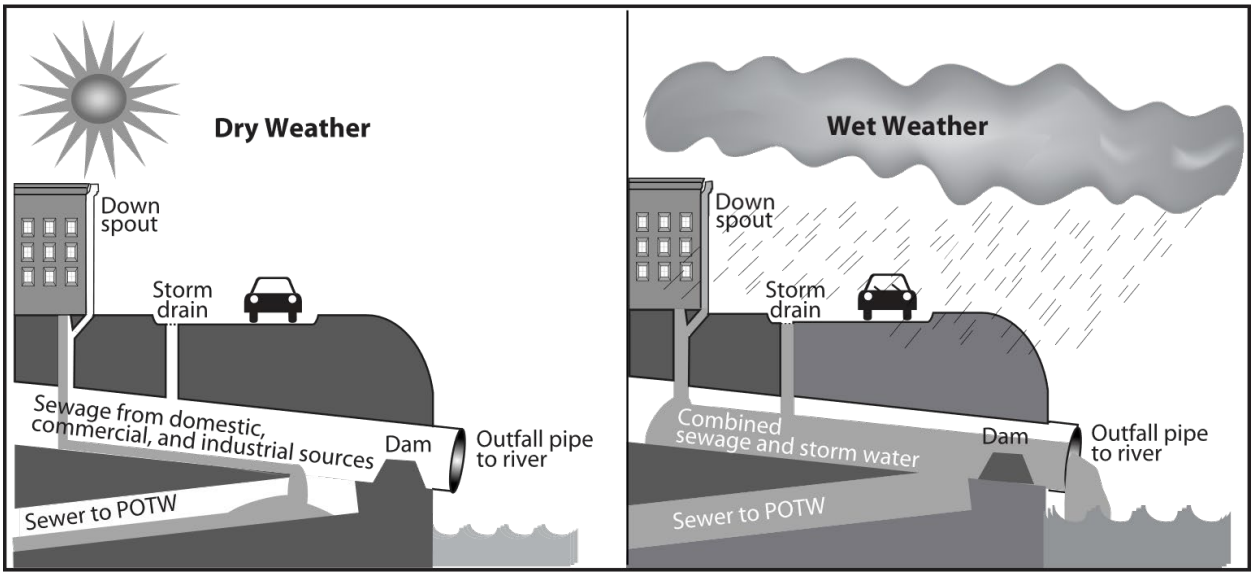

Figure 5. Comparison of Dry and Wet Weather Conditions in Cities with a CSO
Source: U.S. Department of the Interior, Environmental Protection Agency, Report to Congress: Impacts and Control of CSOs and SSOs, (Washington, D.C.: 2004), 2-2. https://www.epa.gov/sites/production/files/2015-10/documents/csossortc2004_full.pdf

Camden has a combined sewer system, which was standard for the period of construction. This is not uncommon as many texts on sewage construction during the late 1800s and early 1900s did not see the negative impact of draining untreated sewage into waterways, since dilution was taking place.[46] Currently, low-cost infrastructure improvements are being sought in Camden

[46] Leonard Metcalf and Harrison P. Eddy, *Sewerage and Sewage Disposal, a Textbook*, (New York: McGraw-Hill Book Company, 1922), 18.

for green and grey infrastructure to reduce combined sewer overflows, which occur at 21 CSO sites in Camden (Figure 6).[47]

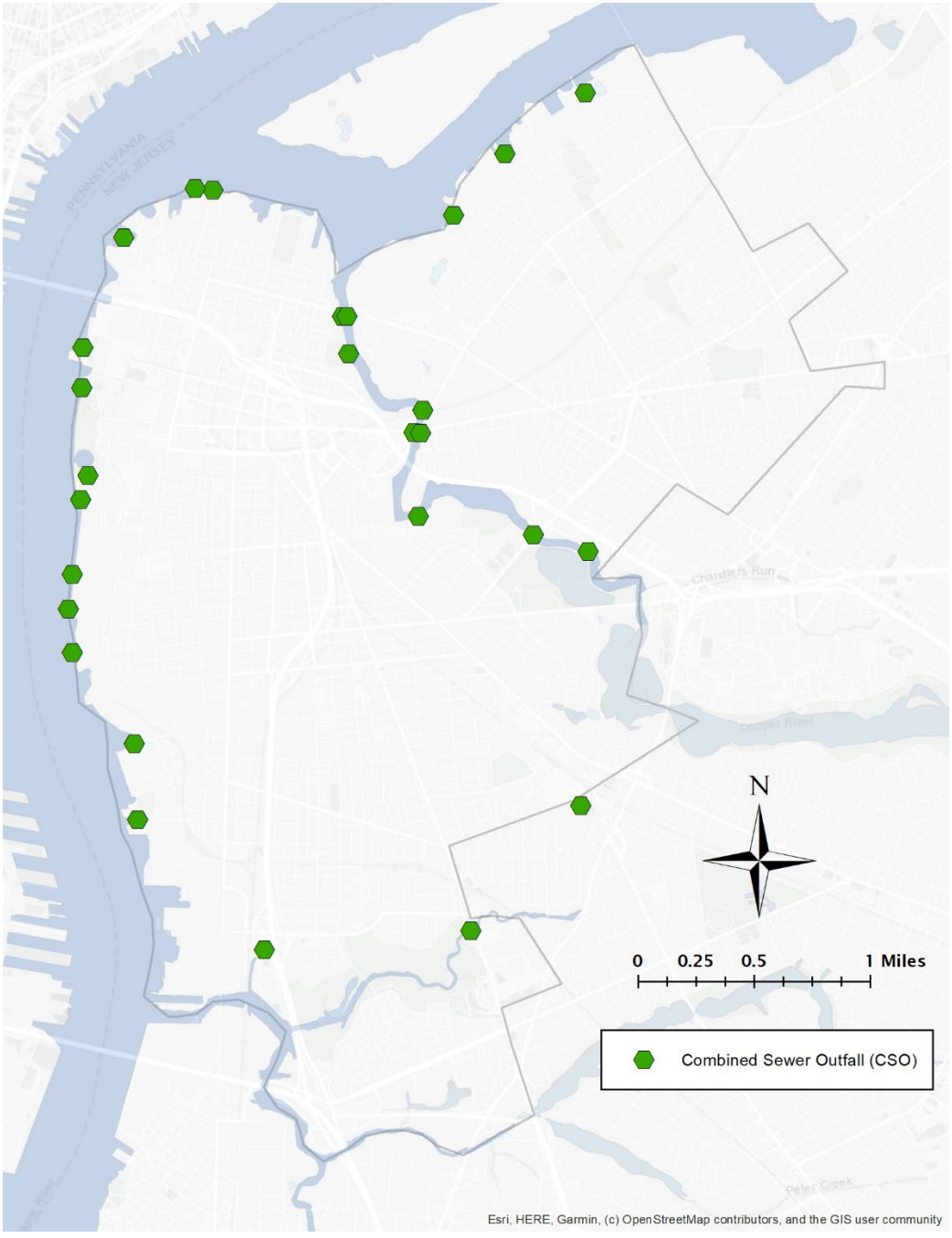

Figure 6. Camden's 21 CSOs

[47] U.S. Environmental Protection Agency, *Camden County Municipal Utilities Authority: A Wet Weather Case Study of Incorporating Community Interests into Effect Infrastructure Decision-Making*, (U.S. Environmental Protection Agency, 2018).

Brick Sewers

Brick sewers were constructed in the United States by the 1850s. For larger conduits, brick was a favored option, while vitrified clay or cast iron was preferred for smaller pipes. The earliest brick sewers had flat bottoms, or bottoms that curved with the natural base of the trench. Engineers experimented with multiple sewer cross sections, including horseshoe, basket-handle, catenary, semi-elliptical, gothic, parabolic (delta), U-shape, semi-circular, and rectangular shapes (Figure 7).[48]

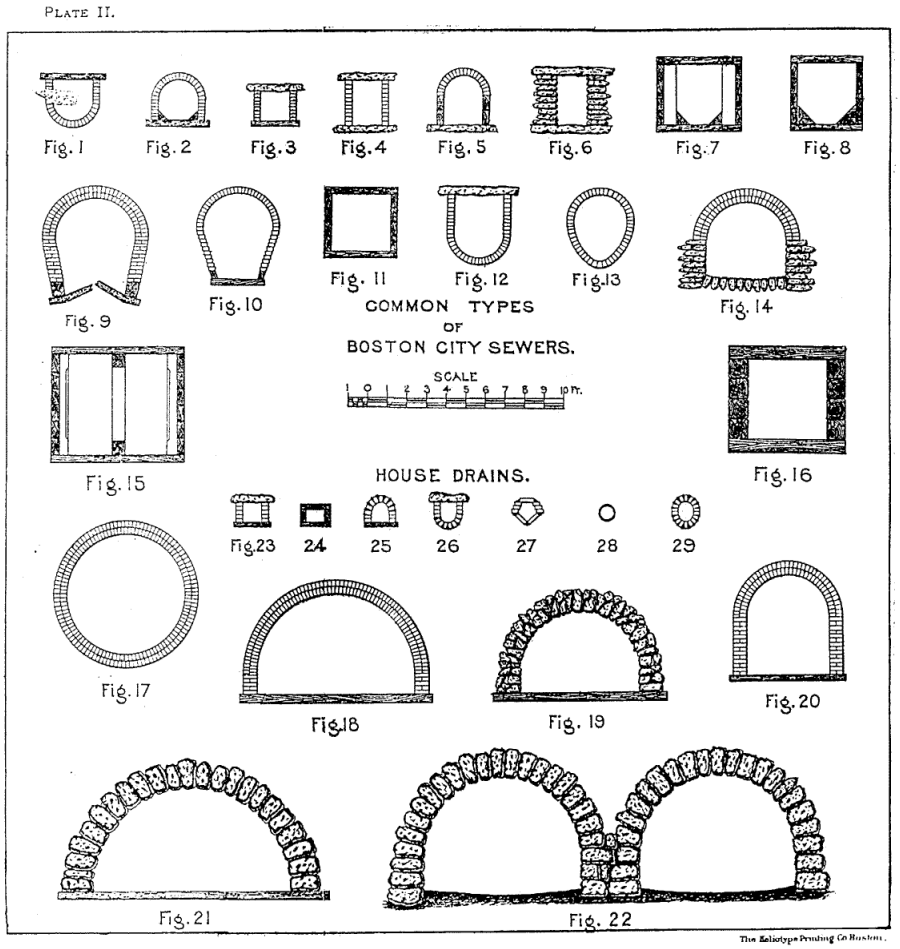

Figure 7. Non-Circular Sewer Shapes
Source: Eliot C. Clarke, Main Drainage Works of the City of Boston, 2nd edition (Boston: Rockwell and Churchill, City Printers, 1885), Plate II.) http://www.sewerhistory.org/wp-content/uploads/2013/09/1885_bmb101523e2b5434c5d.gif

[48] Donald A. Krueckeberg, *Introduction to Planning History in the United States*, (New Brunswick: Rutgers University, 2018 [1983]); Metcalf and Eddy, *Sewerage and Sewage Disposal.*

English engineer John Phillips designed the oval or egg-shaped brick sewer in 1846 (although a slightly different egg-shaped design had been constructed by John Roe by 1842) and they were built in the United States soon after. Phillips' design, slightly modified in 1847 and 1874 to make it stronger and better at self-cleaning in low-flow situations, was soon recognized as being the best design for sewers with an intermittent flow, such as in a combined system. The egg-shaped pipes allowed for higher flow velocities in dry conditions than circular pipes, while maintaining a large capacity for wet-weather events (Figure 8).[49]

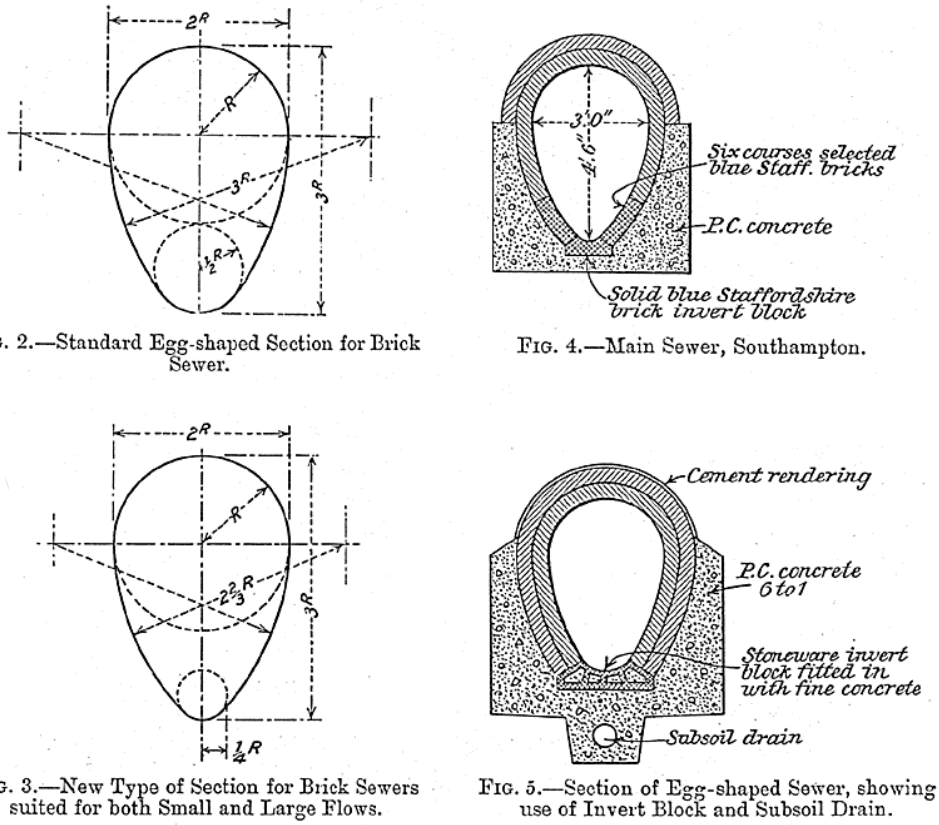

Figure 8. Cross-Sections of Egg-Shaped Brick Sewers
Source: W. H. Maxwell and J.T. Brown, eds, The Encyclopaedia of Municipal and Sanitary Engineering, (New York: D. Van Nostrand Company, 1910), 428

[49] Baldwin Latham, *Sanitary Engineering, A Guide to the Construction of Works of Sewerage and House Drainage*, (London: E. & F.N. Spon, 1978); Marston, *Sewers and Drains*, 39; Metcalf and Eddy, *Sewerage and Sewage Disposal*; John Phillips, *On the Drainage and Sewerage of Towns*, (London: E & F.N. Spon, 1872); Christopher Hamlin, "Edwin Chadwick and the Engineers, 1842-1854: Systems and Antisystems in the Pipe-and-Brick Sewers War," *Society for the History of Technology*, 1992: 680-709; Glenn R. Modica, *The History of the Newark Sewer System*, (Cranbury: Richard Grubb & Associates, Inc., 2001), 6.

Egg-shaped sewers were not without weaknesses:

> …disadvantages of the egg-shaped section are that it is less stable, more liable to crack, requires more masonry, and in general is more difficult to construct than the circular section. In very stiff earth or in rock it is sometimes possible to excavate the bottom of the trench to conform to the shape of the invert of the sewer, but in general, in yielding earth or where foundations are poor and piles or platforms are needed, the egg-shaped section requires more masonry backing under the haunches to support the arch than does the circular sewer. Hence the egg-shaped section may be more expensive than the circular section in many cases, and much more expensive than some of the other sections.[50]

A circular section permits the highest velocity of flow and is the most efficient option for pipes that will be at least half full (Figure 9). They are also stronger and less expensive than egg-shaped sewers to construct. In situations where a uniform flow was expected, such as in separate systems and smaller diameter laterals leading from buildings to the main pipe, circular brick sewers were more likely to be built.

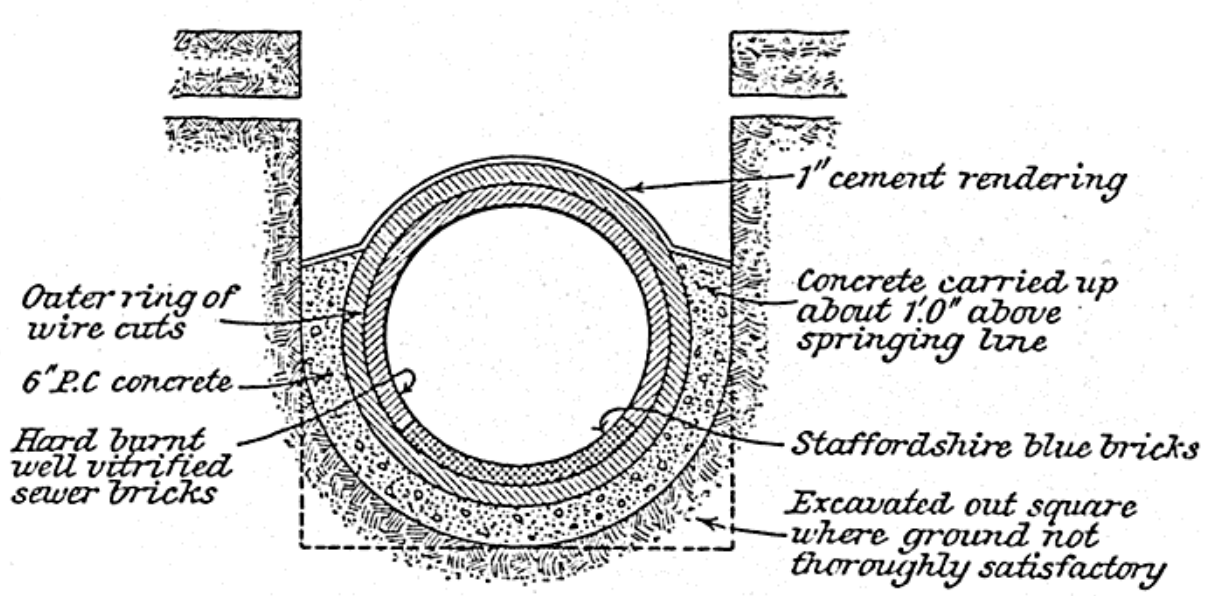

Figure 9. Cross-Section of Circular Brick Sewer
Source: W. H. Maxwell and J.T. Brown, eds., The Encyclopaedia of Municipal and Sanitary Engineering, (New York: D. Van Nostrand Company, 1910), 429

[50] Metcalf and Eddy, *Sewerage and Sewage Disposal*, 258.

Several types of brick were used for sewer construction. Paving bricks, which are smooth and impervious, were used for the bottoms of sewers, while regular building bricks, which are cheaper, were sufficient for the rest of the structure. The bricks were usually soaked in water for twenty-four hours to decrease sewage absorption. The bottom half of the sewer was constructed first and allowed to settle before construction began on the top half.[51]

In some cases, the invert of the sewer was made with solid or hollow shaped blocks made of terra cotta or vitrified clay instead of regular bricks (Figure 10).

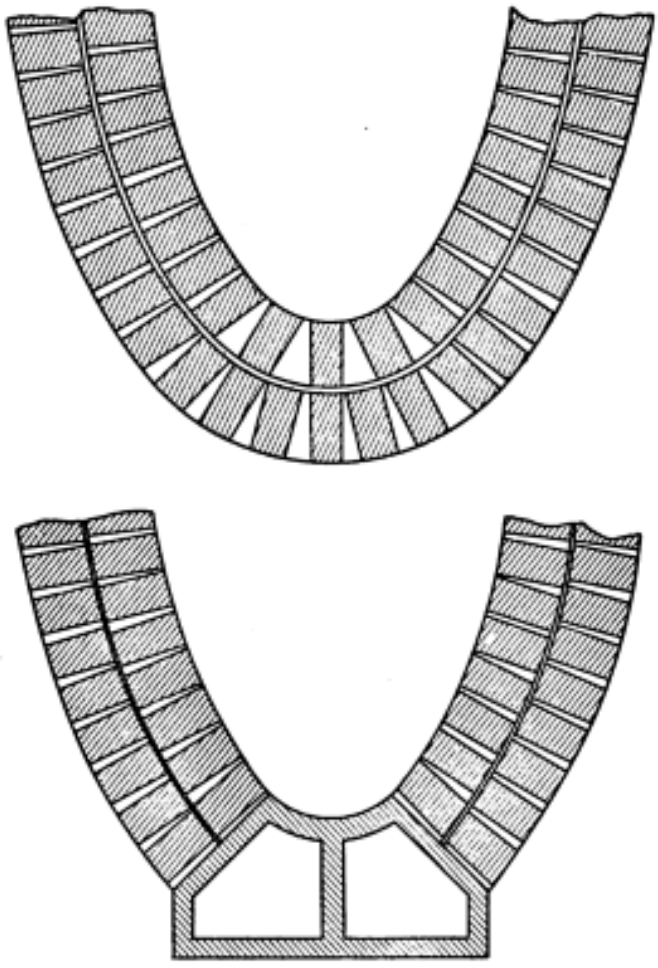

Figure 10. Invert Block Diagram
Source: Henry N. Ogden, Sewer Construction, (New York: John Wiley & Sons, 1908), 31.

[51] Henry N. Ogden, *Sewer Construction*, (New York: John Wiley & Sons, 1908), 30, 51; Folwell, *Sewerage*, 182.

The hollow blocks were supposed to drain groundwater, but their effectiveness was questioned, and some builders would fill the voids in hollow blocks with concrete before installing them. In some situations, a separate, smaller pipe was installed under the brick sewer to drain ground water. When the ground underneath the sewer was soft, a concrete or timber base or cradle could be placed to prevent shifting or settling of the sewer (Figure 11).

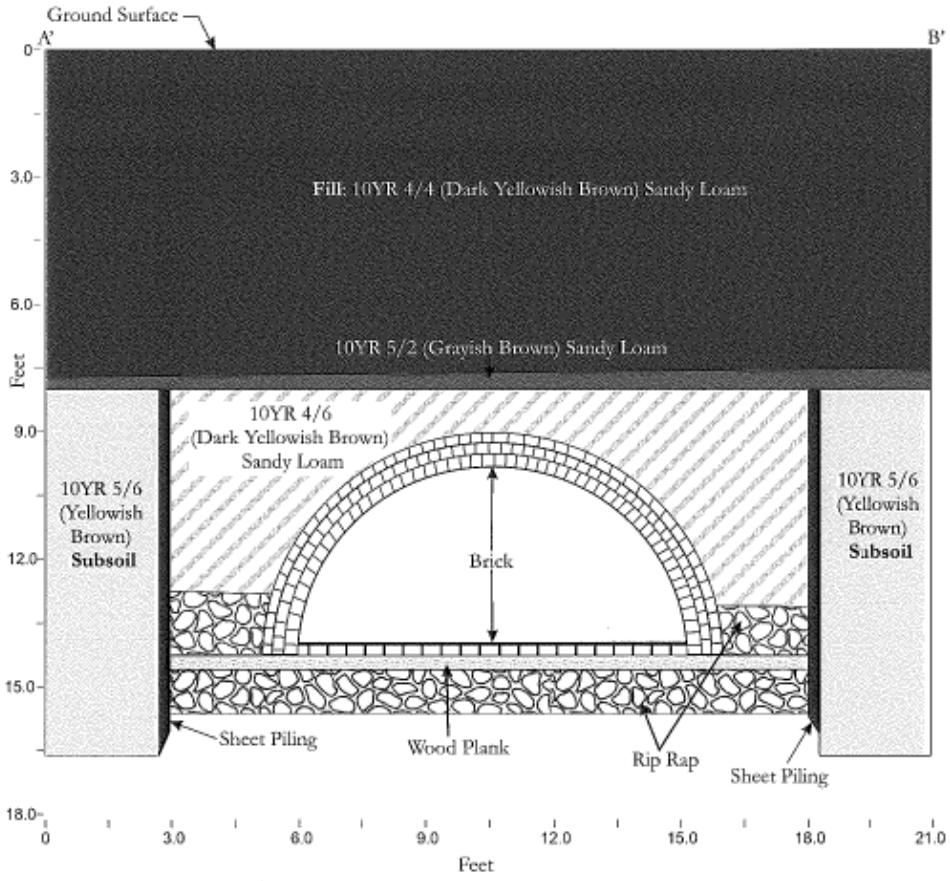

Figure 11. Brick Arch Sewer Cross Section
Source: Scott Wieczorek and Michael Tomkins, Archaeological Monitoring North Hudson Sewerage Authority, H1 Screening and Wet Weather Pump Station, City of Hoboken, Hudson County, New Jersey, (Cranbury: Richard Grubb & Associates, Inc., 2012), 4-18.

When sewer trenches were excavated into bedrock, concrete was used to fill the area in between the sewer and the bedrock, and cement was used as mortar (Figure 12).[52]

[52] Latham, *Sanitary Engineering*; Ogden, *Sewer Construction*, 30, 34; "Impervious Sewer Pipes," *The Manufacturer and Builder*, 12, no. 3 (March 1880), 54; Ogden, *Sewer Construction.*

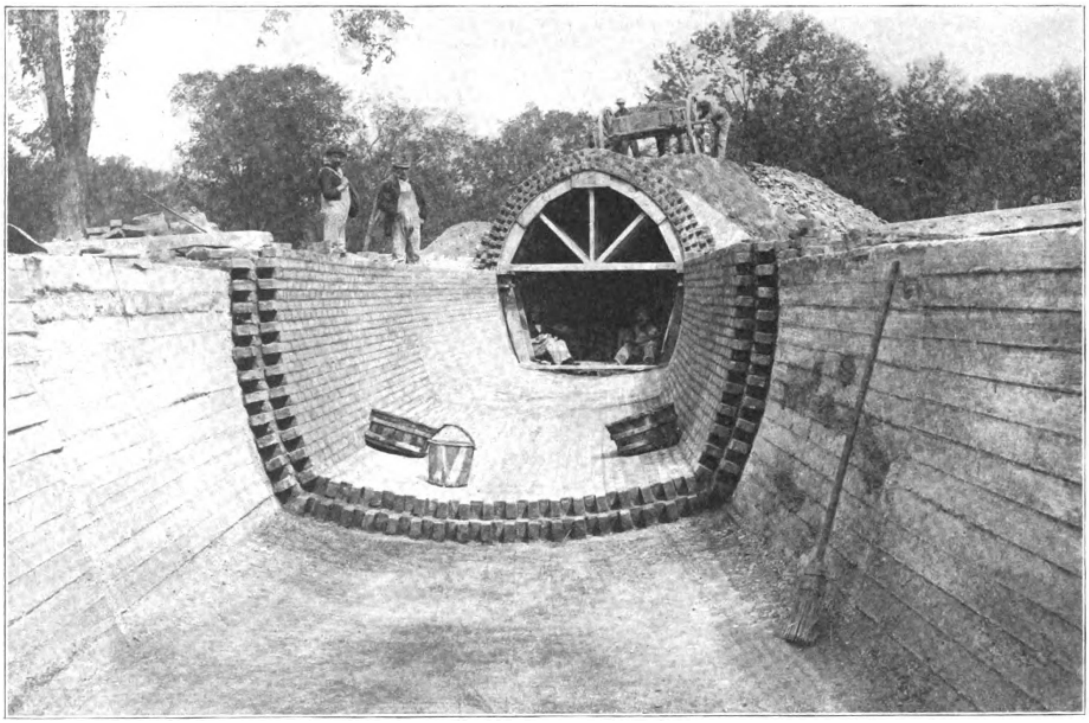

Figure 12. Combined Brick and Concrete Sewer Construction
Source: Anson Marston, Sewers and Drains, (Chicago: American School of Correspondence, 1908), cover.

Other Materials

Wood Sewers

Wood sewers include hollowed-out logs, pipes constructed from wooden staves or planks, and box sewers made of wood planks notched together. They were sometimes used in wet conditions, such as with submerged outfalls. In Boston, it was estimated that prior to the creation of a municipal system, "[p]robably one-half of the larger main sewers are wholly or partly built of wood and have flat bottoms."[53] Wooden stormwater outfalls were used in Camden and New

[53] Eliot C. Clarke, *Main Drainage Works of the City of Boston*, 2nd, (Boston: Rockwell and Churchill, City Printers, 1885), 14.

York City, though the rest of their stormwater systems were made of brick or other materials.[54] A storm sewer made of yellow pine boards from 1830 was reported in the Camden & Amboy Railroad yard in South Amboy, New Jersey.[55] Tidal box sewers made of wood were installed in Hoboken beginning in 1860.[56]

Wooden pipes were also used for laterals until around the middle of the nineteenth century, when iron or vitrified clay laterals became more common.[57] Wooden timbers continued to be used for sewer foundations, shoring, and piling even after brick and concrete became more common for sewers. Timber shoring used during construction may have been left in place after the sewer was completed.[58]

Stone Sewers

Stone sewers were not common, but they were one of the earliest types of sewers in America, emerging around the same time as wood sewers.[59] Some early drainage systems used stone-lined channels to control stormwater or direct water away from buildings, and these were constructed by private companies into the twentieth century. In other cases, stone bedrock was

[54] Charles R. Pennington and Paul S. Schopp, *Stage IA Cultural Resources Survey, Combined Sewer Overflow Planning Study, City of Camden and Gloucester City, Camden County, New Jersey*, (Cranbury: Richard Grubb & Associates, 1998); Martin Reinbold et al., *Phase IB Archaeological Investigation of the Combined Sewer Overflow (CSO) Site C10 for the Camden County Municipal Utilities Authority's Combined Sewer Overflow Replacement Project, Kaighns Avenue and Front Street, City of Camden, Camden County, New Jersey*, (Metuchen: ARCH2, 2009); Martin Reinbold et al., *Phase IB Archaeological Investigation Addendum, Combined Sewer Overflow (CSO) Site C05/10 for the Camden County Municipal Utilities Authority's Combined Sewer Overflow Replacement Project, Kaighns Avenue and Front Street, City of Camden, Camden County, New Jersey*, (Metuchen: ARCH2, 2010); Nancy Zerbe, "Monitoring report for the Combined Sewer Overflow Project, CSO Site C05/10. ARCH2, Letter submitted to Elizabeth Davis, NJDEP," August 24, 2009; Nancy Zerbe, "Monitoring report for the Combined Sewer Overflow Project, CSO Site C10/15. ARCH2. Letter submitted to Elizabeth Davis, NJDEP," January 29, 2010; Folwell, *Sewerage*, 142; Reinbold et al., *Phase IB Archaeological Investigation Addendum,* 11.
[55] Reinbold et al., *Phase IB Archaeological Investigation Addendum,* 11.
[56] Cushman et al., *Archaeological Monitoring, North Hudson Sewerage Authority, Grand Street Combined Sewer Rehabilitation, City of Hoboken, Hudson County, New Jersey*, (Cranbury: Richard Grubb & Associates, 2015), 3-1.
[57] Goldman, *Building New York's Sewers*, 86.
[58] Latham, *Sanitary Engineering*.
[59] Krueckeberg, *Introduction to Planning History in the United States*.

left in place to form the bottom of a storm sewer. [60] Stone sewers were built in Lexington, Kentucky around 1880 and were also used in New York City and Boston (Figure 13).[61] Camden's Line Ditch sewer, completed in 1907, used stone for its walls. The floor was concrete poured onto a timber base built on wooden pilings, and the top consisted of a brick arch.[62]

Figure 13. Men Examining Sewer Stonework, Boston
Source: Edgar Sutton Dorr Collection, (ca. 1880-1889). https://ark.digitalcommonwealth.org/ark:/50959/p2677196n

[60] Betty J. Cosans, "Archeological Investigations of a Proposed Urban Redevelopment Site, New Brunswick, New Jersey," (1983); Richard L. Porter et al., *Archaeological Data Recovery, N.J. Route 18 Extension Interim Improvements, N.J. Route 18 (River Road) Between Landing and Metlars Lanes, Piscataway Township, Middlesex County, New Jersey, Volume 1,* (New Brunswick: Rutgers University, Center for Public Archaeology, 1995); Yost and Modica, *Stage 1A Cultural Resources Survey*; Lynn Alpert, *Cultural Resources, Railroad Avenue/Main Street Stormwater Improvements, Califon Borough, Hunterdon County, New Jersey*, (Cranbury: Richard Grubb & Associates, Inc, 2013).
[61] Maygarden et al., "National Register Evaluation of New Orleans Drainage System, Orleans Parish, Louisiana," 7; Krueckeberg, *Introduction to Planning History in the United States.*
[62] "Passing of Line Ditch in South Camden Means Much to that City," *Philadelphia Inquirer*, (Philadelphia: Philadelphia Inquirer, November 1, 1906).

Vitrified Clay Pipe Sewers

Vitrified clay has many ideal qualities for sewer pipe – hardness, impermeability, smoothness, and resistance to acid, steam, and silt abrasion – but it is brittle and prone to cracks or breaking, especially if not installed correctly.[63] Clay is fired at a high temperature to achieve vitrification, where it solidifies into a hard, nonporous glass.[64] A salt-glaze or slip glaze was used to ensure that the pipe was impermeable and smooth.[65]

While the earliest use of clay for pipes dates back thousands of years, one of the earliest commercial producers of vitrified clay pipe in the United States was Hill, Merrill and Company, near Akron, Ohio, who began production in 1849; many other companies followed suit.[66] Most vitrified clay pipes were circular, although a small number of egg-shaped vitrified clay sewers were installed in the United States, and at least one manufacturer in England designed a clay pipe that was circular on the outside but had an elliptical interior cross section.[67]

By the end of the nineteenth century, vitrified clay pipes were widely used for small (less than 24 inches) diameter sewer pipes. Pipe wall thickness eventually became standardized into single strength ("Ohio Standard") or double strength form; 12 inches or larger diameter double strength pipe walls had to have a thickness equal to 1/12th of the internal diameter of the pipe.[68] Earlier pipe sections were generally no more than 2 feet in length, but by the beginning of the twentieth century, manufacturing techniques had improved so that up to 3 feet long sections

[63] Ogden, *Sewer Construction*, 1-2.
[64] Tony Hansen, "Vitrification," 2015.
[65] Jon C. Schladweiler, "Early Sewage Conveyance Systems," *Sewer History*, 2004.
[66] Schladweiler, "Early Sewage Conveyance Systems"; Edward J. Sikora, "ASTM and the National Clay Pipes Institute: 100 Years of Teamwork and Achievement," *ASTM Standardization News*, 2004.
[67] Ogden, *Sewer Construction*, 9.
[68] Monmouth Mining & Manufacturing Company, "Sewer and Culvert Pipe, Drain Tile, Well Tubing, Paving Brick, &c, &c. Monmouth Illinois (catalog)," 1890.

could be made. Each pipe would have an enlarged diameter "bell" at one end, so that the normal diameter end of the next pipe would fit into it to create a bell-and-spigot joint (Figure 14).

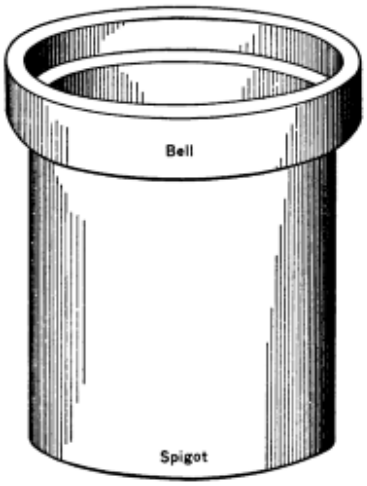

Figure 14. Bell and Spigot Design
Source: Henry N. Ogden, Sewer Construction, (New York: John Wiley & Sons, 1908), 12.

In 1891, the Portland Stoneware Company introduced the deep-and-wide socket in addition to the standard socket (Figure 15).

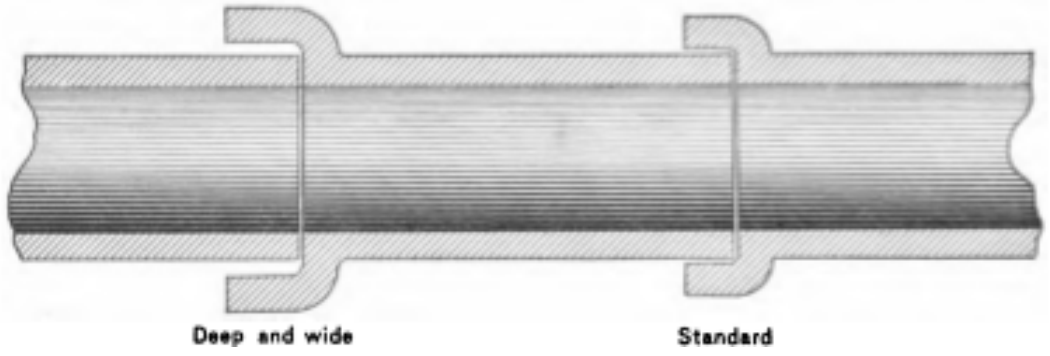

Figure 15. Standard vs Deep and Wide Joints
Source: Henry N. Ogden, Sewer Construction, (New York: John Wiley & Sons, 1908), 12.

Laboratory experiments demonstrated that the deep-and-wide socket allowed for greater leakage, though it produced a tighter line overall. This socket could be sealed with cement mortar or other

materials to make the joints water-tight and reduce unwanted infiltration or exfiltration of liquids.[69]

Concrete Sewers

Concrete is made of aggregate (i.e., stone, sand, and gravel), cement, and water. Concrete sewers can be either poured-in-place (monolithic) or constructed out of precast concrete pipes. Concrete was also used as a reinforcement or base for other types of sewers. Like brick sewers, both precast and poured concrete sewers could have circular, egg-shaped, or other cross sections (Figure 16). Precast sections would be joined together using a bell and spigot connection, or other, sometimes proprietary, methods.[70] The individual precast sections could be constructed at a company factory, or, especially for larger diameter pipes, cast near where the pipes were to be installed.

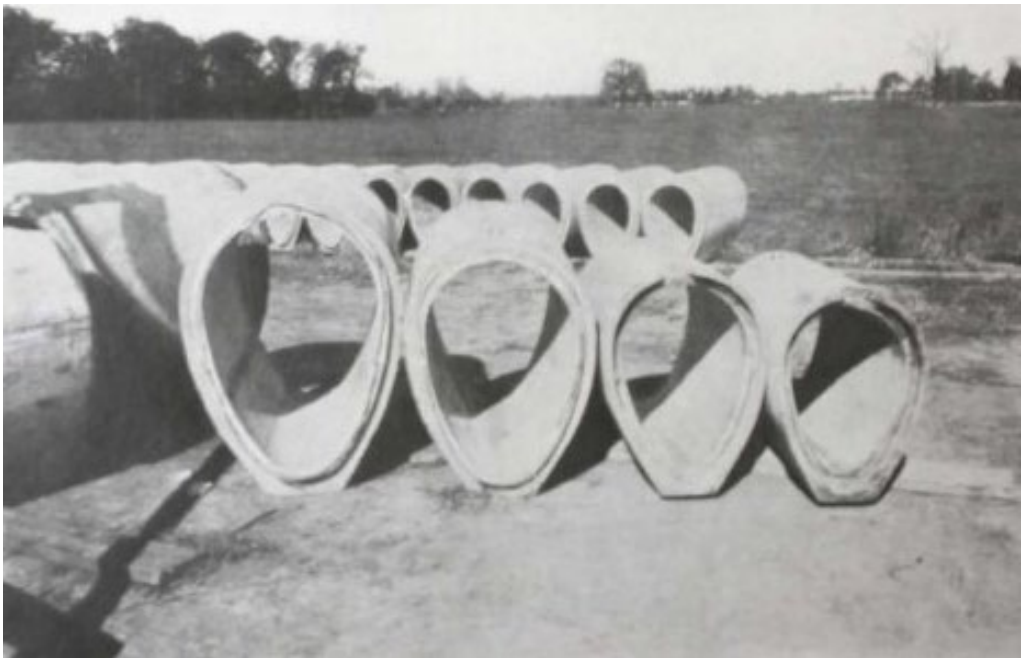

Figure 16. Egg-shaped Reinforced Concrete Pipe Sections
Source: Lock Joint Pipe Company, "Lock Joint" Reinforced Concrete Pipe, (New York: Lock Joint Pipe Company, 1918).

[69] Ogden, *Sewer Construction*, 8, 10, 11, 22.
[70] Lock Joint Pipe Company, "*Lock Joint" Reinforced Concrete Pipe*, (New York: Lock Joint Pipe Company, 1918).

During the mid-to-late nineteenth century, concrete and brick were sometimes used together, with one material being used for the invert and the other for the arch of a sewer pipe, or the interior of a concrete pipe would be completely lined with brick.[71] In the twentieth century, as concrete technology improved and became less expensive, these practices became less common.[72] Reinforced concrete, in which steel or other materials are included as mesh or rods in the concrete, was invented in 1854 but was not used for water pipes until 1905 (Figure 17).[73] Asbestos cement pipe, in which asbestos fibers are mixed with cement to give the pipes a high bursting strength and corrosion resistance, was first used in the United States in 1931 and patented in 1942.[74]

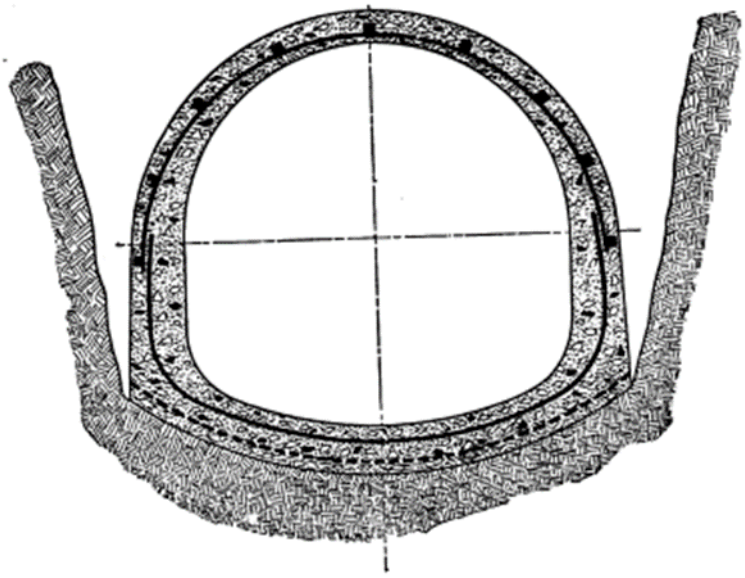

Figure 17. Reinforced Concrete Conduit used by the Jersey City Water Supply Company
Source: Henry N. Ogden, Sewer Construction, (New York: John Wiley & Sons, 1908), 81.

[71] Metcalf and Eddy, *American Sewerage Practice,* 16; Ogden, *Sewer Construction*; Jon C. Schladweiler, "Early American Sewerage Engineers Part 4," *Sewer History*, 2004; H.W. Shimer, "Equipment and Methods Employed in Building Sewers in San Francisco, Calif,." *Municipal and County Engineering* 56, No. 4 (1919):136-140.
[72] Ogden, *Sewer Construction*, 68.
[73] J.G. MacGregor et al., *Reinforced Concrete: Mechanics and Design*, Vol. 3, (Upper Saddle River: Prentis Hall, 1997), 5.
[74] Arthur B. Christopher, Asbestos-Cement Pipe, United States of America Patent 2,269,436, January 13, 1942, 1.

The earliest use of concrete pipe in the United States is thought to be a 6-inch pipe in Mohawk, New York, that transported domestic sewage from the Francis E. Spinner House to the Erie Canal in 1842.[75] Concrete pipes were installed in Brooklyn's municipal system by 1861 and a single concrete or cement pipe built as an extension of a brick sewer was constructed in Hoboken in 1867.[76] D.E. McComb pioneered the use of concrete for large sewers in the Washington, D.C. sewer system beginning in 1883. Several cities, including Duluth and St. Paul, Minnesota, Milwaukee, Wisconsin, and Pawtucket, Rhode Island used concrete for at least some of their sewers in the late nineteenth and early twentieth centuries, and Trenton installed its first concrete sewers in 1903.[77] The 1907 Camden Line Ditch sewer is a perhaps unique example of a sewer that incorporated concrete, brick, stone, and timber in its construction.[78]

San Francisco abandoned all-brick sewers in the early twentieth century and used vitrified salt-glazed ironstone for pipes between 8 inches and 24 inches, and concrete for larger pipes. Their concrete sewers were poured in place with steel reinforcing rods as needed, and a vitrified brick lining was installed in the invert. A vitrified clay underdrain pipe was installed underneath the concrete pipe in wet environments. Standard sewer shapes were circular, egg-shaped, and egg-shaped but with a flat slab top, but other shapes, such as horseshoe, were also used.[79] By 1918, over 400 American and Canadian municipalities were constructing concrete sewers; New Jersey locations included Atlantic City, Ampere, Bayonne, Belleville, Bloomfield, Crafton,

[75] Hill and Griffith Company, "Concrete Casting News from the Hill and Griffith Company: Concrete Pipe – Its History and Production," 2016.
[76] Portland Cement Association, "Concrete Sewers," (Portland Cement Association, 1918), 4; Laura Cushman et al., *Archaeological Monitoring, North Hudson Sewerage Authority, Grand Street Combined Sewer Rehabilitation, City of Hoboken, Hudson County, New Jersey*, (RGA, Inc., 2015), 3-1.
[77] A. Grant Lee, "Century concrete pipe does exist," *Canadian Concrete Pipe Association*, (n.d.); G.M. Wood, "The future and the present of concrete pipe," *Cement and Engineering News* 28 (1916): 231-233; Stephen Israel, *Report on the Identification of the Historic and Prehistoric Cultural Resources Along Lamberton Street Southerly of Cass Street, Trenton, Mercer County New Jersey: An Assessment Study for the Plan of Action*, (1976), 8.
[78] "Passing of Line Ditch in South Camden Means Much to that City," *Philadelphia Inquirer*.
[79] Shimer, "Equipment and Methods Employed in Building Sewers in San Francisco, Calif."

Clifton, Commission, East Orange, Irvington, Jersey City, Marion, Millburn, Montclair, Newark, Paterson, and Perth Amboy.[80]

Cast Iron Pipe Sewers

After first being used at Versailles, France in the mid-1600s, cast iron pipes were used for water distribution in some cities in the mid-1700s. In the first decades of the 1800s, the city of Philadelphia switched its drinking water system from wood to cast iron, and other cities soon followed.[81] Widespread use of cast iron in sewer systems came later. In the nineteenth century, it was used for smaller pipes in areas of high pressure and in shifting environments like sand or under water.[82] In situations along a sewer line in which a siphon was required, wrought iron or cast iron pipes, which could be made airtight, were recommended even if a different material was used for the rest of the sewer line.[83]

The diameter of cast iron pipes can range from 4 inches to 60 inches in the United States (Figure 18). They are almost always circular and are joined together by a bell and spigot joint, bolted together with internal flanges at the joints, or held together by poured hot lead. The pipes can also curve, which is achieved by resting straight pipes on bent railroad lines, heating the pipes, and then letting them settle into shape under their own weight. Cast iron pipes can be lined with tar or cement to protect them from corrosion. [84]

[80] Portland Cement Association, "Concrete Sewers."; Per John F. Snyder's *The Story of New Jersey's Civil Boundaries, 1606-1968* there was only one town with the word commission in their name at the time of the Portland Cement Association's "Concrete Sewers" publication: Hackensack Commission.
[81] Jon C. Schladweiler, "Pipes – ancient/early types (1)," *Sewer History*, 2004.
[82] Folwell, *Sewerage*, 141; Jay N.Meegoda et al., *Culvert Information Management System – Demonstration Project. New Jersey Institute of Technology,* Report No. FHWA-NJ-2009-017, 2009, 5.
[83] Ogden, *Sewer Construction*, 133.
[84] J.F. Springer, "Iron and Steel Sewer Pipe," *Municipal Engineering LI*, no. 3 (1916): 87; Folwell, *Sewerage*, 141; Rafter and Baker, *Sewage Disposal in the United States*, 359; Springer, "Iron and Steel Sewer Pipe," 87.

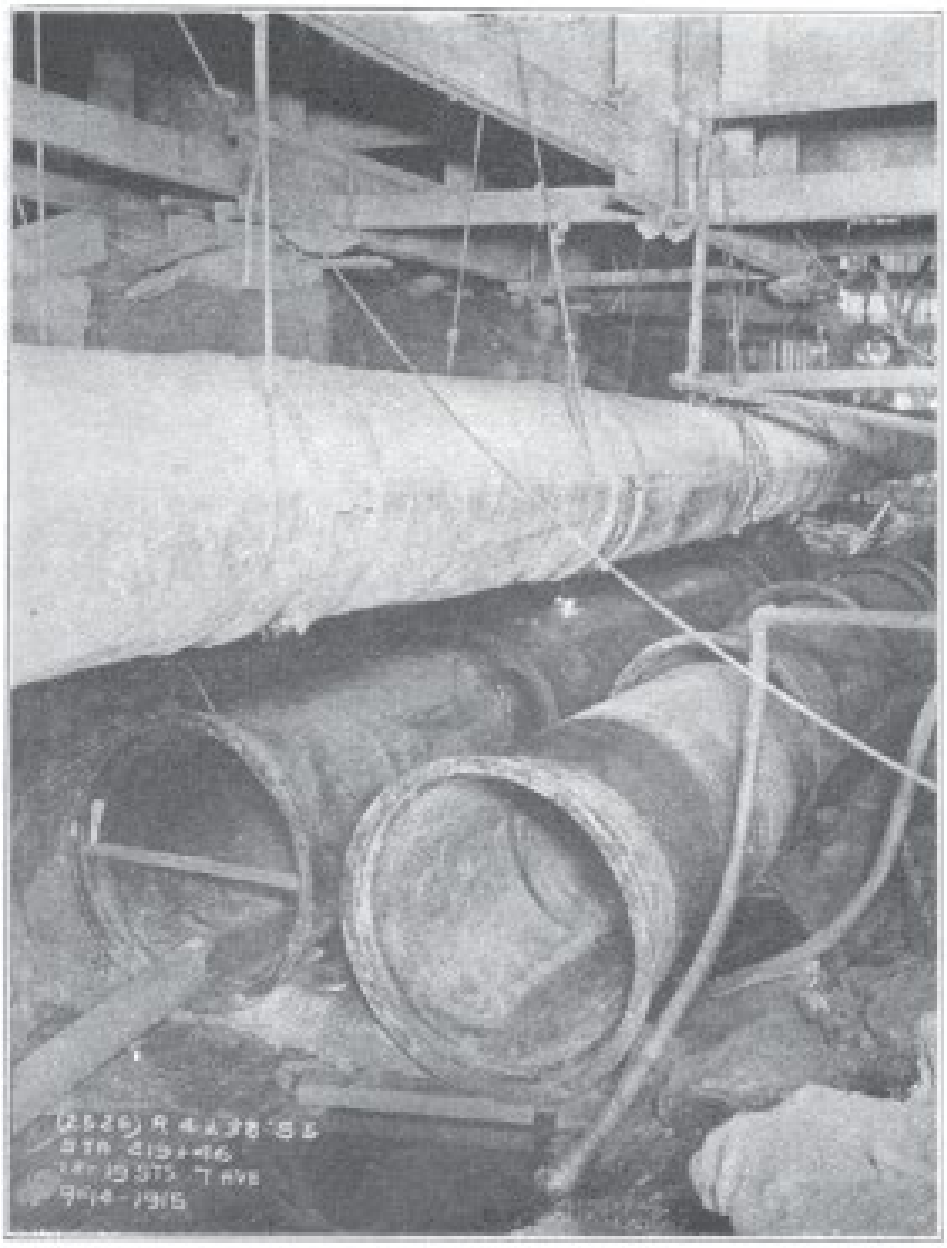

Figure 18. Cast Iron Sewers
Source: J.F. Springer, "Iron and Steel Sewer Pipe" (Municipal Engineering LI, no. 3, 1916), 89.

Other Materials

Corrugated steel pipe for general construction was first introduced in 1896. Steel sewers are usually thin, much lighter than their cast iron counterparts, and may be lined with cement.

They are more likely to be used in culverts and similar structures, rather than as sewer pipes, although Jersey City used steel for a 6-foot diameter sewer.[85]

Wood fiber pipes, more commonly known as Orangeburg pipe after its primary manufacturer, were invented in the middle of the nineteenth century. They were primarily used for electrical conduits until the end of World War II, when they were marketed for sewers and drainpipe in houses.[86]

Polyvinyl chloride (PVC), a synthetic plastic polymer, was discovered in the nineteenth century but not used for pipes until 1932 in Germany. Beginning in the 1950s, PVC and other types of plastic were used for pipes in the United States and have increasingly been incorporated into sewage systems.[87]

Construction Nuances: Shapes and Slopes

Many factors impact the longevity of the sewer pipe, including the materials, shapes, sizes, and slopes of pipe construction. Much of the period of construction for this study was also a period in which these construction method nuances were being formalized.

Materials directly correlated with the shapes and sizes of pipes that could be produced. Brick and concrete provided greater flexibility in producing unique shapes, including circular, egg, oval, etc., whereas many terra cotta pipes were circular in form. Materials also had to be considered for their economic viability when constructing the sewer system of an entire city.

[85] Jay N. Meegoda et al., *Culvert Information Management System*, 5; Springer, "Iron and Steel Sewer Pipe," 88.
[86] Philip P. Gray and Ernest E. Werle, Method of Impregnating Porous Materials, United States of America Patent 1,930,646, October 17, 1933, 1.
[87] Robert Walker, "The Early History of PVC Pipe," *Uni-Bell PVS Pipe News*, 1990, 1-2.

Producing a circular brick sewer, rather than an elliptical brick sewer, was considered to be the most economical.[88]

Metcalf and Eddy suggest that arch construction was equally nuanced. The gothic, the parabolic, and the semi-elliptical arches were stronger at supporting loads than the circular arch. Initially, masonry arch construction was informed by a cursory understanding of the stresses on arches. As reinforced concrete sewers were used with a greater frequency, designers and engineers invested effort into understanding the stresses in the pipe. By the early 1900s, plain concrete arches gained popularity over masonry arches because it was thought to better respond to changing stresses because of the perceived elasticity of the material.[89]

Brick construction was further nuanced by the bond pattern. There are three major types: all the bricks are laid as stretchers (running bond); a mix in which the bricks are laid as a combination of stretchers and headers (common or American bond, Flemish bond, English bond, or Dutch bond); and, where the masonry has been divided into blocks and stacked (stack bond) (Figure 19).[90]

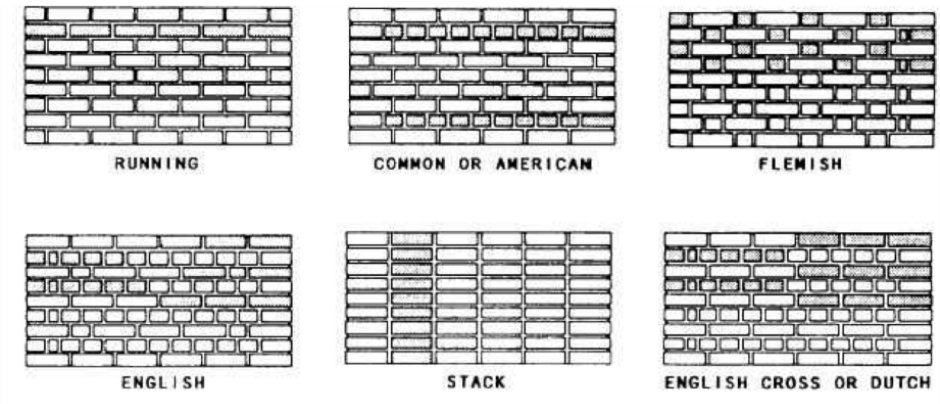

Figure 19. Popular Brick Bonds
Source: Integrated Publishing, "Builder 3&2 Volume 1."
http://constructionmanuals.tpub.com/14043/css/Figure-8-33-Types-of-masonry-bonds-234.htm

[88] Metcalf and Eddy, *Sewerage and Sewage Disposal*, 255.
[89] Ibid., 255, 261, 263, 265.
[90] Ibid., 264.

Once the brick was laid on the mortar, the joint would be made flush with the brick in order to ensure that the interior surface of the pipe would be smooth. If the joint was not done correctly or had deteriorated, the joint would be pointed, a process by which the joint would be filled in again to ensure that it was flush. Other nuances in brick laying include thickness of the joints, which should be no more than 1/2-inch, usually between 1/4-inch to 3/8-inch. Variations are also seen in the manner in which the brick has been laid into a mortar bed to adhere it.[91]

The main cause for cracks is the loose and improper filling, backfill, around the pipe and the trench.[92] Metcalf and Eddy state that it would be "practically impossible" to press the soil so firmly that it would not shift the pipe.[93] In their analysis, if the horizontal diameter of the pipe lengthened by 0.04-inch under the vertical loading, then the pipe would crack or break. The surrounding ground is incredibly important to the structural integrity of the pipe, as once the ground is unable to provide support, damage to the pipe is likely.[94] In Camden, Rule 5 of the Plumbers' Code addresses the importance of proper compaction of soil, noting that both the bottom of the trench must be graded and compacted, and as the trench is filled up after the installation of the pipe, the compactness of the filled in soil must match the original compactness.[95]

Other factors which impact longevity and survivability include slope and ground soil. Specifications for slope and soil were laid out in the Plumbers' Code of 1899, which was part of Camden's Ordinances and covered private line to main sewer line connection. Rule 6 of the Code states that in instances where the ground is freshly filled in, the pipes must be of extra-heavy

[91] Metcalf and Eddy, *Sewerage and Sewage Disposal*, 266.
[92] Ibid., 267.
[93] Ibid., 237.
[94] J.P. Davies et al., "Factors influencing the structural deterioration and collapse of rigid sewer pipes," *Urban Water* 3 (2001): 75.
[95] City of Camden, *Compiled and Revised Ordinances of the City of Camden*, 625.

cast iron. Rule 7, which appears to cover the common types of soil found in Camden, states that when the soil is naturally loam, sand, or rock, the pipe "may be" of a cylindrical earthenware pipe. Rule 8 states that the slope must be 1/8-inch to the foot.[96] Per an 1884 report by Onan B. Gross, the Special Sanitary Inspector for Camden, the north-south streets have favorable inclines for the sewer lines, particularly along shorter lengths.[97]

A 2008 study of historic brick and concrete sewers in Leuven, Belgium, explored different causations for failure, particularly material, slope, and age. The study concluded that reinforced concrete sewers have a slightly higher probability of survival over brick sewers of the same age; off-site production of concrete pipes in the controlled factory environment typically aged better than brick sewers, which are constructed in situ.[98] The study divided slopes as either flat (having a slope equal to or less than 1%) or steep (having a slope greater than 1%), wherein there was no noticeable difference in survival probability regardless of slope; the only change was based on age and material.[99] Their data contradicted previous studies that have shown that flatter slopes are prone to damage due to the buildup of sediment deposit and corrosion due to hydrogen sulfide generation. Considering that Camden's sewers' connections had flatter slopes, it would be interesting to study the slopes of the collapsed sewers, their materials, and their age in order to model survivability. It is likely that Camden's sewers over the age of seventy-five years, with a slope greater than 1% might need to be immediately surveyed for their condition; however, the study in Leuwen would need to be replicated in Camden to verify or refute its claim, particularly because it demonstrated the inverse of prior studies.

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[96] City of Camden, *Compiled and Revised Ordinances of the City of Camden*, (Camden: R.H. Freeman & Co., Printers, 1907), 625.
[97] Onan B. Gross, *Report of Special Sanitary Inspector for Camden, N.J., as made to the New Jersey Board of Health*, (Trenton: John L. Murphy, State Printer, 1884), 18.
[98] E. Ana et al., "Investigating the effects of specific sewer attributes on sewer ageing - a Belgian case study," *11th International Conference on Urban Drainage*, (Edinburgh, Scotland, 2008), 5.
[99] Ana et al., "Investigating the effects of specific sewer attributes on sewer ageing," 5.

4. Contextualizing Camden

Geographic Context

The City of Camden is located on the Delaware River, which bounds the city (Figure 20).

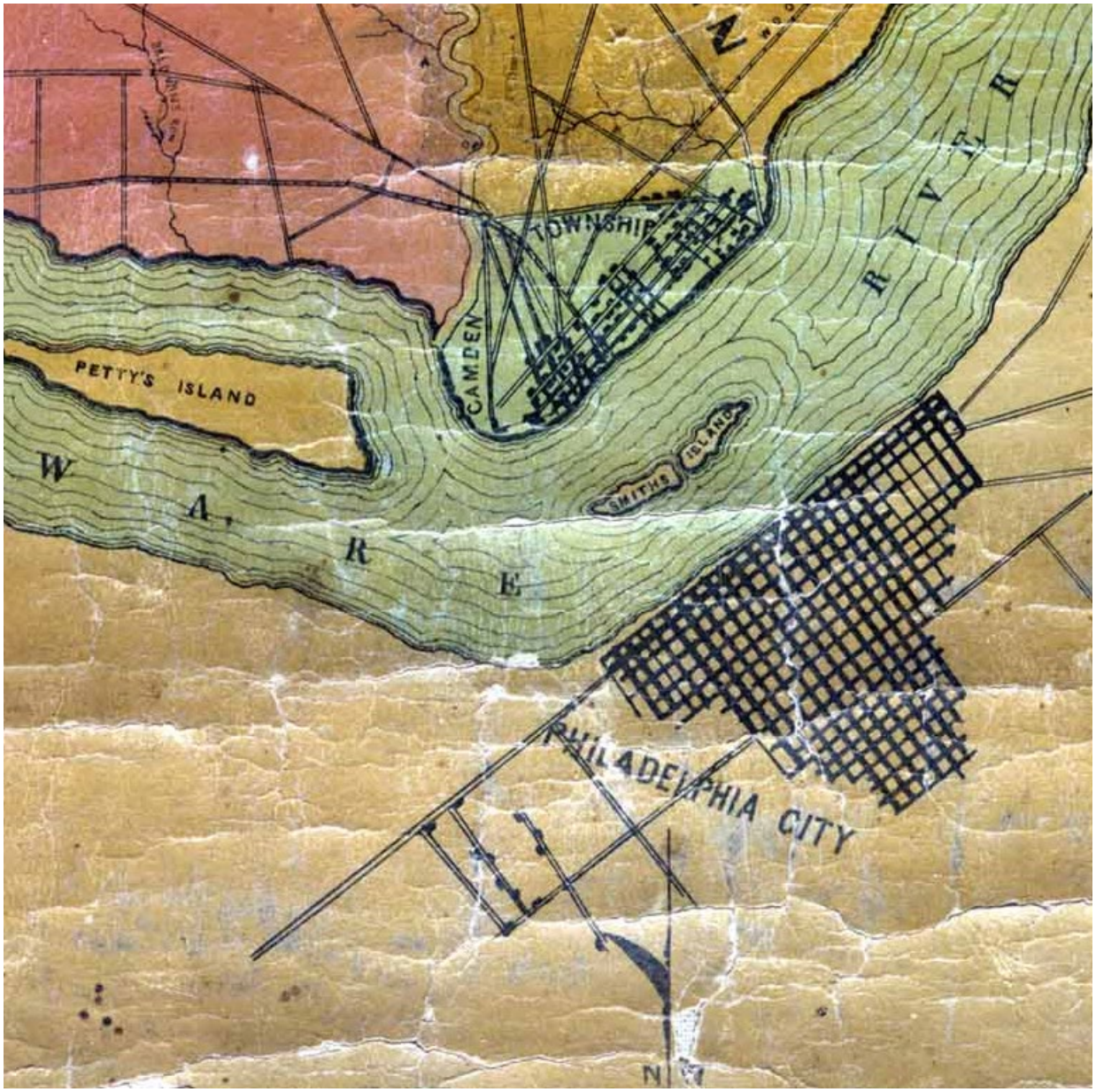

Figure 20. Close up of A Map of Camden County (1846). Scale not available.
Source: John Clement, Jr., A Map of Camden County, State of New Jersey (1846).
http://mapmaker.rutgers.edu/CAMDEN_COUNTY/CamdenCounty_1846.jpg

Cooper's Creek and Little Newton Creek, locally known as Line Ditch, are both tributaries of the Delaware River (Figure 21). Little Newton Creek runs along the southern edge of the city, and Cooper's Creek was once the eastern boundary.

Figure 21. Close up of A Topographical Map of the Vicinity of Camden. Scale not available.
Source: George H. Cook and C.C. Vermeule, A Topographical Map of the Vicinity of Camden (Geologic Survey of New Jersey, 1888).
https://libimages1.princeton.edu/loris/figgy_prod/15%2F76%2F74%2F157674f02b8f4229b27ce2fd768e4c21%2Fintermediate_file.jp2/full/full/0/default.jpg

Nearby cities like Philadelphia, located directly across the river, and New York, located to the north, were both major commercial and trading centers that were instrumental to Camden's growth.

Figure 22. Soil Map of Camden. Scale not given.
Source: NRCS SoilWeb. https://casoilresource.lawr.ucdavis.edu/gmap/

The soil in Camden is classified as UR, Urban land (Figure 22). Per the Natural Resources Conservation Service (NRCS), surfaces in areas classified as UR are covered by buildings, concrete, pavement, and other structures that cover disturbed and natural soil material.

Historic Context

The Dutch West India Company, chartered in 1621, settled a colony in the area around present-day Camden in 1622.[100] In 1626, the Dutch constructed Fort Nassau along the Delaware River, in present-day Gloucester County, to be used as a trading port. Fort Nassau was in use until 1651, when it was dismantled by the Dutch. Shortly after, in 1664, the English took control of the Delaware River and began settling along the river. *The Concession and Agreement of the Lord Proprietors*, which promised religious freedom to anyone who settled in New Jersey, enticed Quakers who were escaping religious persecution in England to come to New Jersey.

One of the earliest Quaker settlers in Camden was William Cooper in 1677.[101] Other settlers included Richard Arnold, Archibald Mickle, Thomas Sharp, and John Kaighn. Much of Camden's early history and land ownership is connected to the Coopers, who owned land north of Line Street, the Mickles, who owned the land from Line Ditch to Newton Creek, and the Kaighns, who owned the land between Line Street and Little Newton Creek.

In 1679, William Cooper built Pyne Point plantation, which was to be both his abode and a meeting place for the other Quaker settlers.[102] The Quakers were influential in the development of the region; Willian Penn established the Pennsylvania Colony and the city of Philadelphia in 1682. The establishment of Philadelphia is significant to Camden's development, as Philadelphia attracted trade from West Jersey and hastened the charter of a ferry connecting Camden and Philadelphia in 1688.

[100] Boyer, *The Civil and Political History of Camden County and Camden City*, 3.
[101] Pennington and Schopp, *Stage IA Cultural Resources Survey*, 6-4.
[102] Cooper, *Historical Sketch of Camden*, 11.

Developing a city and a ferry system

In 1688, William Royden was granted the license to launch a ferry to connect Camden and Philadelphia, which was most likely located at Cooper Street.[103] Eventually, Royden left the ferry business, which was then taken over by the Coopers. By 1715, Daniel Cooper was operating two ferry boats, considered sufficient for the population at the time, and most likely supplemented by personal conveyances.[104] The importance of transportation to Philadelphia led to the construction of another ferry site in 1747 at Federal Street; this ferry was used to pass Cooper's Creek.[105] Eventually, the ferry connection between the east and west side of Camden was replaced by a bridge. Over the years additional ferry landings came to be located at Cooper's Point, Market Street, Plumb Avenue, and Kaighn's Avenue, and near Federal Street (Figure 23).[106]

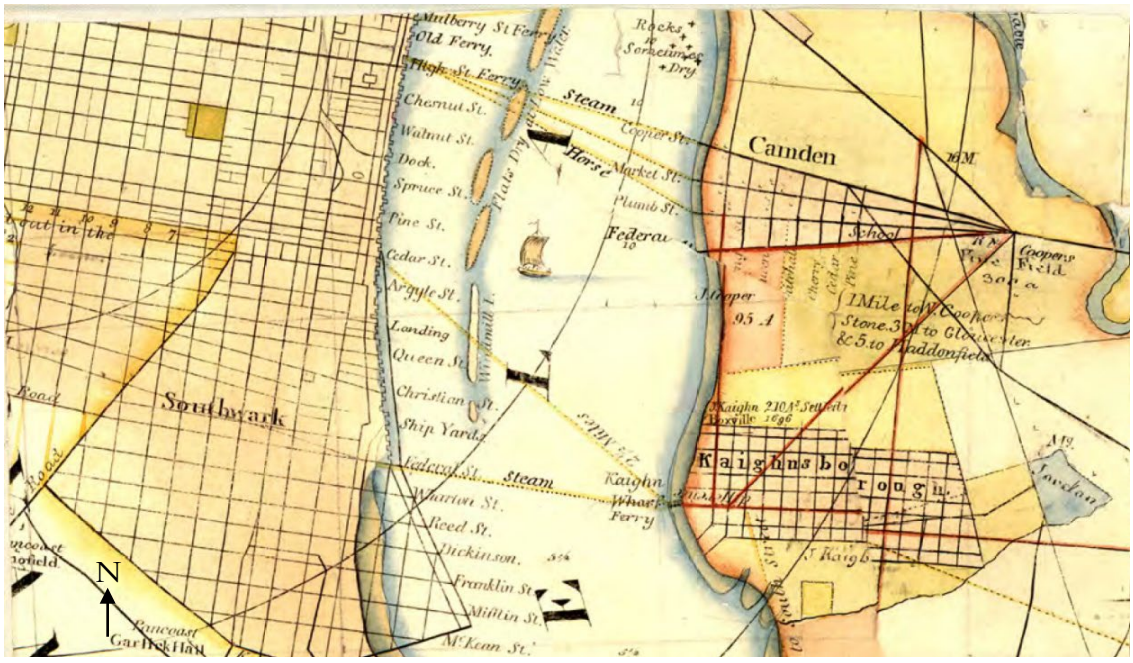

Figure 23. Close up of SE Corner of A Plan of the City of Philadelphia and Environs. Scale not available. Source: John Hills, Hill's Record & Historical Map or A Plan of the City of Philadelphia and Environs (1810). http://www.phmc.state.pa.us/bah/dam/mg/di/m011/PDFs/m011Map0106_4.pdf

[103] Charles S. Boyer, *Annals of Camden, No. 3, Old Ferries, Camden, NJ*, (Privately printed, 1921), 3, 13.
[104] George R. Prowell, *The History of Camden County, New Jersey*, (Philadelphia: L.J. Richards & Co., 1886), 364.
[105] Cooper, *Historical Sketch of Camden*, 15.
[106] Ibid., 10.

Small communities developed around the ferry landings, including Kaighnton at Kaighn's Point and Camden Village around the Federal Street Ferry. In 1809, two more steamboats were added to Camden's inventory.[107] By 1828, twelve steam ferry boats were on the river, and by 1843, there were fourteen steam ferry boats.[108]

Camden's growth as a suburb of Philadelphia can be attributed to the sale and purchase of empty lots in Camden to Philadelphia businessmen. In 1764, Jacob Cooper received 100 acres of land from his father William. Jacob envisioned Camden as a commuter town and divided the land into lots to be sold to the businessmen who worked across the river.[109] A majority of Jacob's 127 lots were sold to Philadelphians.[110] Though Camden existed as an assembly of small communities around the many ferry landings, the town limits would be regularly extended into the early nineteenth century, transforming an agricultural city into a commercial and industrial city.[111] In 1809, Kaighnton sprung up at the Kaighn's Point Ferry, and in 1820, Edward Sharp developed "Camden Village" within the vicinity of Federal Street Ferry (Figure 24). These ferry-centric settlements would be bound and incorporated into the Town of Camden in 1828, with a population of 1,143.[112] Camden was bounded by the Delaware River, from the mouth of Cooper's Creek to the mouth of Line Ditch, then to the east side of Broadway, then to the east side of Newton Avenue, to the south side of Federal Street, to the middle of Cooper's Creek, and then to the Delaware River.[113]

[107] Cooper, *Historical Sketch of Camden*, 30.
[108] Prowell, *The History of Camden County, New Jersey*, 366.
[109] Boyer, *The Civil and Political History of Camden County and Camden City*, 29.
[110] Pennington and Schopp, *Stage IA Cultural Resources Survey*, 6-4.
[111] Boyer, *The Civil and Political History of Camden County and Camden City*, 31-32.
[112] Ibid., 37.
[113] Cooper, *Historical Sketch of Camden*, 36.

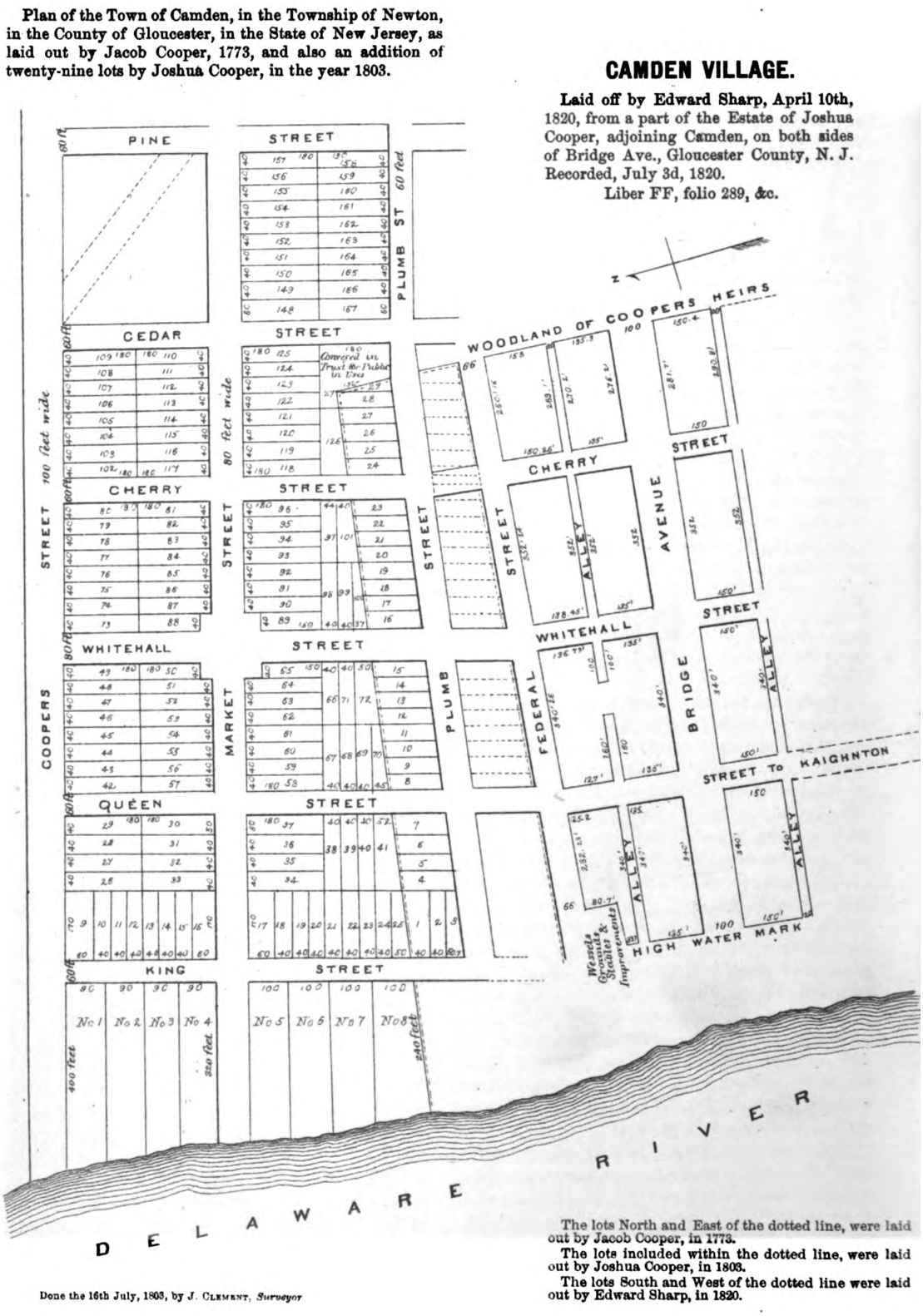

Figure 24. Camden Village (1803). Scale not given.
Source: George R. Prowell, The History of Camden County, (Philadelphia: LJ Richards & Co., 1886), 418-419.

Richard Fetters, a prominent Camden businessman, purchased lots in South Camden from the Kaighn family, which he offered for sale in 1833; the area came to be known as Fettersville. Lots north of Cooper Street, owned by Richard M. Cooper, remained farmland until 1842. As farmland, the plot was untaxed and generated substantial revenue, especially since Richard M. Cooper was not receptive to selling the land to non-Coopers or converting it for any other purpose. Following his death and the collapse of the United States Bank in 1842, the plot went to his son William, who divided the land into building lots and sold them. The proximity of these lots to the Cooper's Point Ferry made them attractive to commuters to Philadelphia.[114]

Early industrial activity, though limited, took place near the ferry terminals during the late eighteenth and into the early nineteenth century. There was a nailery on Third Street and smitheries could be found near the ferry terminals at the close of the eighteenth century. Prior to that, timber was a developing industry, with timber rafts navigated downriver from the upper Delaware as early as 1765. Camden's waterfront developed into a site for processing, building, and storing, with the first known sawmill established in Camden in 1822 by William Carman. The wood processed in Camden was used in the shipyards, which sprung up in Camden during the 1840s.[115]

The industrial activity in the vicinity of the ferry terminals would be a boon to the railroads. The Camden & Amboy Railroad chartered in 1830, with construction completed in 1834, connected to the ferry terminus to carry its passengers onwards to Philadelphia.[116] The 1834 construction associated with the Camden and Amboy Railroad led to infilling the shoreline to create new acreage to be used for railyards, ferry terminals, and industrial activity that the railroads

[114] Boyer, *The Civil and Political History of Camden County and Camden City*, 32, 33; Cooper, *Historical Sketch of Camden*, 15.
[115] Pennington and Schopp, *Stage IA Cultural Resources Survey,* 6-5.
[116] Prowell, *The History of Camden County, New Jersey*, 349-351.

could fulfill. The 1865 map of Camden's riverfront marks the original high and low water lines from 1832 and their present locations in 1865, now farther out into the Delaware River (Figure 25).

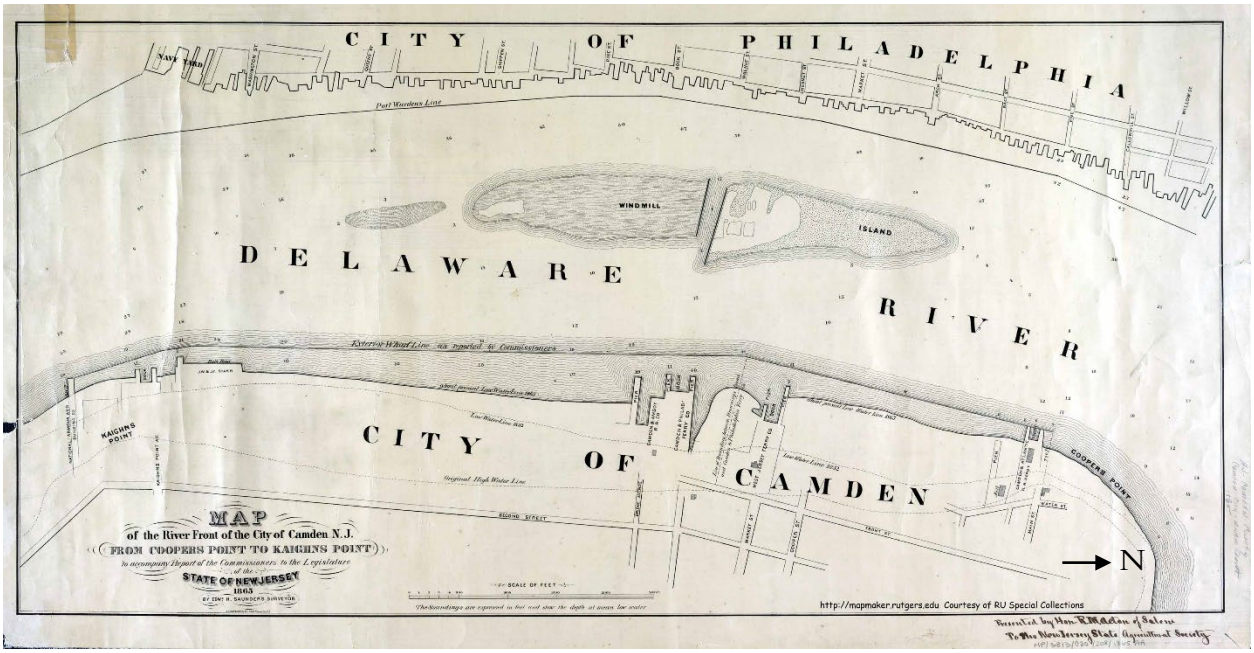

Figure 25. Map of the River Front of the City of Camden, N.J., from Cooper's Point to Kaighn's Point (1865). Source: Edward H. Saunders, Map of the River Front of the City of Camden, N.J., (1865). mapmaker.rutgers.edu/CAMDEN_COUNTY/DelRivCityofCamden_1865.jpg

Industrial and Population Boom

Prowell defined the growth of the City of Camden as being "slow but sure."[117] With the Camden and Amboy Railroad, Camden became the convergence point for the rail and ferry lines that connected New Jersey and Pennsylvania. The connection to Philadelphia was beneficial because the city was a key trading center and a supplier of anthracite coal, which was the primary fuel used in the manufacturing industry at the time. Much of Camden's industry was located along the Delaware River or the Cooper River (Figure 26).

[117] Prowell, *The History of Camden County, New Jersey*, 403.

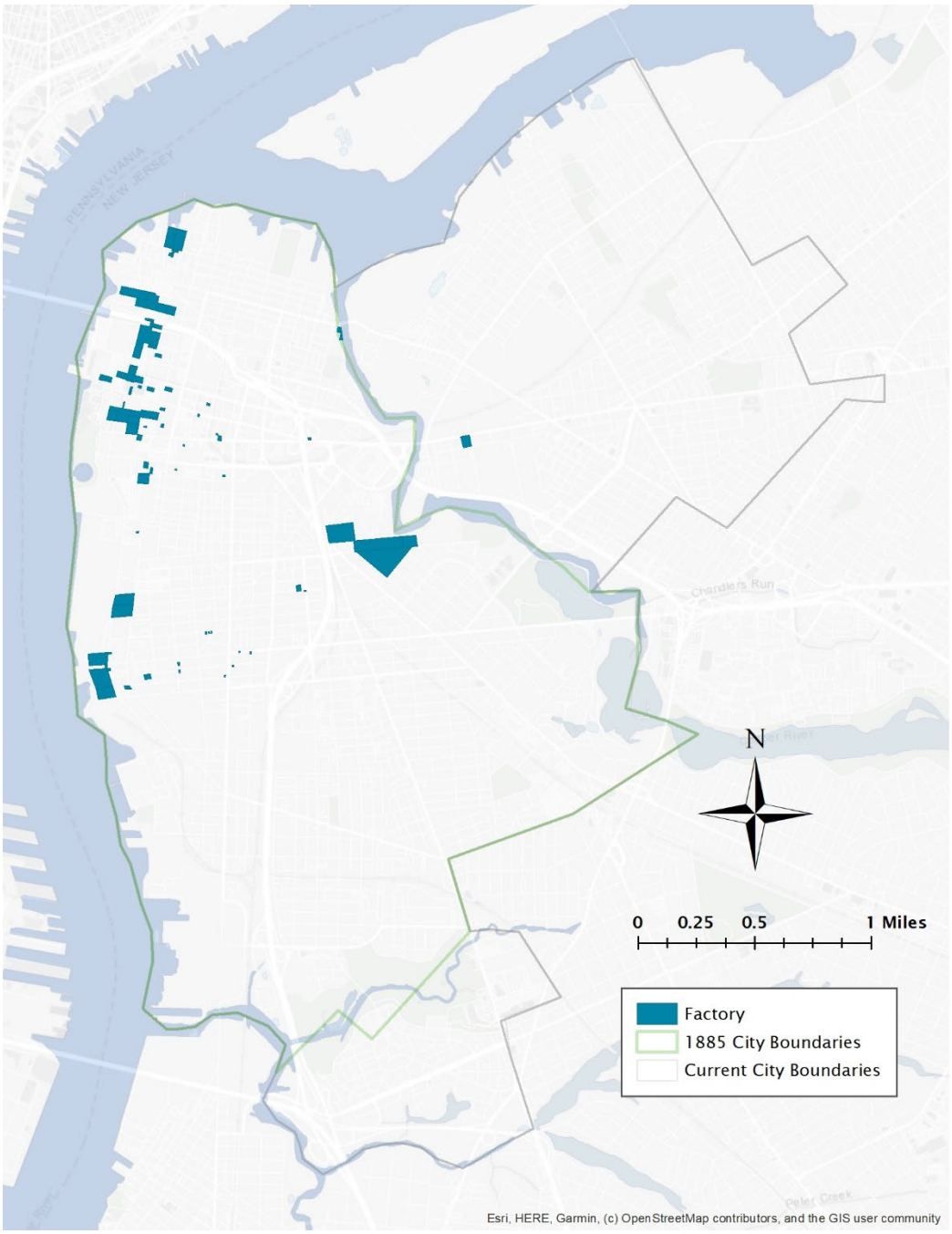

Figure 26. Map of Camden's Industries, in 1885.
Data sourced from 1885 Sanborn Maps of the City of Camden, Sheets 2-23.

There were many different manufacturing establishments to be found in Camden. The following is by no means a complete catalog of all the manufacturing activity in Camden.

Cooper River was the site of some of the earliest chemical industry in Camden. It started with William Fleming who produced oxides of cobalt, nickel, metallic nickel, and hydrate of copper. Sassakon Chemical Works set up a factory along the river, shortly after Fleming. Fleming's company passed hands to Buck, Simonin & Co, who later sold the works to Moro Philips. From 1861 to 1905, Joseph Wharton's American Nickel Refinery could be found on the banks of the Cooper River.[118]

The Esterbrook Steel Pen Company was established in Camden in 1860 and was one of the first of its kind within the country (Figure 27). Still, two decades after its establishment, there were only two or three other steel pen makers in the country. The steel came in from Sheffield, England, and was transformed into pens and nibs at the Camden factory.[119]

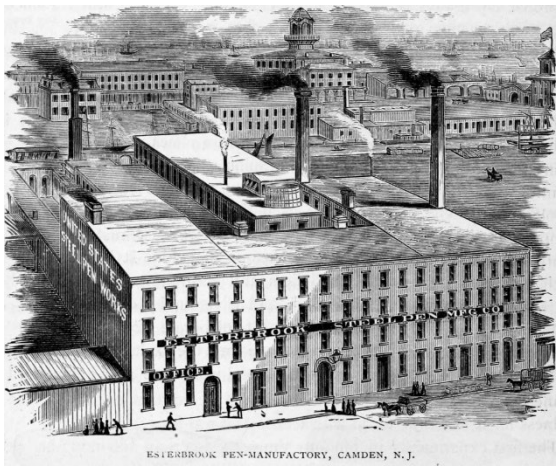

Figure 27. Esterbrook Steel Pen Company
Source: Albert S. Bolles, Industrial History of the United States *2nd ed. (New York: Augustus M. Kelley, Publishers, 1966), 344.*

Woolen and worsted mills were a significant part of Camden's industry. Established in 1863, Furbush & Gage was a manufacturer of machinery used in woolen mills. From its inception the company provided employment to three hundred people. In 1869, following internal restructuring the company was renamed M.A. Furbush & Son Machine Co. The Camden

[118] Pennington and Schopp, *Stage IA Cultural Resources Survey,* 6-6.
[119] Prowell, *The History of Camden County, New Jersey*, 61.

Woolen Mills Company had been operating woolen mills since 1863, and the company was organized in 1882.[120]

The Joseph Campbell & Co, established in 1876 and known for Campbell's soups, was the result of a merger between the Anderson Canning Company, established in 1867, and Joseph Campbell (Figure 28).[121] In 1897, Campbell introduced their eponymous Campbell's condensed soup cans. The soup cans were a financial boon to the company; the company was able to ride out economic depressions because people purchased the condensed soup cans as it was an affordable yet filling meal.[122]

Figure 28. Campbell's Soup Company, Camden, New Jersey
Source: The Encyclopedia of Greater Philadelphia, Campbell Soup Factory Towers (1980).
https://philadelphiaencyclopedia.org/wp-content/uploads/2013/05/Campbell-Soup-Factory-Towers.jpg

[120] Prowell, *The History of Camden County, New Jersey*, 508, 524.
[121] Ibid., 537.
[122] Cranston, *Camden County, 1681-1931,* 68.

Another major industry in Camden was leather work. The Keystone Leather Company established a factory in Camden in 1895. The company was located on the Cooper River and had its own wharfage. The plant covered nearly ten acres and occupied three city blocks.[123]

Continuing the tradition of shipbuilding from Camden's early industrial history, the New York Shipbuilding Corporation was established in South Camden in 1899 (Figure 29).[124] The Company continued to use the site until 1967.[125]

Figure 29. New York Shipbuilding Corporation's Camden Factory
Source: Unknown, Postcard Images of Camden, NJ (ca. 1960s).
http://www.dvrbs.com/Postcards/CamdenPostcards/Postcard353-Nyship-b.jpg

The Victor Talking Machine Co. opened its doors in 1894, and by 1901 was associated with the tagline "His Master's Voice." By the time it was purchased by RCA in 1929, the plant

[123] Cranston, *Camden County, 1681-1931,* 73.
[124] Ibid., 57.
[125] Pennington and Schopp, *Stage IA Cultural Resources Survey,* 6-7.

had thirty-eight buildings with its own water system and spanned fifty-one acres along the Camden waterfront (Figure 30).[126]

Figure 30. Victor Talking Machine Co., Camden, NJ, prior to 1929.
Source: Unknown, Postcard Images of Camden, NJ.
http://www.dvrbs.com/postcards/CamdenPostcards/Postcard163-Victor-1b.jpg

By 1910, Camden's major industries, measured solely by the value of products produced, were tanning, currying and finishing of leather, followed very closely by shipbuilding, tertiary industries including manufacturing of phonographs and graphophones, foundry and machine-shop products, and woolen and worsted goods.[127]

[126] Pennington and Schopp, *Stage IA Cultural Resources Survey,* 6-7.
[127] U.S. Department of the Interior, Census Office, *Thirteenth Census of the United States Taken in the Year 1910, Volume III, Manufactures, 1909, General Report and Analysis, (*Washington, D.C.: Government Printing Office, 1913), 749.

Census Data on the Industrial and Population Booms

Camden County was formed from parts of Gloucester County, on March 13, 1844. Census data for both the City of Camden and Camden County have been available from the 1850s onwards.[128] Along with population, a tally of manufacturing establishments was also conducted. As part of this, the definition of a "manufacturing establishment" was regularly revised. Between 1900 and 1910, the definition was revised to exclude all neighborhood, household, and hand industries, only including factories with a value of products greater than $500.[129] Between 1920 and 1930, the Census raised the minimum product value required to be considered a manufacturing establishment from $500 to $5,000.[130] The total number of manufacturing establishments in Camden for the period of study rose, dropped following the revision of the definition of "manufacturing establishments," and then fluctuated minimally (Figure 31).

[128] John P. Snyder, "The Story of New Jersey's Civil Boundaries 1606-1968," Trenton: New Jersey Geological Survey, Reprinted, originally published 1969, Bulletin No. 67, Bureau of Geology and Topography, Trenton, 2004, 38.
[129] U.S. Department of the Interior, Census Office, *Thirteenth Census of the United States Taken in the Year 1910, Volume III, Manufactures, 1909, General Report and* Analysis, (Washington, D.C.: Government Printing Office, 1913), 19.
[130] U.S. Department of the Interior, Bureau of the Census, *Census of Manufactures: 1929* (Washington, D.C.: Government Printing Office, 1930), 3.

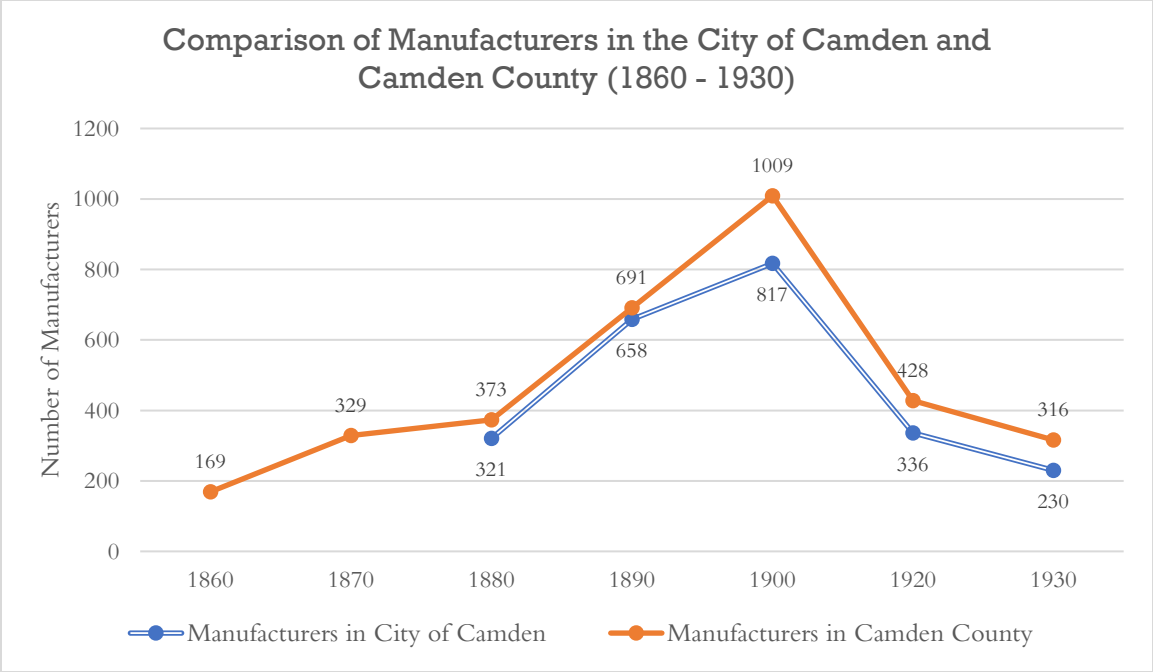

Figure 31. Comparison of Manufacturers in the City of Camden and Camden County (1860 - 1930)
Data sourced from United States Census data from 1860-1930

Camden's industry contributed to the Civil War efforts, which resulted in the manufacturing industry of the county doubling between 1860 and 1870. Additionally, the Panic of 1873, which sent the country into a depression, did not negatively impact the growth in the number of manufacturers in Camden County. In 1890, the City of Camden had 95% of the total manufacturing establishments in Camden County. After 1890, the percentage of manufacturing establishments in the City of Camden compared to Camden County dropped. The peak in the number of manufacturing establishments in 1900 is attributed to the inclusion of all trades, suggesting that the City of Camden was a manufacturing hub, with factories supplemented by hand, household, and neighborhood trades. With revised data provided by the Census for 1899, 1904, and 1909, a more accurate comparison can be made on the growth of the manufacturing industry (Figure 32). It is evident that the number of factories in the city did not fluctuate as was perceived; rather there was a significant number of people engaged in the hand trade industries in the early history of the city.

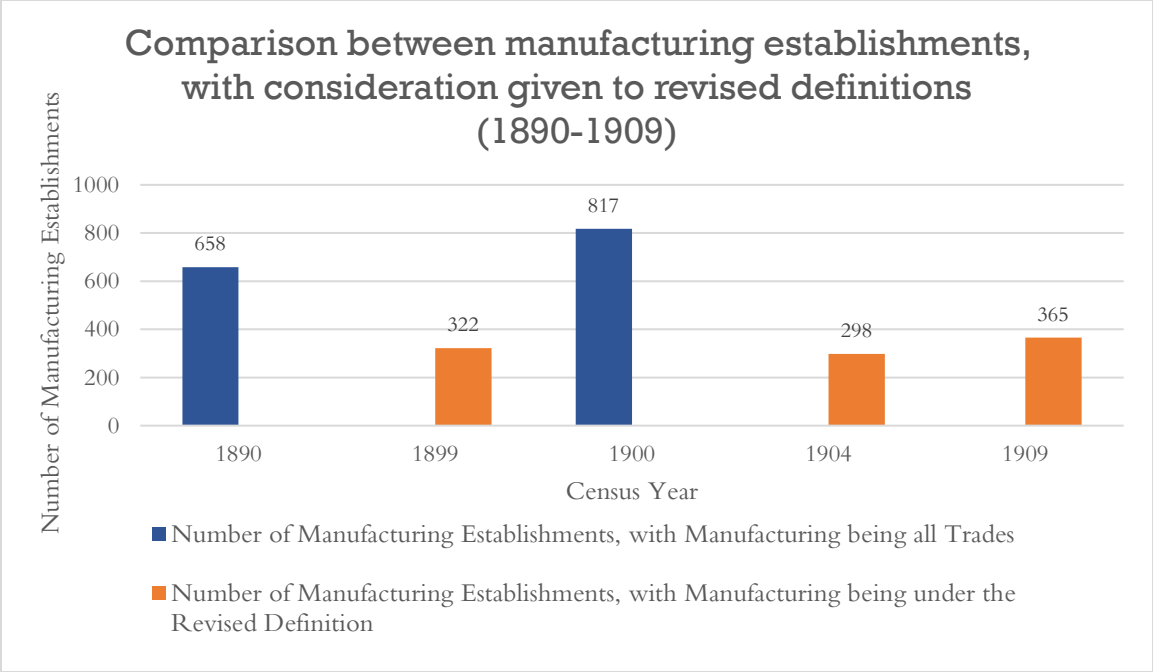

Figure 32. Comparison between Manufacturing Establishments, with Consideration Given to Revised Definitions (1890-1909)
Data sourced from United States Census data from 1860-1930

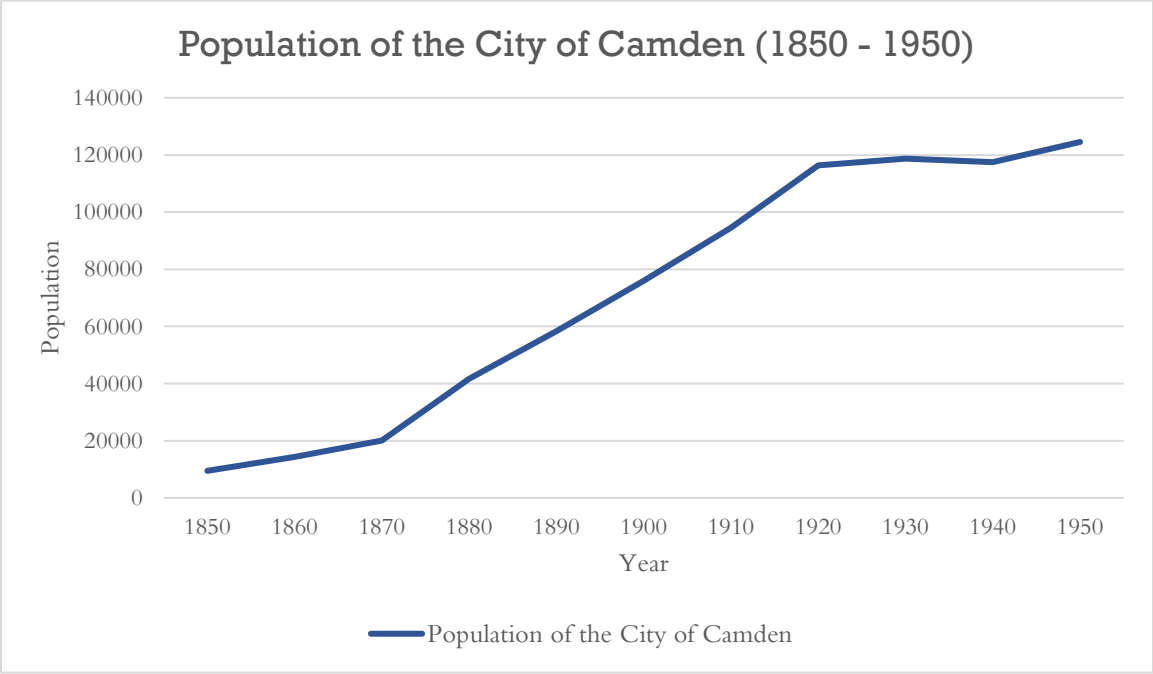

Figure 33. Population of the City of Camden (1850 - 1950)
Data sourced from United States Census data from 1850-1950

In 1828, when Camden was incorporated, the population was 1,143, which tripled by 1830, and tripled again by 1850 (Figure 33).[131] Per Census data from 1850, the population was 9,479.[132] The location of Camden encouraged the growth of local industry, which attracted a working-class population.

In 1899, the water supply of Camden switched from river water to the artesian wells, as the Sanitary Code for the City of Camden committed the city to providing a plentiful water supply to ensure the smooth running of the sewer system. According to a 1901 pamphlet by the Business Men's League, of Camden, which aimed to call attention to the efforts of then mayor Cooper B. Hatch and his administration, Camden's growth was due to the new water plant and the general state of cleanliness within the city. Additionally, the pamphlet indicated that the growth in the population resulted in the occupation of empty housing units.[133]

George Reeser Prowell, a Camden historian writing in 1886, looked at the building permit data in the City of Camden from 1859 to 1886 and noted that 6,576 permits were issued over twenty-seven years. He stated a single permit could suffice for the construction of multiple units, additions, and alterations. Prowell noted that a builder in Camden informed him that he had constructed twenty-seven individual units from a single permit.[134] Considering the Business Men's League statement that the empty housing units filled up at the end of the nineteenth century, it is likely that flurry of building activity was a speculative market spurred by the fast-increasing population. In addition to the many housing units in the city, Camden did have a few

[131] Boyer, *The Civil and Political History of Camden County and Camden City*, 37, 54.
[132] U.S. Department of the Interior, Census Office, *The Seventh Census of the United States: 1850*, (Washington, D.C.: Robert Armstrong, Public Printer, 1853), 137.
[133] Business Men's League, of Camden, *A few points about Camden*, (Camden: Business Men's League of Camden, 1901), 12.
[134] Prowell, *The History of Camden County, New Jersey*, 547.

tenements (Figure 34, Figure 35). Many factory workers in Camden, by 1930, were said to have owned their house or were able to rent it at an affordable rate.[135]

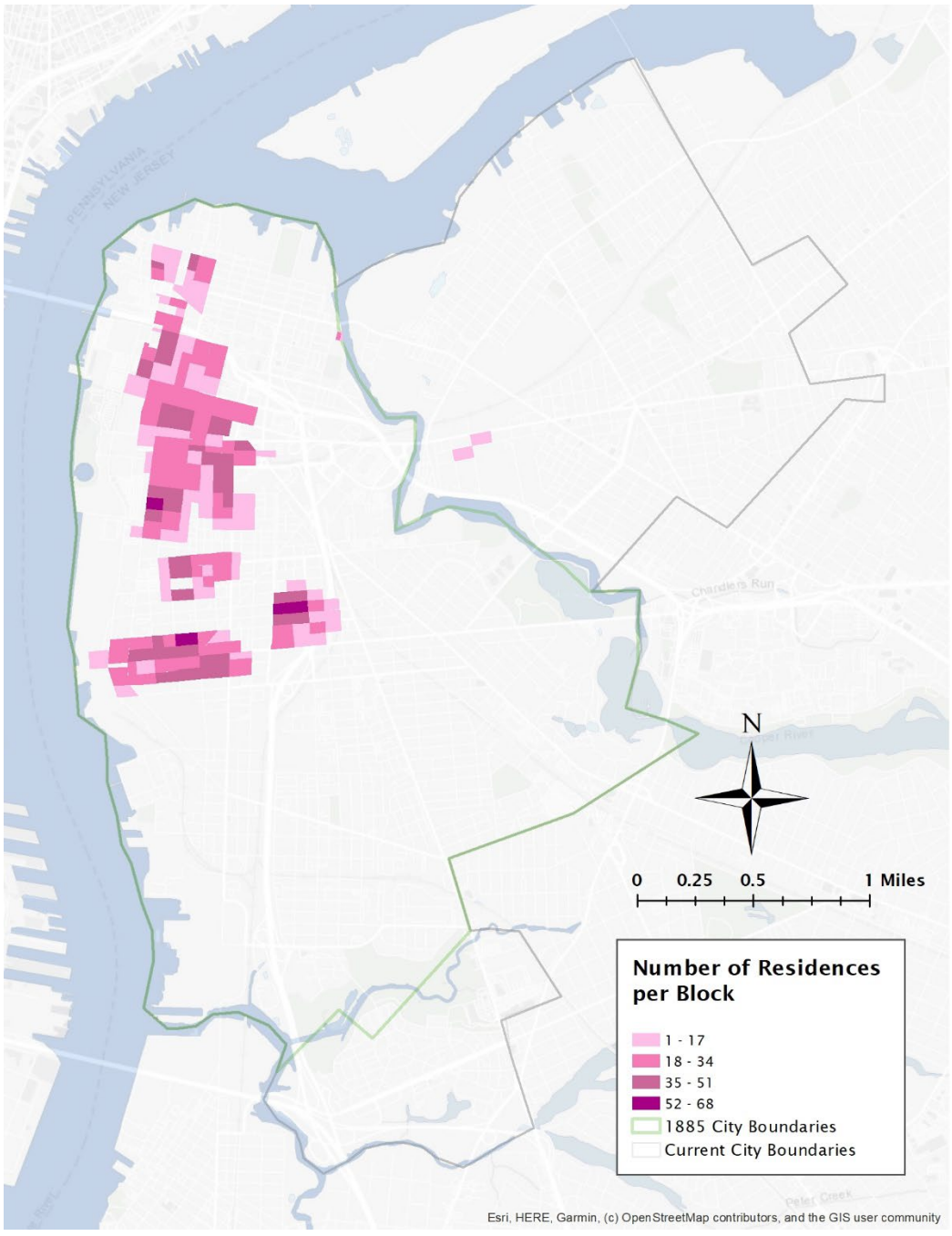

Figure 34. Map of Camden's Residential Structures, in 1885
Data sourced from 1885 Sanborn Maps of the City of Camden, Sheets 2-23.

[135] Cranston, *Camden County, 1681-1931*, 73.
The data for this is unverified and comes from factory owners in Camden, who stated that their employees were paid a living wage, which in turn afforded them mortgages.

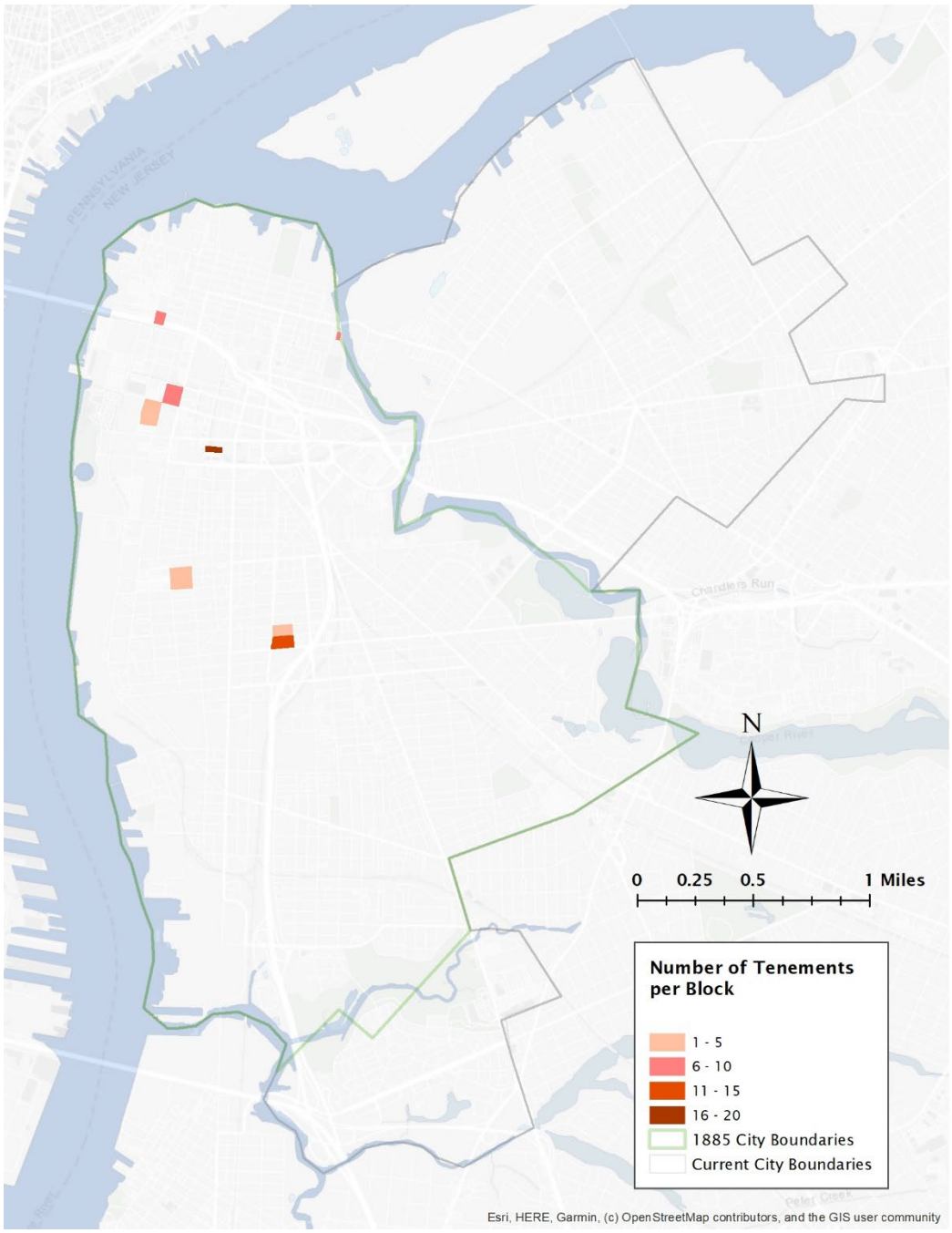

Figure 35. Map of Camden's Tenements, in 1885
Data sourced from 1885 Sanborn Maps of the City of Camden, Sheets 2-23.

Transportation Infrastructure

The City of Camden grew as an industrial city with the introduction of the Camden and Amboy Railroad, which connected Camden to South Amboy, another transportation hub, in

1834. The railroad network that grew during the nineteenth and twentieth centuries better connected Camden with Pennsylvania and New York, provided favorable conditions for factories, and attracted a workforce to these factories.

In 1852, the Camden and Atlantic Railroad was chartered by the New Jersey Legislature. By 1854, it was the first rail line that connected the interior of New Jersey to the Atlantic Ocean. Simultaneously, the Cooper family-owned ferries would be sold to the Camden and Atlantic Railroad, bought back in 1856, and sold again to the Camden and Atlantic Railroad in 1872.[136]

In May of 1871, the Pennsylvania Railroad Company initiated the process to lease the railroad lines and surrounding land from individual companies throughout the state. The lease was finalized in March 1873, for a term of 999 years, and included properties owned by the United Railroad and Canal Companies, which was consolidated in January 1867 and included the United Companies, Philadelphia and Trenton Railroad Company, the New Jersey Railroad and Transportation Company, and the Delaware and Raritan Canal Companies. The consolidation under the Pennsylvania Railroad Company was concurrent with the economic depression known as the Panic of 1873. A little over a decade later, in 1886, the Pennsylvania Railroad Company fully controlled the ferries and had established a transportation monopoly (Figure 36).[137]

[136] Prowell, *The History of Camden County, New Jersey*, 353, 366.
[137] Ibid., 352, 376.

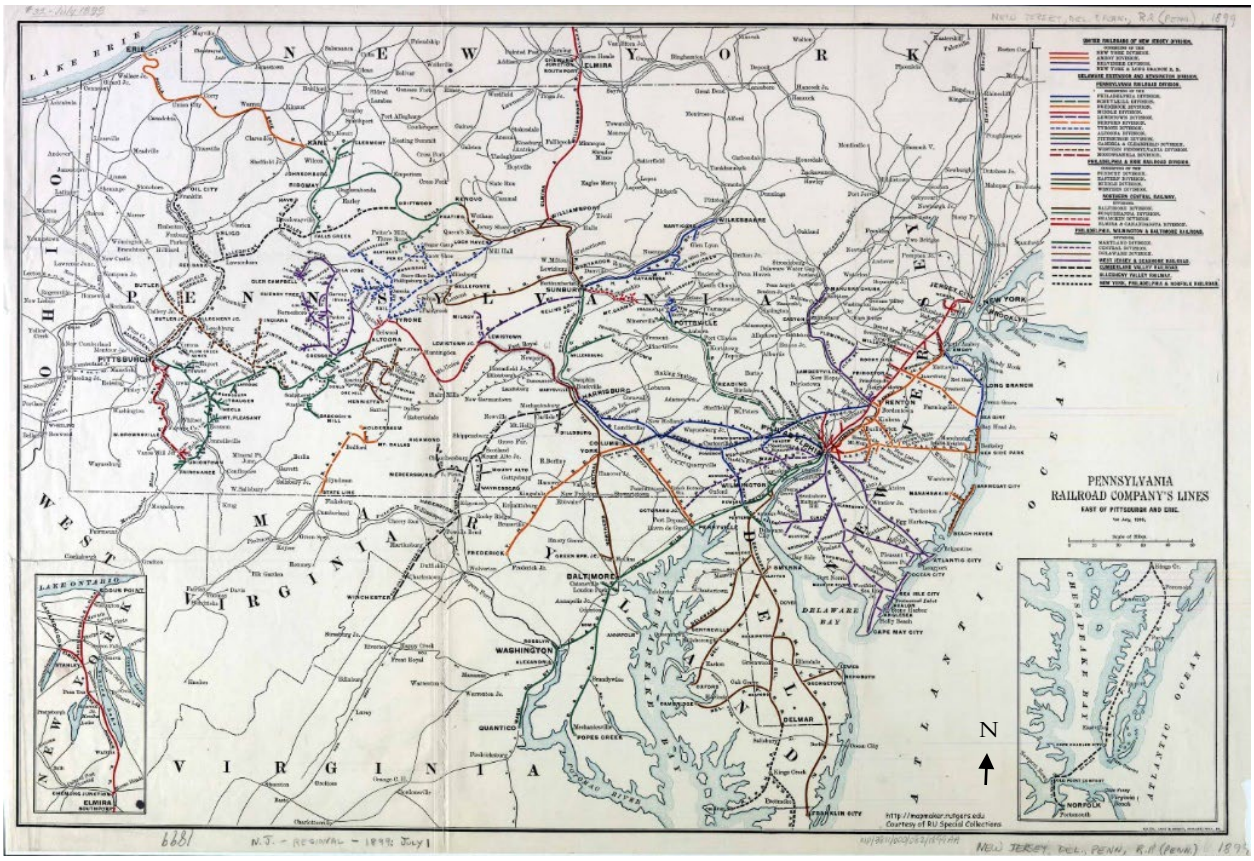

Figure 36. Pennsylvania Railroad Company's Lines, July 1, 1899.
Source: Allen, Lane & Scott, Pennsylvania Railroad Company's Lines (Philadelphia: 1899).
http://mapmaker.rutgers.edu/HISTORICALMAPS/RAILROADS/Pennsylvania_RR_1899.jpg

In addition to a vast railroad and ferry system, a trolley system developed in the latter half of the nineteenth century (Figure 37). In 1866 the first trolley company in Camden, the Camden Horse Railroad Company, was incorporated. Tracks were laid in 1870 and the trolley was transporting passengers by 1871. The goal of the horse railroad was to connect the residents of Camden with the ferry system. [138]

[138] Jeffery M. Dorwart, *Camden County, New Jersey, The Making of a Metropolitan Community, 1626-2000*, (New Brunswick: Rutgers University Press, 2001), 68.

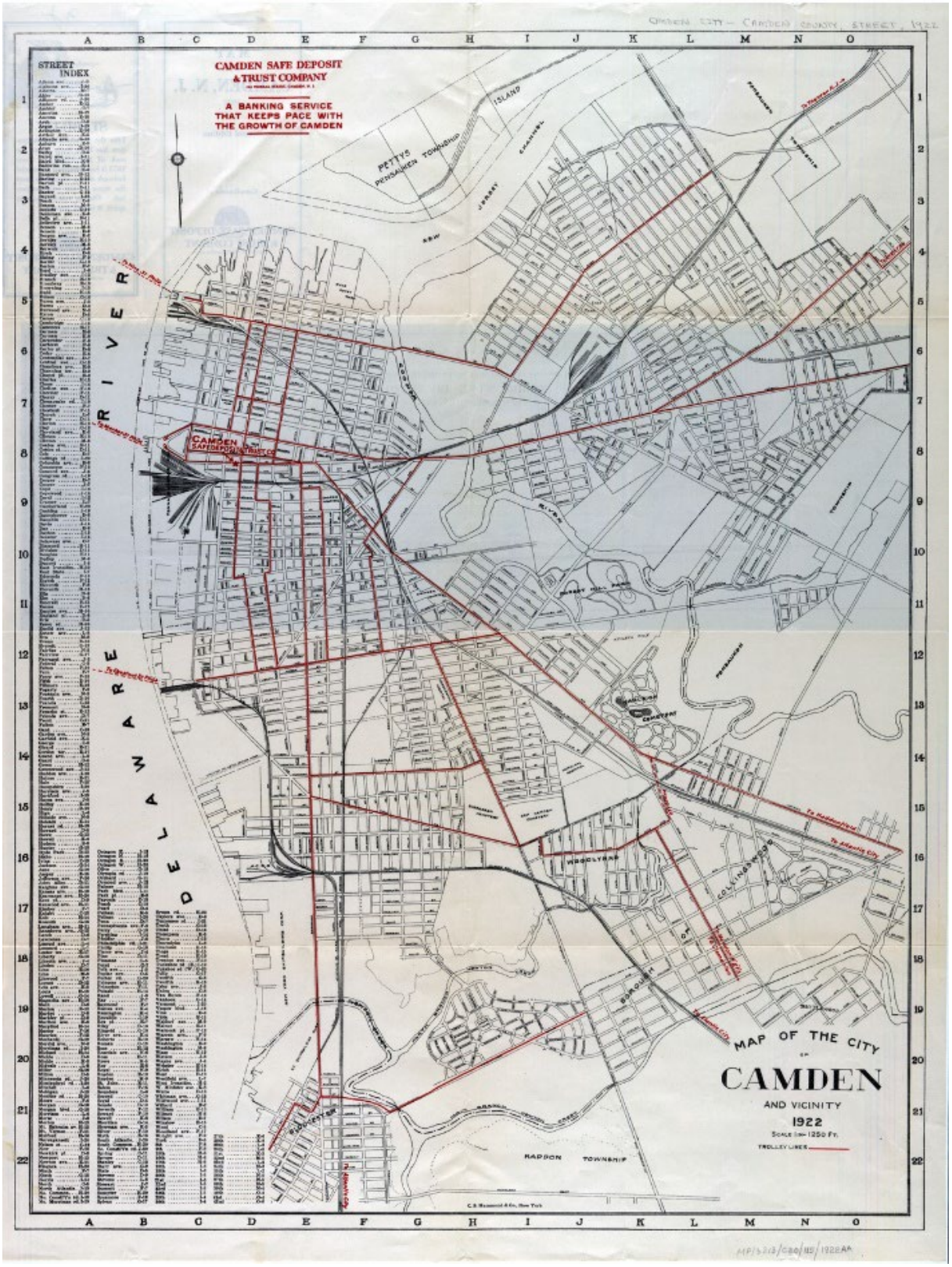

Figure 37. Map of the City of Camden and Vicinity in 1922, with Trolley Lines in Red.
Source: Map of the City of Camden and Vicinity (Maplewood, NJ: C.S. Hammond & Co. 1922).
https://rucore.libraries.rutgers.edu/rutgers-lib/15609/JPEG/1/play/3

In 1893, the West Jersey Traction Company was organized to connect Camden to nearby towns. Dispute between the Camden Horse Railroad Company and the West Jersey Traction Company would be resolved by their merger in 1896, under the new name Camden Suburban Railway Company, which would be absorbed into the South Jersey Gas and Traction Company in 1904. And by 1910, the South Jersey Gas and Traction Company was absorbed into the Public Service Railroad Company, which was a subsidiary of the larger Public Service Corporation (PSC).[139]

The trolley system brought with it urban and rural development. Vacant lots on the riverfront and downtown property were sold at top prices to be transformed into sites for factories and row houses. The trolley system resulted in population concentrations along trolley routes. As the numbers of factories and houses grew, the sewer system was expanded to accommodate them.[140]

Camden Sewer History

Camden, like most American cities, did not install public sewers before the middle of the nineteenth century. People in the burgeoning city used privy pits to dispose of sanitary waste. While some drainage systems had been built by the 1850s, the earliest municipally owned sewer, likely meant for flood control, was built beneath Federal Street in 1860.[141] It is not yet clear when sewage removal was incorporated into the Camden system, as the Camden Sewer Notebooks do not have entries for the number of house connections to sewers until 1893.

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[139] City of Camden, "Industrialization," *City of Camden*, March 2019.
[140] Paul W. Schopp, *Camden Historic Survey, City of Camden, Camden County, New Jersey, Volume I: Survey Narrative*, rev. ed., original by William Bassett and Lynn Drobbin, (Cranbury: Richard Grubb & Associates, 2007), 26.
[141] Ann Marie T. Cammarota, *Changing Pattern: The Suburbanization of Southern New Jersey Adjacent to the City of Philadelphia*, (Philadelphia: Temple University, 1996), 111; New Jersey Board of Health, *Twenty-Third Annual Report of the Board of Health of the State of New Jersey, 1899*, 86.

In 1865, cholera had become rampant in Europe, and Camden began to prepare for its arrival in the United States. The Camden City Medical Society appointed a committee to prevent an epidemic. The committee reported that the streets were unpaved and filled with trash, cesspits were overflowing, pigs were kept within people's yards, and there was little drainage of standing water. The City Council responded by establishing their sanitary committee to enforce existing regulations and clean up Camden. They were successful, with the nuisances they found abated before the summer of 1866. Ultimately, there were only thirty-nine cases of cholera in the city that year.[142] Buoyed by their success, the city continued its efforts to increase public health by continuing to improve drainage and waste management. By the end of the 1860s, sewers in Camden operated well enough that the citizens, reportedly, did not mind the additional tax burden required.[143]

However, not all of Camden lived in sanitary conditions. Included in the *Report of the Board of Health of 1877* is a "Report on Epidemics and Endemics, that have occurred in the State of New Jersey since 1870," which covered the appearance of smallpox in May 1872 in an African American neighborhood. Though sewer systems had been under construction in Camden for over a decade, this neighborhood lacked sanitary sewer systems and relied on privies.[144] The report described appalling conditions including "houses and yards were small and filthy, with pig-pens and privy-wells often overflowing in close proximity to the houses."[145] Existing research informs the correlation between the sewer systems and neighborhoods based on social class. This relationship can be understood through the concept of capital investment, with the construction

[142] John R. Stevenson, "A History of Medicine and Medical Men," In *The History of Camden County, New Jersey*, by George R. Prowell, (Philadelphia: L.J. Richards & Co., 1886), 257.
[143] Cowen, *Medicine and Health in New* Jersey, 82.
[144] Theodore R. Varick, "Report on Epidemics and Endemics, that have occurred in the State of New Jersey since 1870," in *Report of the Board of Health of the State of New Jersey*, (Trenton: Naar, Day & Naar, Printers, 1877), 109.
[145] Varick, "Report on Epidemics and Endemics," 109.

of the sewer system in a neighborhood being demonstrative of infrastructure improvements. The inverse is also true; capital disinvestment, the act of not investing in infrastructure improvements in parts of the city, does not encourage the growth of those areas.[146] Constructing a sewer system would result in cleaner streets, encourage housing construction, and retain or encourage the growth of affluent communities.

Where construction was happening, it was performed by John Ambruster and his company. Ambruster served on the city council in 1857 before being contracted to build the earliest recorded sewers beneath Cooper and Federal Streets in 1863.[147] These sewers were later rebuilt or replaced.[148] However, it is unsurprising that some of his other sewers may still exist today; in 1876, Ambruster was given a commendation in the Centennial International Exhibition for his masonry and its "ingenious and skillful workmanship and pleasing results, due to the peculiar bond employed."[149] Ambruster built sewers through 1880. Daniel L. Pine and William Thompson were also early sewer contractors, beginning their work in 1868 and 1874 respectively. Aaron Ward built the most miles of sewer in Camden (Figure 38). Between 1877 and 1918, he constructed over thirty miles of brick and vitrified clay sewers, along with at least one concrete outlet.[150] There were almost fifty miles of sewers in Camden by the end of the nineteenth century.[151] While constructing sewers, Aaron Ward was also innovating; in 1885, he patented a machine for pressing bricks on site (Figure 39).

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[146] Neil Smith, Paul Caris, and Elvin Wyly, "The 'Camden Syndrome' and the Menace of Suburban Decline, Residential Disinvestment and its Discontents in Camden County, New Jersey," *Urban Affairs Review* 36, 4 (2001): 498.
[147] Prowell, *The History of Camden County, New Jersey*, 435.
[148] Division of Capital Improvements and Project Management, "Camden Sewer Notebooks."
[149] Francis A. Walker, "International Exhibition, 1879. Reports and Awards, Volume VIII," (Washington, D.C.: Government Printing Office, 1880), 273.
[150] Division of Capital Improvements and Project Management, "Camden Sewer Notebooks."
[151] New Jersey Board of Health, *Twenty-Third Annual Report of the Board of Health of the State of New Jersey, 1899*, 105; New Jersey Board of Health, *Twenty-Fourth Annual Report of the Board of Health of the State of New Jersey, 1900*, (Trenton: John L. Murphy Publishing, 1901), 111.

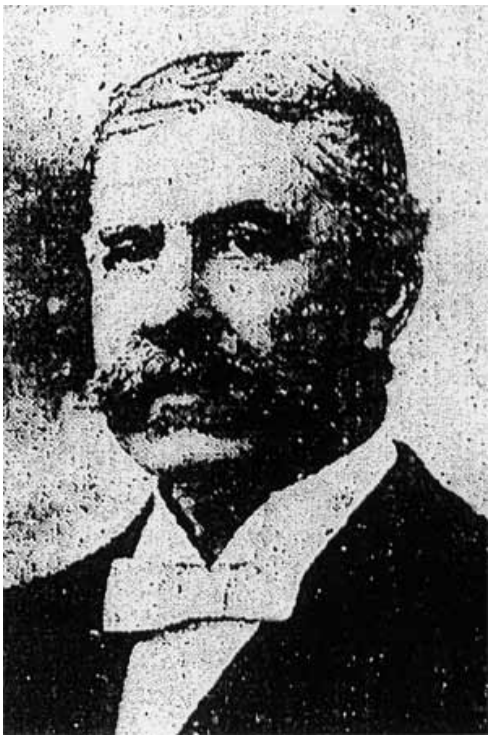

Figure 38. Aaron Ward
Source: Unknown photo.
http://www.dvrbs.com/people/CamdenPeople-AaronWard.htm

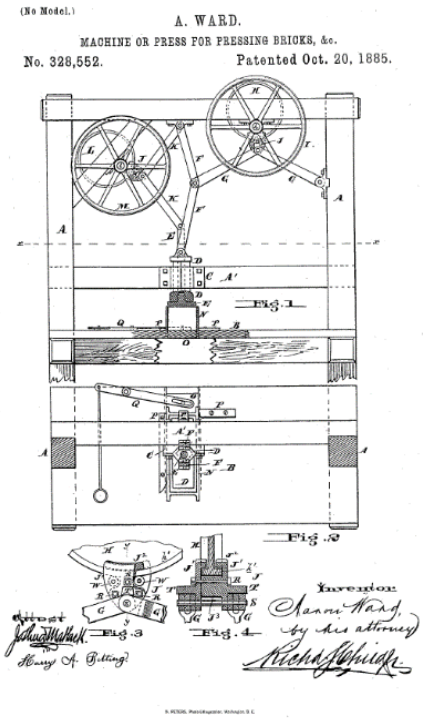

Figure 39. Aaron Ward's Patent for a Machine or Press for Pressing Bricks
Source: Aaron Ward, Patent # US328552A, (Camden: 1885).
https://patents.google.com/patent/US328552A/en?oq=US328552

Around this time, the City of Camden's Board of Health (BOH) was working to ensure that the health of the citizens would not be compromised as a result of poor food quality, lack of modern sanitation (residential to sewer connections), poor water quality, or similar issues. Accordingly, in 1886, the BOH established the Sanitary Code, which addressed sanitation and health in the city. Later, in 1899, the BOH established the Plumbers' Code, to ensure that all plumbers working in the city were employing the same set of standards, using materials and methods deemed appropriate, etc.

The quality of construction, however, may be open to question as the City of Trenton's engineer, C.C. Haven, claimed in 1897 that "in 8 years of sewer usage and construction, that not a single break or stoppage has been reported in Trenton; where as in Camden, New Jersey some

122 breaks were reported in their sewers."[152] Haven further added that there are grave consequences to permitting large quantities of steam and hot water to enter a brick sewer system.[153] Within the Plumbers' Code, Rule 36 states

> [n]o steam exhaust, blow-off or drip pipe from a steam boiler shall connect with the sewer or with any drain, soil pipe or waste pipe. Such pipes must discharge into a tank or condenser, from which a suitable outlet to the drain may be provided.[154]

Another probable reason for the breaks was the lack of funds within the municipality to conduct repairs. In his 1884 report, Onan B. Gross noted that between June 1st to September 1st, 1884, forty-eight nuisances were ordered to be abated. Thirty of these were privy-well overflows and the remaining were defective drainages. Some of the forty-eight nuisances were abated by owners or by city funding; however, eight or nine breaks remained unabated as the city lacked the money to complete repairs.[155] By 1904, according to the BOH report, Camden was almost entirely sewered, with only a few streets still waiting for their connections.[156] In 1907, the city's population of 83,363 people discharged thirteen million gallons of sewage into the Delaware River every day, more than any other New Jersey town. The state described Camden's system as

> 60 miles of combined sewers draining six square miles in area. It is estimated that there are 17,500 house connections and 35 factory connections including woolen, iron, chemical, machine, candy, soap and dye factories. There are no separate sewers or separate storm drains. The sewage is discharged into the Delaware river and Coopers creek through 18 outlets, 11 on the Delaware river and 7 on Coopers creek...A trunk sewer is being constructed at Ferry avenue which will intercept some of the smaller outlets. Another trunk sewer is planned to discharge into Newton creek to drain part of the territory of the city.[157]

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[152] Israel, *Report*, 53.
[153] Ibid., 53.
[154] City of Camden, *Compiled and Revised Ordinances of the City of Camden*, 631.
[155] Gross, *Report of Special Sanitary Inspector for Camden, N.J.,* 27.
[156] New Jersey Board of Health, *Twenty-Eighth Annual Report of the Board of Health of the State of New Jersey, 1904*, (Paterson: News Printing Co., 1905).
[157] New Jersey Sewerage Commission, *Report of the State Sewerage Commission of 1906 to the Legislature of 1907*, (Trenton: MacCrellish & Quiqley, State Printers, 1907), 111.
The number of factory connections reported is significantly lower than the number of factories reported in Camden, in other data sources. Additionally, the discrepancy is further evident when looking to the *Report of the State*

The second trunk sewer referred to in the New Jersey Sewerage Commission's 1906 report was the Line Ditch Sewer. The Line Ditch sewer, Aaron Ward's proudest accomplishment, covered the Little Newton Creek and drained the surrounding swamp (Figure 40, Figure 41).[158] It ran between what is now Kaighns Avenue and Carl Miller Boulevard, from around 10th Street to the Delaware River. The sewer, completed in 1907, was considered an engineering marvel for the time, due to the quicksand it had to be placed in.[159] Ward had previously lost his fortune when he was unable to complete a city project due to supply issues, and the city refused to pay him. He considered the Line Ditch project to be the reason he could rebuild, even though he underbid other contractors considerably.[160]

Sewerage Commission to the Legislature of 1900, wherein Camden reported 8,033 factory connections. The reason for this discrepancy is unknown; however, one possible reason is that the data in the reports of the State Sewerage Commission is typically self-reported.

[158] "Passing of Line Ditch in South Camden Means Much to that City," *Philadelphia Inquirer*.

[159] "Aaron Ward Dies at 4-Score Mark," *Camden Courier*, (Camden: Camden Courier, June 28, 1915).

[160] "Passing of Line Ditch in South Camden Means Much to that City," *Philadelphia Inquirer*.

Figure 40. Newton Creek Line Ditch
Source: Camden County Historical Society, No. 5015

Figure 41. Newton Creek Line Ditch
Source: Camden County Historical Society, No. 5017

The City of Camden grew over the next two and a half decades, and the sewer system expanded with the city. The eastern part of Stockton was annexed to Camden in 1899, and parts of Camden to the south were as of yet undeveloped in 1906, as seen in the Sanborn maps of the time (Figure 42).[161] Most of the sewers built in the 1910s and 1920s were in these areas of Camden and correspond to the beginning of development there.[162]

[161] John P. Snyder, "The Story of New Jersey's Civil Boundaries 1606-1968," (Trenton: New Jersey Geological Survey. Reprinted. Originally published 1969, Bulletin No. 67, Bureau of Geology and Topography, Trenton, 2004), 104.
[162] Division of Capital Improvements and Project Management, "Camden Sewer Notebooks."

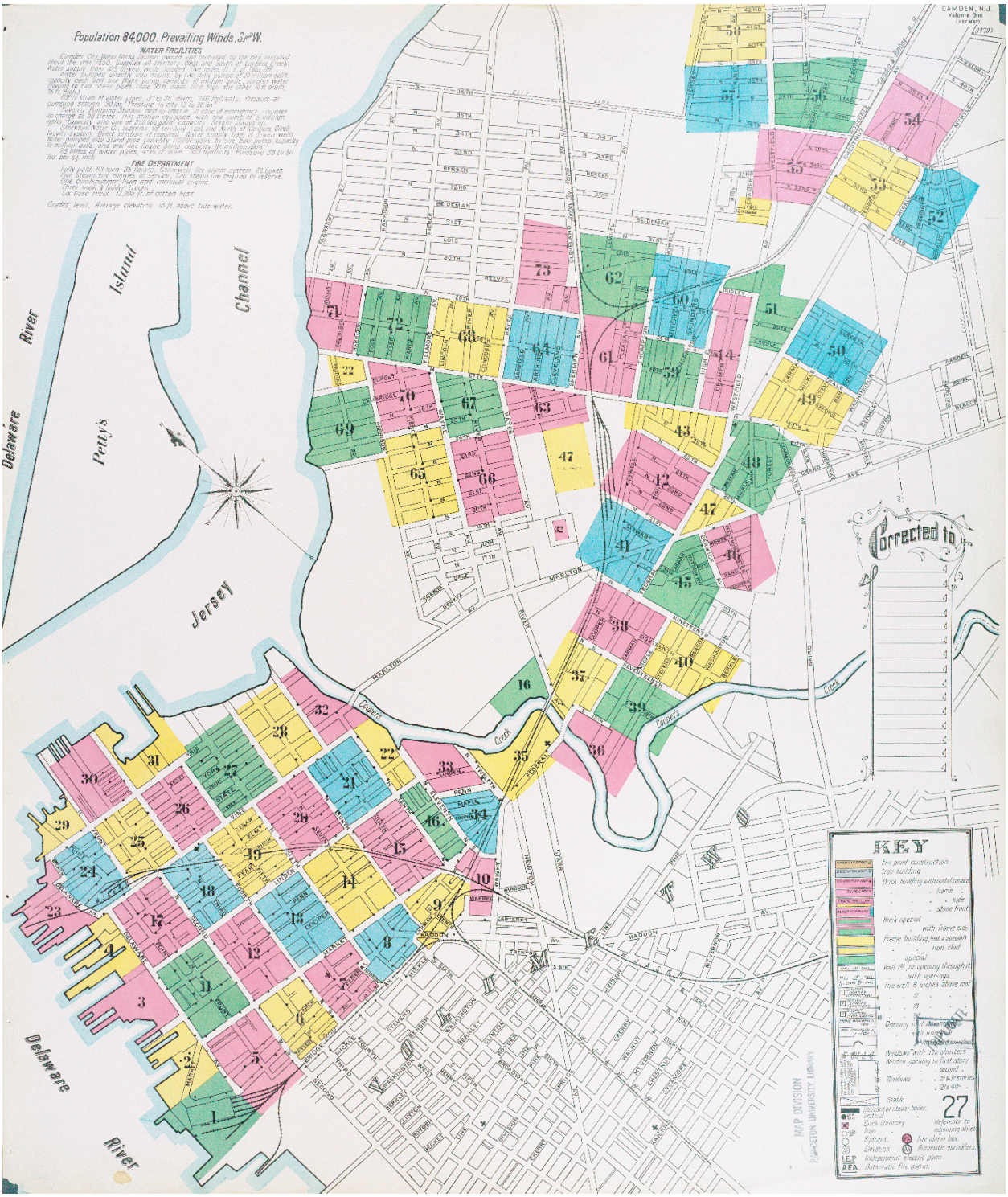

Figure 42. Sanborn Map of the City of Camden (1906). Scale not given.
Source: Sanborn Map Company, Sanborn Fire Insurance Maps: New Jersey (Teaneck, NJ: Chadwyck-Healey, 1906).
https://maps.princeton.edu/catalog/princeton-1v53jz59g

Following the construction of the sewers, the City of Camden, at the instruction of the NJBOH, constructed a temporary sewer treatment plant in 1915. The sewer treatment plant was constructed adjacent to Woodlyne Borough and took in raw sewage from the main sewer on Haddon Avenue.[163] The Report of the Street Commissioner of the City of Camden from 1915 suggests that the City of Camden was pleased with its efforts at constructing a sewer treatment plant; however, the NJBOH was dissatisfied with the plant. The emphasis and the need for the plant were a result of NJBOH proceedings on the pollution of the Delaware River and its tributaries. While the quality of water that came out of the faucet was improving, the rivers and streams themselves remained heavily polluted. In the early twentieth century, the Delaware River's shad population collapsed due to pollution.[164] In 1905 the New Jersey Board of Fish and Game Commissioners were authorized to cooperate with Pennsylvania to restore fish to the Delaware River.[165] New Jersey's Sewerage Commission and Governor also met with their cognates in Pennsylvania to discuss the state of the Delaware River. Their recommendation was that the two states, along with New York, should agree on some joint action to improve the quality of the river.[166] A resolution allowing for the creation of this commission passed the state legislature in 1907.[167] Around this time, the three states already had some of the strictest water pollution laws in the country.[168] In 1936, the three states joined with Delaware to create the

[163] Camden City Highway Department, *Report of the Street Commissioner, City of Camden, New Jersey, for the year Ending December 31, 1915,* (Camden: Magrath Printing House, 1915), 56.
[164] Gerald J. Kauffman, Jr., "The Delaware River Revival: Four Centuries of Water Quality Change from Henry Hudson to Benjamin Franklin to JFK," *Pennsylvania History: A Journal of Mid-Atlantic Studies* 77, no. 4 (2010): 440.
[165] New Jersey, Legislature, *Acts of the One Hundred and Twenty-Seventh Legislature of the State of New Jersey and Fifty-Ninth Under the New Constitution*, (Trenton: MacCrellish & Quigley, State Printers, 1903), 289.
[166] New Jersey Senate, *Journal of the Sixty-Second Senate of the State of New Jersey*, (Trenton: MacCrellish & Quigley, 1906), 456.
[167] New Jersey Senate, *Journal of the Sixty-Third Senate of the State of New Jersey*, (Trenton: MacCrellish & Quigley, 1907), 421.
[168] Edwin B. Goodell, *A Review of the Laws Forbidding Pollution of Inland Waters in the United States*, (Washington, D.C.: Government Printing Office, 1904).

Interstate Commission on the Delaware River Basin (INCODEL). The Commission hoped to coordinate the water pollution programs of the states to make them more efficient and effective. They began in earnest after World War II and built new sewage treatment plants along the river basin.

By 1960, most of the communities and all the cities along the Delaware River had "adequate" sewage treatment, according to the standards of INCODEL at the time.[169] In 1962, the states in INCODEL joined with the federal government to create the Delaware River Basin Commission (DRBC), a pioneering effort to provide comprehensive planning and regulation for the watershed.[170] The DRBC issued stricter standards for waste discharge in 1968 than would be defined in the Clean Water Act four years later, but it would take over two decades for the shad population to begin to recover.[171]

Sanitary Code, Plumbers' Code, and Ordinances

The City of Camden's Ordinances, Sanitary Code of 1886, and Plumbers' Code of 1899 were passed to cover the construction, modification, and regulation of sewer systems. The Ordinances recorded the scope of water pipe and underground infrastructure projects that major corporations and manufacturing establishments had undertaken with city approval, guidelines for the sewer systems, city official positions, and the relevant boards to oversee health and sanitation. The Sanitary Code of 1886 addressed health in the city, as impacted by food and sanitary conditions. The Plumbers' Code of 1899 ensured that plumbers in the city were following the

[169] Richard C. Albert, "The Historical Context of Water Quality Management for the Delaware Estuary," *Estuaries* 11, no. 2 (1988): 102.
[170] Albert, "The Historical Context of Water Quality Management for the Delaware Estuary," 103.
[171] Kauffman, "The Delaware River Revival," 446-447, 451.

same policies for connecting houses to city sewer lines, using materials and methods deemed appropriate. Both codes were regularly amended and updated.

As sewer systems were being built, the Sanitary Code attempted to ensure that the city's residences transitioned from privy vaults and cesspools to water closets and latrines that connected to the public sewer system. The Sanitary Code states

> No privy vault, cesspool or receptacle of filth of any kind shall hereafter be constructed, allowed or maintained upon any lot or premises abutting upon a street in which a public sewer is laid, but proper water closets, school sinks, latrines, or some means approved by this Board, with a properly laid pipe, shall be provided, which shall discharge into said sewer; and all such water closets, latrines, or other means, shall be provided with a flow of water sufficient to wash all filth into the public sewer, under a penalty of twenty dollars for a violation of any part of the provisions of this section.[172]

The Sanitary Code further states

> In streets in which a public sewer shall hereafter be laid, the premises shall be connected with said sewer, and all cesspools or privy vaults existing or maintained on lots abutting on said streets shall, within sixty days after the completion of said sewer, be emptied and filled with fresh earth, and shall not thereafter be used as a receptacle for filth of any kind, under a penalty of twenty dollars for each and every violation of any part of this section.[173]

The city shifted its water supply from river water to artesian wells in 1899, at the same time it annexed Stockton. The shift ensured that there was an abundant supply of clean drinking water, which also ensured a smooth flow in the sewer system. The City of Camden took out bonds, and kept renewing them in greater amounts, to help pay for newly annexed Stockton's sewer construction and other necessary infrastructure improvements.[174] The rest of the code focused on sanitation for the sake of public health, which included the construction of privies too close to water supplies, privy construction to prevent leakage of sewage into the soil, how to handle the sick and contagious diseases, handling offensive materials, and food and drink.

[172] City of Camden, *Compiled and Revised Ordinances of the City of Camden*, 602-603.
[173] Ibid., 603.
[174] Ibid., 733.

The Plumbers' Code standardized the materials and sizing by which connections were made to the main sewer line. The code recommended the slope for pipes connecting private residences to the main sewer line, as well as the material of pipes, dependent on the soil.[175] The Sanitary Code required that sewers were to be constructed of hard brick, and the Plumbers' Code required that the connections from the house, regardless of material but specifically when connecting to a brick sewer, must be made using a terra cotta junction block. The Plumbers' Code required that connections must be made to the public sewer line, even if the sewer line is not on the same street. If the sewer line was in a parallel street, that connection must be made by constructing a private sewer, which was not to pass below private cellars. If that was unavoidable, the line must be of heavy cast iron pipe. It is likely that these extra heavy cast iron pipes are still present on private property, and have not been recorded in the Camden Sewer Notebooks.[176] The Camden Sewer Notebooks do list certain sewers as either privately constructed or constructed by any entity other than the City of Camden (Figure 43).

[175] It is worth noting that there are two rules in the ordinances, regarding lead: "Rule 20. Where lead pipe is used to connect fixtures with vertical soil or waste pipes, or to connect traps with vertical vent pipes, it must not be lighter than D pipe." and "Rule 21. All connections of lead with iron pipes must be made with a brass sleeve or ferrule of the same size as the lead pipe, put in the hub of the branch of the iron pipe and caulked with lead. The lead pipe must be attached to the ferrule by a wiped or overcast joint. All connections of lead waste and vent pipes shall be made by means of solder joints."

[176] City of Camden, *Compiled and Revised Ordinances of the City of Camden*, 625-628, 632.

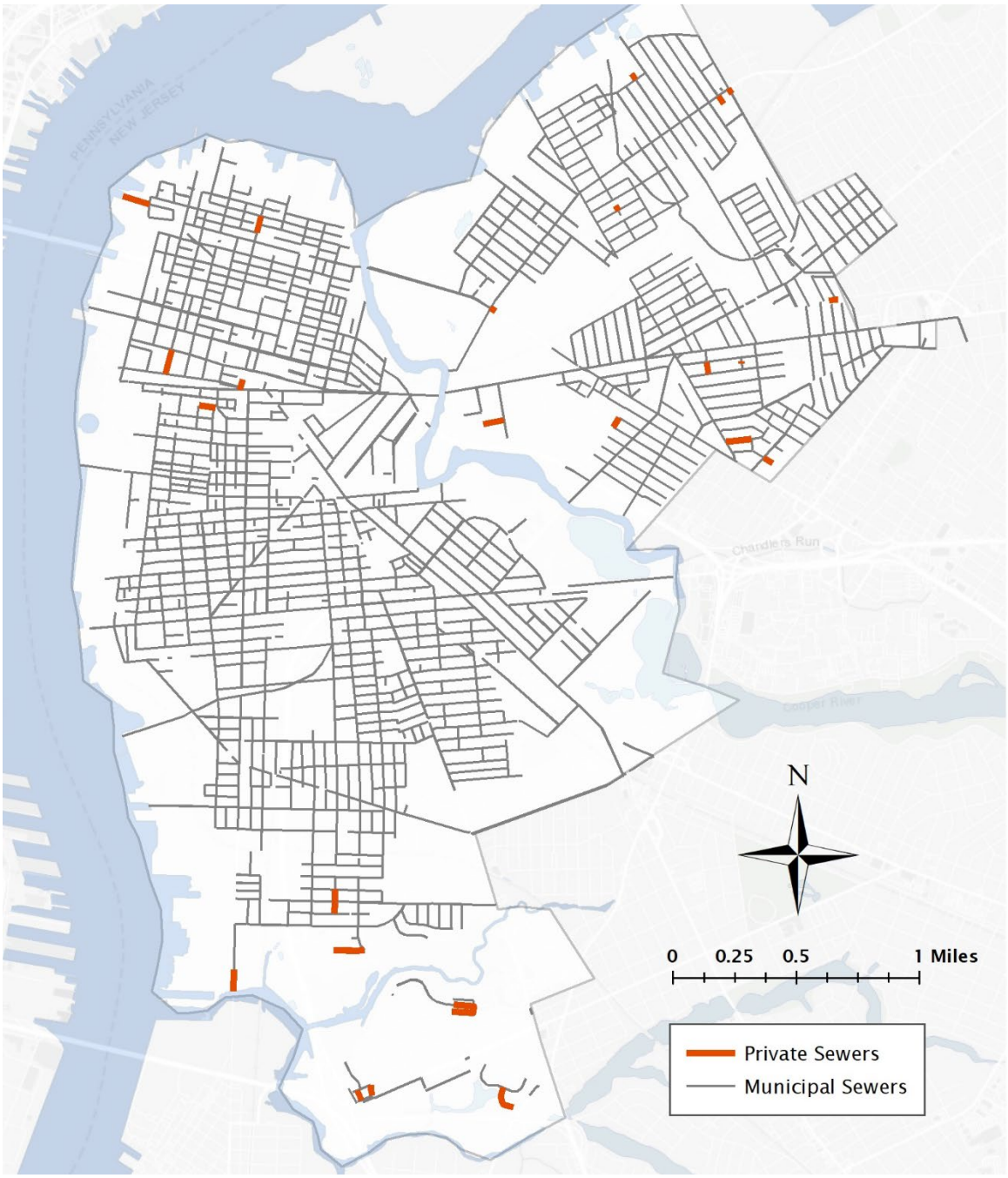

Figure 43. Private and non-City of Camden Sewer Lines in Red.
Data sourced from the Camden Sewer Notebooks

Some of the 1906 ordinances covered the pipe construction responsibilities of private companies. The city gave instructions on how and where to install sewers as well as water lines; Key Stone Leather Company, amongst others, was permitted to lay a water pipe in 1906. In 1907, Camden authorized and empowered the PSC to lay down a terra cotta pipe, which was

intended for sewer purposes. The pipe was to be no more than 15 inches in diameter, and would run from the Line Street culvert, northeast along Border Avenue through to Starr Avenue, then east on Starr Avenue until it reached the car barns.[177]

Chapter 17 of the City of Camden Ordinances states that the "best quality of hard brick" must be used in the construction of any public sewer or culvert, and if the ground has been opened in order to make connections, the dirt used to fill the opening must be rammed in horizontal layers.[178] Ramming the earth around the pipe increased the pipe's longevity and provided further structural support.

Camden Sewer Notebooks

Overall, the Camden Sewer Notebooks record around 168 miles of sewer construction or rehabilitation, almost all of which occurred before the Great Depression (Figure 44).

[177] City of Camden, *Compiled and Revised Ordinances of the City of Camden*, 523, 555.
[178] Ibid., 44, 45.

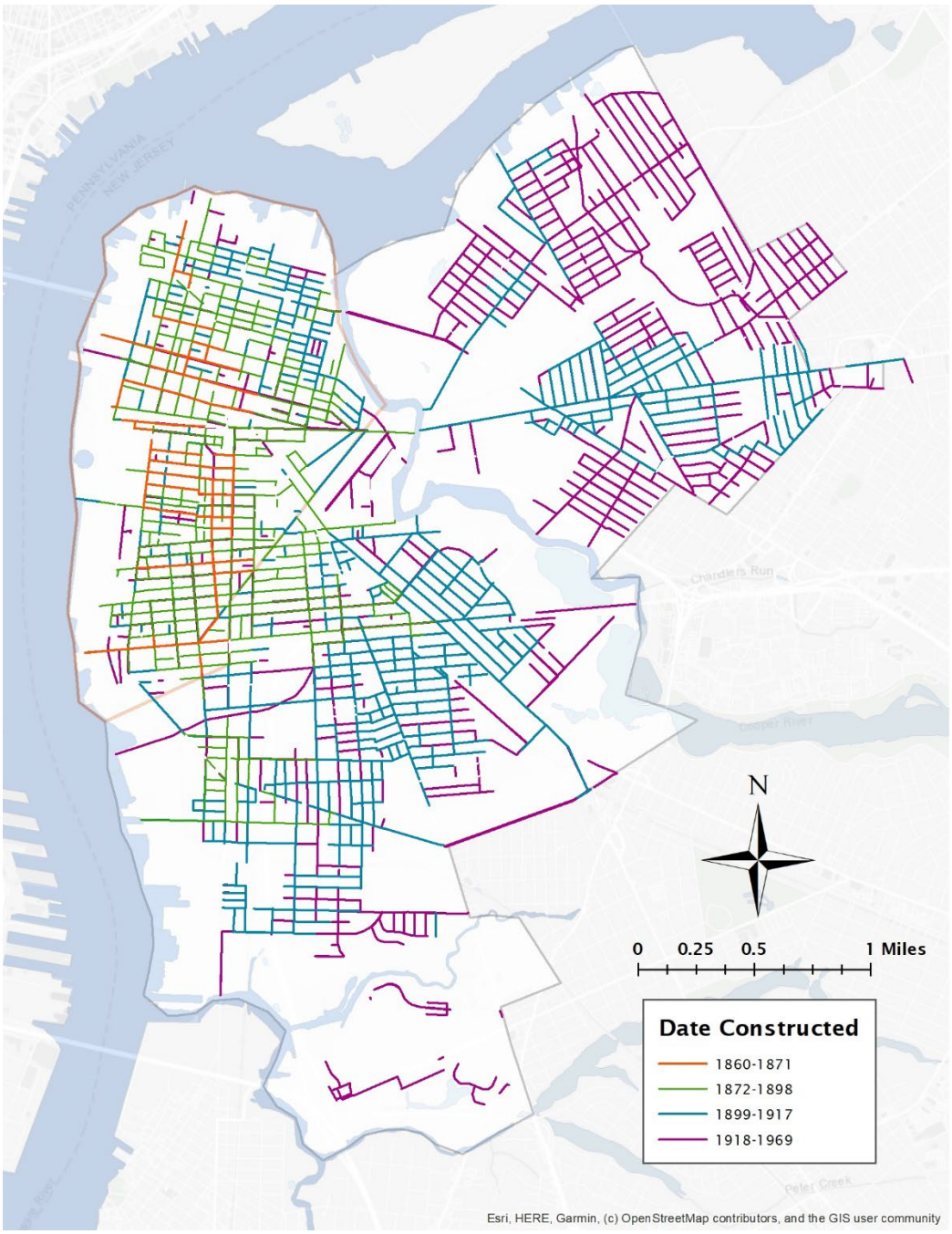

Figure 44. Sewer Construction by Era
Data sourced from the Camden Sewer Notebooks

The sewer system expanded into new neighborhoods as the municipal boundaries were expanded in 1871 and 1899. New construction continued within older parts of the municipality and many of the older sewers were repaired or replaced over time as well. The oldest sewers were often the

first to be rebuilt, with over 60% of the sewers constructed in the 1860s undergoing repair or reconstruction prior to 1970 (Figure 45).

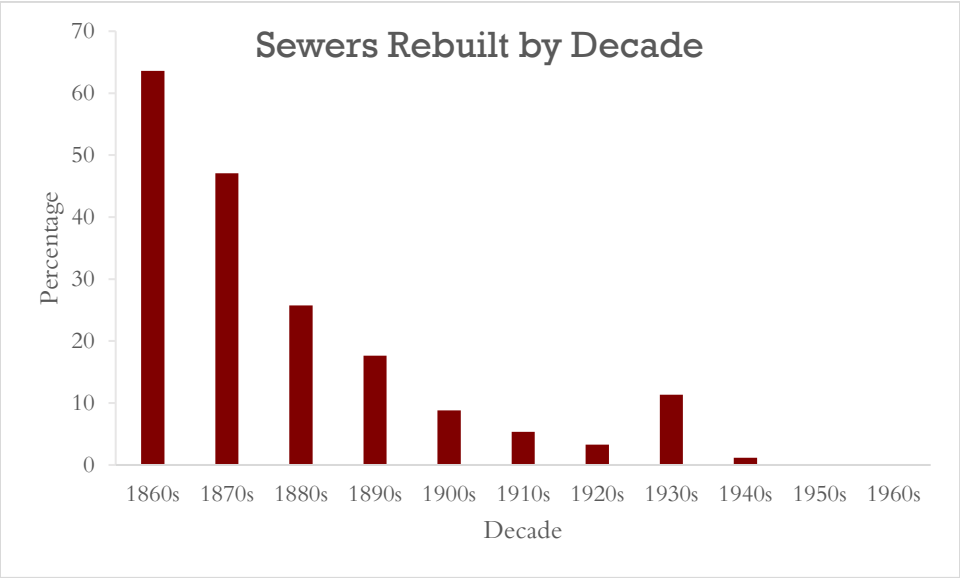

Figure 45. Percentage of Sewers from each Decade that were Rebuilt
Data sourced from the Camden Sewer Notebooks

The Greater Camden Movement in the 1920s caused a boom in sewer construction and rehabilitation (Figure 46). Although Aaron Ward retired near the beginning of the Greater Camden Movement, several other sewer contractors were active during this time, including B.F. Sweeten & Son, W. Penn Corson, and E.R. Morehouse (Figure 47). According to the Camden Sewer Notebooks, over forty miles of sewer were constructed, repaired, or rebuilt during the 1920s, more than any other decade.

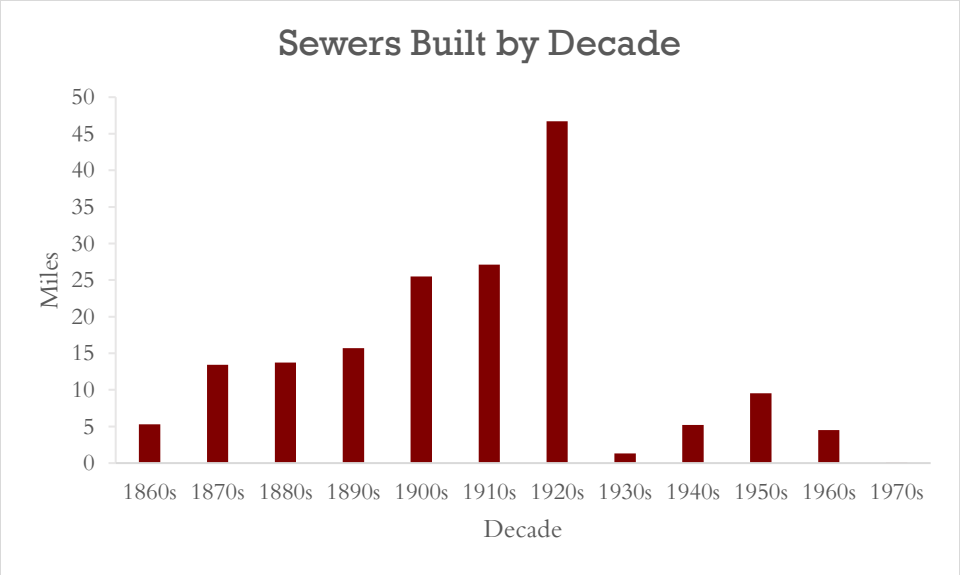

Figure 46. Miles of Sewers Built Each Decade
Data sourced from the Camden Sewer Notebooks

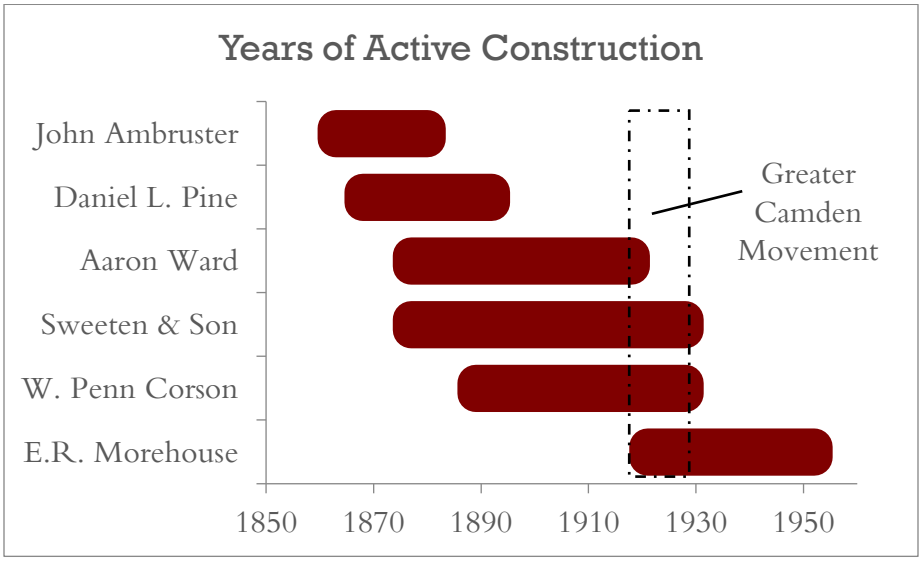

Figure 47. Years of Active Construction by Primary Camden Contractors
Data sourced from the Camden Sewer Notebooks

Materials

The earliest municipal sewer in the notebooks is a 30-inch diameter brick sewer built beneath Cooper Street in 1863. From the 1860s through the end of the 1920s, the majority of

new or replacement sewers were made of brick, and the last brick sewer was constructed in 1942 (Figure 48).[179]

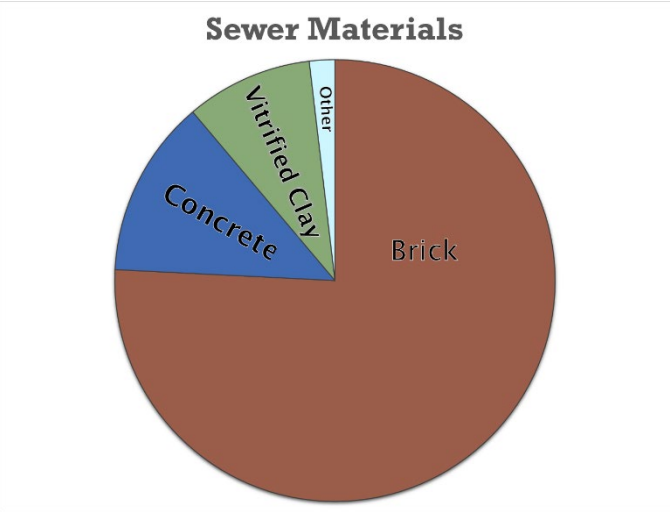

Figure 48. All Materials Used in Sewer Construction in Camden. Data sourced from the Camden Sewer Notebooks

Only two wood sewer segments are recorded in the Camden Sewer Notebooks: a wood box outlet extension on Front Street constructed in 1895, and a wooden outlet on Benson Street constructed in 1904. Wooden box sewers were also identified during archaeological monitoring.[180] Additional wooden outlets may be present where modern outfalls empty into the Delaware River, Cooper River, and Newton Creek. These are the logical locations for older outfalls, especially after Line Ditch and Baldwin's Run were covered in the early part of the century. However, the shorelines have radically changed over the decades. Historic fill covers the banks of the river and extends almost 1,000 feet inland in some areas, and even deeper at the

[179] Division of Capital Improvements and Project Management, "Camden Sewer Notebooks."
[180] Nancy Zerbe, "Monitoring report for the Combined Sewer Overflow Project, CSO Site C05/10. ARCH2. Letter submitted to Elizabeth Davis, NJDEP," (August 24, 2009); Nancy Zerbe, "Monitoring report for the Combined Sewer Overflow Project, CSO Site C10/15. ARCH2, Letter submitted to Elizabeth Davis, NJDEP,"(January 29, 2010); Reinhold et al., *Phase IB Archaeological Investigation Addendum.*

mouth of the Cooper River and Newton Creek. Early outfalls are most likely to be found within or on the edge of this fill area.

Vitrified clay pipes have been used in Camden since at least the 1880s but were increasingly used in the first half of the twentieth century, especially in the 1920s (Figure 49). Concrete pipe was possibly used once in Camden in 1892, for a short length in Federal Street, but was not commonly used in the city until 1919. Beginning in the 1920s, concrete pipe (including a specific type of reinforced concrete pipe made by the Lock Joint Company) became more popular, and by the 1960s almost all sewer construction used concrete pipe. Cast iron pipe was first listed in the 1920s, and the greatest amount of cast iron sewers were constructed in the 1920s and then the 1960s. Over 2,000 feet of corrugated metal pipe was installed in the 1960s beneath Vesper Boulevard to act as storm sewers leading to Cooper River.[181]

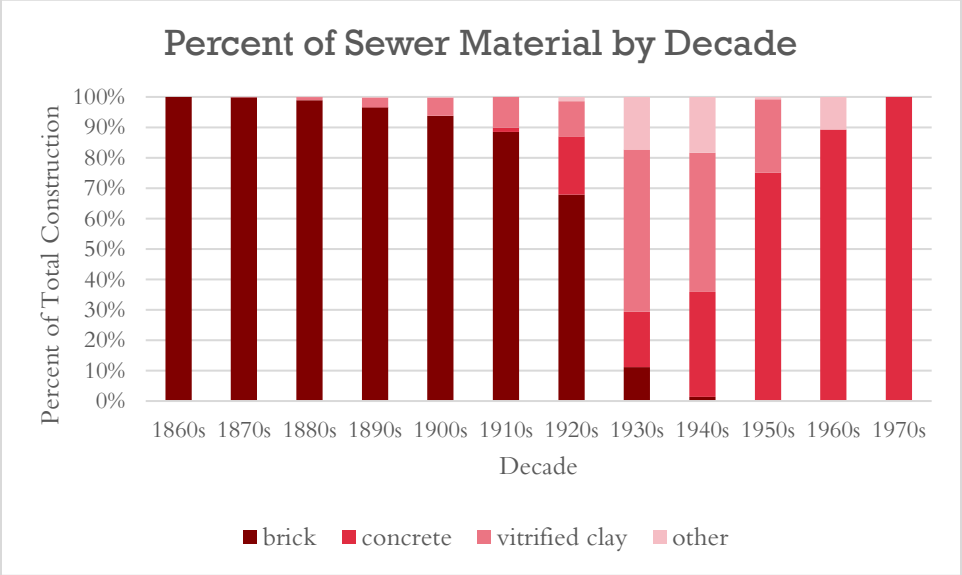

Figure 49. Graph of Sewer Material Percentage of Total Length versus Decade
Data sourced from the Camden Sewer Notebooks

[181] Division of Capital Improvements and Project Management, "Camden Sewer Notebooks."

Shape

The shape or cross section of Camden sewers is inferred from measurements in the Camden Sewer Notebooks. If only one dimension is provided, the sewer is presumed to be circular. If two different dimensions are recorded, the sewer is presumed to be elliptical, which encompasses the possibility that the shape could be egg, flat-bottomed, horseshoe, or similar. Some sewers could be square or rectangular, however. Ground-truthing or monitoring of sewers during rehabilitation would be necessary to confirm this. Of the brick sewers in Camden, 49% are circular and 51% are elliptical. Until the 1880s, most brick sewers were circular, but in the 1890s, there was a shift to elliptical sewers (Figure 50). After the 1910s, more circular sewers were built each decade, until there were no more elliptical sewers constructed, starting in the 1940s. The shift back to circular sewers was not because the techniques for brick sewers changed, but because the types of materials used changed. Instead of brick sewers, contractors shifted towards concrete, metal, and, eventually, plastics.

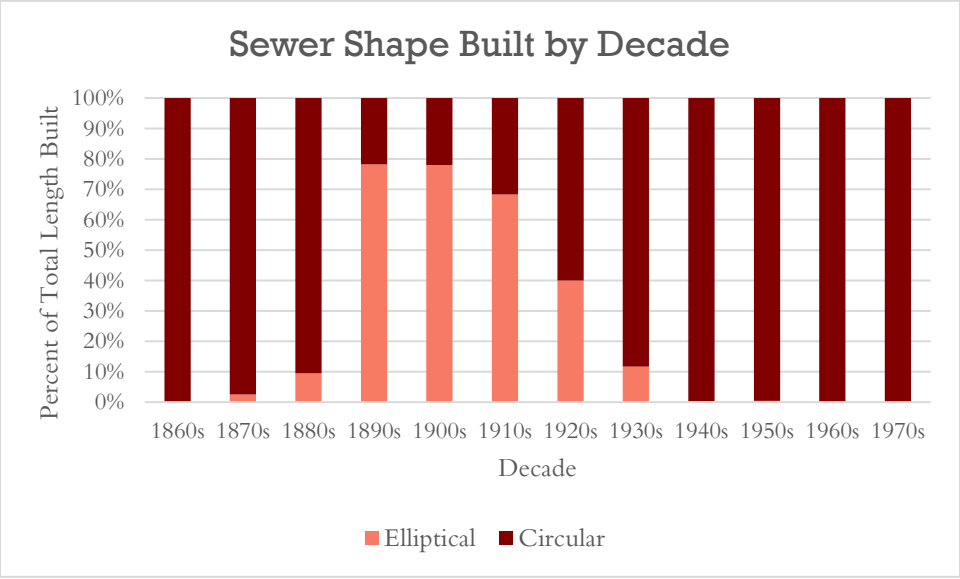

Figure 50. Sewer Shape Built by Decade
Data sourced from the Camden Sewer Notebooks

While almost all concrete and clay pipe sections are circular, there are 585 feet of clay pipe and 2,544 feet of concrete sewers that are not. The single segment of elliptical clay pipe is a 15 by 22.5-inch pipe built beneath Mulford Street in 1930, while the concrete elliptical sewers were built between 1929 and 1951 in various parts of the city.[182] Elliptical sewers made of materials other than brick are certainly feasible. More investigation would be required to determine if these sewers truly represent an unusual pipe style.

Sizes

Circular brick sewers in Camden range in diameter from 7.5 to 72 inches. Over half (52.6%) of these are 36 inches, 15% are 48-inch, and 12% are 24-inch. Elliptical brick sewers have a maximum diameter of 126 inches. The size and shape of brick sewers appear to affect their durability; the ones with a diameter between 24 and 36 inches were repaired or replaced at a much higher rate than any other size range, even accounting for the frequency of each size. Proportionally, within this size range, more circular sewers needed to be repaired or replaced than elliptical. [183] It is not clear why this should be the case; further research is needed.

Cast iron pipes range between 6 and 48 inches in diameter, but 62% of cast iron pipes are 8-inch diameter, with smaller amounts of 6-inch (9%), 20-inch (9%), and 16-inch (8%) diameter pipes.[184]

Concrete sewers range from 6 to 90 inches in diameter. For circular concrete pipes, 15-inch, 30-inch, and 24-inch pipes are the most common. The few elliptical concrete sewers are primarily 22.5, 30. 35, and 60-inch in maximum diameter.[185] Elliptical concrete sewers are

[182] Division of Capital Improvements and Project Management, "Camden Sewer Notebooks."
[183] Ibid.
[184] Ibid.
[185] Ibid.

thought to be relatively uncommon, but they did exist. "Lock joint" pipe is recorded in the Camden Sewer Notebooks, and the Lock Joint Pipe Company did produce some egg-shaped concrete sewer pipes.[186] Therefore, monitoring of these sewers would be valuable to verify their shape and material.

Vitrified clay pipes range from 6 to 36 inches in diameter. The most common vitrified clay pipe diameters are 8 inches, 10 inches, and 12 inches. There are also 585 feet of elliptical clay pipe with a maximum diameter of 22.5 inches.[187] Further investigation is required to verify the sewer's shape and material.

[186] Division of Capital Improvements and Project Management, "Camden Sewer Notebooks."
[187] Ibid.

5. Archaeological Research

Wood, brick, stone, and unlined privy vaults have been excavated on urban sites in Camden and other cities. Privy vault and cesspit architecture, especially any pipes connecting them to buildings or sewers, have the potential to shed light on early, individualistic efforts to manage wastewater. Relevant archaeological resources include the privy vault or cesspit itself, associated artifacts, organic remains (including, for example, parasite remains) and fill, pipes, and associated structures for inflow and outflow. Abandoned privies and cesspits were sometimes filled with household debris and garbage, resulting in important, artifact-rich archaeological deposits that can be used to infer when municipal sewage systems became available.

Archaeological research has also been conducted on the sewer infrastructure of Camden and many other New Jersey cities, including Gloucester City, Trenton, New Brunswick, Hoboken, Weehawken, Union City, Jersey City, Newark, and Paterson (Table 3).

Table 3. CR Reports on New Jersey's Sewer Infrastructure

County	*City*	*Resource Name*	*Description*	*Sources*
Camden	Camden, Gloucester City	Camden and Gloucester City CSOs, wood and brick sewers		Pennington and Schopp, 1998
	Gloucester City	Gloucester City Sewers	Nineteenth century brick sewers	Howson, 1996
Cape May	Cape May Point	Cape May Point Sewers	1906 terra cotta sewers	P/RA Research, Inc., 1980
Essex	Newark	Newark Sewers	1854 brick sewers	McEachen et al., 2000
	Newark	Newark Sewers	1854 brick sewers	McEachen et al., 2003
	Newark	Newark Sewers		Boylan 1978

County	*City*	*Resource Name*	*Description*	*Sources*
Hudson	Hoboken, Union City	Hoboken, Union City Sewers	Twentieth century brick sewers	Modica and Walker, 2004
	Hoboken	Grand Street Sewer	Wood sewers	Cushman and McEachen, 2015
	Hoboken	14th Street and CSO H-7 Outfall Sewer	1880-1908 brick sewer, cast iron sewer	Moore et al., 2006
	Hoboken	Hoboken Sewers	1869-1880 wood box sewers	Abplanalp and Springate, 2006
	Hoboken	Hoboken Sewers	Pine wood sewers	Cushman et al., 2015
	Hoboken	Hoboken Sewers and Tidal Gate	1895 brick sewer and brick tidal gate with cast iron mechanisms	Wieczorek and Tomkins, 2012
	Jersey City	Jersey City Sewers	Sewers on Brown Pl, Princeton Ave, Linden Ave, were likely built 1887-1898	Grossman-Bailey, 2011
	Jersey City	Jersey City Sewers	19 Discontiguous Sewer Mains, Mix of brick, non-brick, and unknown	Bulger et al., 2019
	Union City	Kerrigan Avenue Sewer	Brick sewer constructed between 1900 and 1920	Scharfenberger, 2006
Mercer	Trenton	Lamberton Interceptor	1891/1892 brick sewer	Israel, 1976
	Trenton	Lamberton Interceptor	1891/1892 brick sewer	Hunter, 1982
	Trenton	Petty's Run	1870s stone and brick sewer	Hunter and Burrow, 2014
Middlesex	New Brunswick	Albany Street Sewer	1839-1840 stone sewer	Cosans, 1983
	New Brunswick	Lyle Brook	Nineteenth century brick and other sewers	Yost and Modica, 2003
Passaic	Paterson	Paterson Sewers	1874 brick sewer	Lore and Tomkins, 2008

In 1998, a Stage IA cultural resources survey of combined sewer outfalls in Camden and Gloucester City was conducted prior to improvements in the associated regulator chambers. Twenty-eight CSOs were evaluated in Camden (Table 4). Of these, seven of the ones that would be affected by construction were made of brick; monitoring and recording during construction was recommended.[188] In 2000, eleven of the CSO sites in Camden were tested using backhoe trenching. Several of these CSOs were ones that had been identified in 1998 as containing brick sewers. However, none of the trenches exposed the sewers, and the sewers were not discussed as part of the analysis.[189] In 2009 and 2010, six CSO sites identified as having brick sewers either underwent further testing or were monitored during construction. Of these, two contained wooden box sewers and four contained brick sewers. Only one site, C09/14, did not have any historic sewers in it.[190]

Table 4. Archaeological Reports from the City of Camden

CSO	*Location*	*Methodology*	*Results*	*Notes*	*Sources*
C09/14	Second and Benson Sts.	Monitoring	Concrete sewer complex	Not culturally significant	Zerbe, 2009
C05/10	Kaighns Ave. and Front St.	Stage IB	No intact historic cultural features found		Reninbold et al., 2009
C05/10	Kaighns Ave. and Front St.	Monitoring	Brick sewer, wooden box sewer found	Brick sewer destroyed during construction	Zerbe, 2009
C16/23	Linden and 11th Sts.	Monitoring	Oval-shaped brick sewer	Sewer remains in use	Zerbe, 2009
C02/08	South 2nd St. and Jefferson Ave.	Monitoring	Brick sewer, brick manhole, concrete tide chamber, concrete conduit, metal water main, concrete pipe	Brick sewer destroyed during construction	Zerbe, 2009

[188] Pennington and Schopp, *Stage IA Cultural Resources Survey*.
[189] Gregory Lattanzi and Charles Bello, *Phase IB Archaeological Investigation: Camden CSO Project, City of Camden and Gloucester City, Camden County, New Jersey*, (Cultural Resource Consulting Group, 2000).
[190] Nancy Zerbe, "Monitoring report for the Combined Sewer Overflow Project, CSO Site C09/14. ARCH2. Letter submitted to Elizabeth Davis, NJDEP," September 10, 2009; Reinbold et al., *Phase IB Archaeological Investigation*.

CSO	*Location*	*Methodology*	*Results*	*Notes*	*Sources*
C19/24	Pine St. and Magnolia Ave.	Monitoring	Abandoned brick sewer, modern concrete sewer		Zerbe, 2010
C10/15	Arch St and Delaware Ave.	Monitoring	Brick paving, wooden box sewer, modern sewer pipe	Wooden sewer heavily damaged, possibly by modern sewer construction	Zerbe, 2009
C05/10	Kaighns Ave. and Front St.	Stage IB Addendum		Video inspection of wooden sewer	Zerbe, 2010
	Cooper Street		Wood-lined privy pits		Affleck et al., 2012

In 2001, video footage and photographs were taken of brick sewers prior to and during a reconstruction project (Figure 51, Figure 52).[191] It was determined that, while the entire sewer system may be eligible, the reconstruction would have no effect because the segments slated for rehabilitation had collapsed or were seriously damaged and had lost their integrity.[192]

[191] WRC/D&B Environmental Engineers, *Sewer Reconstruction Project, Various Locations City Wide, City of Camden, New Jersey, Project No. S340641-01*, (WRC/D&B Environmental Engineers, 2001).
[192] Elizabeth Davis, "Memo to David Hung, BES-DS," (New Jersey Department of Environmental Protection, Trenton, New Jersey, July 12, 2001).

Figure 51. Brick Sewer under 9th Street, from Pearl to Vine
Source: WRC/D&B Environmental Engineers, Sewer Reconstruction Project, Various Locations City Wide, City of Camden, New Jersey, Project No. S340641-01, (WRC/D&B Environmental Engineers, 2001).

Figure 52. Brick Sewer under Liberty Street, from Haddon Ave to Green Street
Source: WRC/D&B Environmental Engineers, Sewer Reconstruction Project, Various Locations City Wide, City of Camden, New Jersey, Project No. S340641-01, (WRC/D&B Environmental Engineers, 2001).

In 2010, as part of a combined sewer outfall replacement project, a brick sewer and a wooden box sewer were uncovered along Kaighns Avenue, between Front Street and the Delaware River.[193] Based on the location and size, the brick sewer was likely built in 1915 to replace a sewer originally constructed in 1870. The original contractor was John Ambruster, and the second contractor was Aaron Ward. At the western end of the brick sewer was a wooden sewer box of unknown length that appears to have been constructed in two parts. The point where the wooden box sewers and the brick sewer met is over 200 feet from the current shoreline, and the original wooden sewer is less than 30 feet long. The second section is interpreted as an addition constructed when a new ferry terminal extended into the river around 50 feet from the original shoreline. Based on this interpretation, the extension would have been built in 1880, well before the brick sewer was rebuilt. The wooden sewers had evidently undergone repairs at some point, possibly at the same time as the sewer replacement in 1915.[194] There is no entry in the Camden Sewer Notebooks for this outfall.

[193] Zerbe Nancy, "Monitoring report for the Combined Sewer Overflow Project, CSO Site C05/10. ARCH2, Letter submitted to Elizabeth Davis, NJDEP," August 24, 2009.
[194] Reinbold et al., *Phase IB Archaeological Investigation Addendum.*

The Smith-Maskell site (28CA124) is in the backyards of 312, 318, and 322 Cooper Street and partly within the Cooper Street Historic District. Among the features excavated were wood-lined box privies, barrel privies, and a brick-lined shaft privy. Three wooden privies (Features 3, 4, 35) were associated with a dwelling at 318 Cooper Street constructed around 1810 and in use during the early nineteenth century. A 10-foot by 10-foot brick shaft privy (Feature 31) was likely built in the mid-nineteenth century and may have been shared with the adjacent dwelling at 312 Cooper Street. Artifacts found in this feature dated between 1869 and 1924. A second brick shaft feature (Feature 49) had a metal drainage pipe in its northwest quadrant that was oriented towards a corner of the building at 312 Cooper Street and may have served to drain household wastewater after the advent of indoor water service (by the 1850s) but before the sanitary sewer system was established.[195] Cooper Street between 3rd and 4th Streets had a sewer by 1863, the earliest recorded in the Camden Sewer Notebooks.

As part of a 2018 project to install cured-in-place lining in the Cooper Street Sewer west of Delaware Avenue, a 72-inch diameter brick sewer was recorded.[196] The top of the sewer had been truncated and covered with a flat concrete slab. In one section, wooden beams had been placed across the bottom of the sewer with the ends inserted into holes in the sewer wall. The Camden Sewer Notebooks indicated that the original sewer at this location had been built in 1881, was made of brick, and was 6 feet in diameter. The Camden Sewer Notebooks also noted that it had been repaired, and possibly extended, in 1925. The concrete slab is probably related to this repair work. The purpose of the beams is unknown; possibly they were used as support for

[195] Affleck et al., "*A Bright Pattern of Domestic Virtue and Economy,*" 4.48.
[196] Camden County Municipal Utilities Authority, Upgrades to Camden City's Combined Sewer Overflow System Sewer Photos, Project No. 340640-22, (2018).

scaffolding or the sewer itself during repairs and mistakenly left in place. Since they were blocking the flow of the sewer, they are to be removed during this project.

As part of a project to reduce combined sewer overflows in the City of Camden, investigations in 2020 included CSO 24, located at Buren Avenue and North 27th Street. A brick outfall dating to 1906 was identified and documented, before being demolished and replaced with new concrete pipe because it was partially collapsed. Excavation of the pipe revealed 60 feet of historic brick pipe, constructed of double-later brick, 54 inches in diameter, and circular in shape. The excavation also revealed the wooden shoring which was used for the original installation of the pipe.[197]

[197] Johnson, Mirmiran and Thompson, Inc., *Combined Sewer Overflow (CSO) C24 Archaeological Monitoring Report, Camden City Municipal Utilities Authority (CCMUA) Dredging of Camden City's Combined Sewer Overflows to Reduce Combine Sewage Flooding (Project No. 340640-23), City of Camden, Camden County, New Jersey*, (Prepared by Johnson, Mirmiran and Thompson, Inc. for Camden City Municipal Utilities Authority, 2020), i, 10.

6. National Register Eligibility

The National Register of Historic Places (NRHP) is a list of significant prehistoric and historic districts, sites, buildings, structures, and objects. The National Register Criteria for Evaluation (36 CFR Part 60.4) was developed to assist in the evaluation of properties that may be eligible for inclusion in the NRHP. In order to be listed or eligible, a property must be significant and retain integrity.

> The quality of significance in American history, architecture, archaeology, engineering, and culture is present in districts, sites, buildings, structures, and objects that possess integrity of location, design, setting materials, workmanship, feeling, and association, and
> A. that are associated with events that have made a significant contribution to the broad patterns of our history; or
> B. that are associated with the lives of persons significant in our past; or
> C. that embody the distinctive characteristics of a type, period, or method of construction or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or
> D. that have yielded, or may be likely to yield, information important in prehistory or history.

To be listed on the NRHP, the resource must retain its integrity, which is evident in its historic qualities including: location, design, setting, materials, workmanship, feeling, and association.[198] Properties can be nominated as sites, historic districts, or as part of a Multiple Property Submission (MPS). A historic district is a geographical boundary that contains historic properties that have similar or related architectural characteristics, cultural cohesiveness, or any combination of the aforementioned.[199] A historic district is nominated en bloc and any additional buildings determined to be contributing can be added later, by extending the contiguous boundary if they fall outside it. The MPS is a nomination organized by historical theme, geographical area, and chronological period. Any buildings, sites, structures, and objects that are nominated for an MPS

[198] National Register of Historic Places, "How to Apply the National Register Criteria for Evaluation. National Register Bulletin 15," (Washington, D.C.: National Park Service, 1997).
[199] National Register of Historic Places, "How to Apply the National Register Criteria for Evaluation. National Register Bulletin 15."

must fit within the existing thematic parameters to qualify for listing, otherwise the parameters will need to be modified as relevant properties are identified.[200] In an MPS, the properties can span the boundaries of a city, state, or the country.

Several sewer system components have been listed on the NRHP as individual structures, buildings within an MPS, and as a structure within a historic district that is part of a state-wide MPS (Table 5).

Table 5. NRHP listed sewer system infrastructure across the United States.

Location	*Category of Property*	*Resource Name*	*Applicable Criteria*	*NRHP #*
Providence, Rhode Island	Buildings in an MPS: Public Works and Utilities - Sewage Treatment Facilities in Providence, 1895-1935 Thematic Resource	Sludge Press House (Demolished)	A	88003104
		Chemical Building / Blower Building		88003106
		Return Sludge Pumping Station		88003105
		Washington Park Sewage Pumping Station		88003107
		Reservoir Avenue Sewage Pumping Stations		88003108
Seattle, Washington	Bridges, Trestles and Aqueducts in an MPS: Historic Bridges and Tunnels in Washington State Thematic Resource	Arboretum Sewer Trestle	C	82004229
San Germán, Puerto Rico	Structure: Los Tuneles de San Germán; Vaulted Brick Tunnel Storm-Sewer System	Alcantarilla Pluvial sobre la Quebrada Manzanares	A, C	90000552
Houston, Texas	District: Willow Street Pump Station Historic District	Willow Street Pumping Station	A	04000547

[200] Camden currently has one MPS, titled "Banks, Insurance, and Legal Buildings in Camden, New Jersey (1873-1938) MPS," which was nominated in 1990. This MPS is bound by the boundaries of the City of Camden and contains 19 listed buildings that represent "Camden's historic role as the legal and financial center of South Jersey," from the Panic of 1873 to the eve of World War II. The nomination listed criteria for four building types.

Location	*Category of Property*	*Resource Name*	*Applicable Criteria*	*NRHP #*
Washington, D.C.	Building: Main Sewerage Pumping Station	Main Sewerage Pumping Station	A, C	12000297
Des Moines, Iowa	Structure in a Historic District in an MPS: Civic Center Historic District in The City Beautiful Movement and City Planning in Des Moines, Iowa, 1892-1938	River Walls	C	88001168

Additional sewer infrastructure in several states has been determined eligible for the National Register (Table 6). A comprehensive list is not available, but in addition to those in New Jersey includes:

Table 6. NRHP eligible sewer system infrastructure across the United States.

Location	*Category of Property*	*Resource Name*	*Detail*	*Applicable Criteria*	*Sources*
Seattle, Washington	Structure: The Lake Union Sewer Tunnel	The Lake Union Sewer Tunnel	6-foot diameter brick tunnel	A, C	Sheridan, 2012
Los Angeles, California	Structure: Harris Place Sewage Pumping Plant	Sewage Pump Station #669	2nd oldest pumping plant in LA	A, C	Murray et al., 2011
Tarrytown, New York	Structure: Tarrytown Sewage Treatment Plant	Tarrytown Sewage Treatment Plant	Partially funded by PWA during the Great Depression	A, C	Jennings, 2011
Queens, New York	Structure: Tallman Island Water Pollution Control Plant (WPCP)	Tallman Island WPCP	First plant in the US to treat sewage with the step aeration process	A, C	Blasland, Bouck & Lee, Inc. and Tams Consultants, Inc., 2006
Denver, Colorado	Structure: Delgany Street Public Sanitary Sewer	Delgany Street Public Sanitary Sewer	Brick sewer constructed by Italian masons	D	Mead & Hunt, 2017

Location	*Category of Property*	*Resource Name*	*Detail*	*Applicable Criteria*	*Sources*
New Orleans, Louisiana	Historic District: New Orleans Drainage System District	New Orleans Drainage System	Drainage Pumping Stations; Drainage System	A, C	Maygarden et al., 1999
Des Moines, Iowa	Structure: 8-foot by 6-foot brick sewer		Known as Bird's Run Drain		Magel, 2017

Criterion A

Some of the sewerage sites that are eligible for or listed on the NRHP have been found to be significant under Criterion A, which defines significance by a property's association with events that have "made a significant contribution to the broad patterns of our history."[201]

The Alcantarilla Pluvial sobre la Quebrada Manzanares in San Germán, Puerto Rico is a vaulted brick tunnel stormwater sewer system that was constructed to cover a naturally occurring stream. Individual landowners constructed the system in piecemeal fashion from 1835 to 1918. Under Criterion A the system is significant to the development of the San Germán community, which was regularly threatened by the possibility of the local stream flooding. The construction of the sewer system mitigated the threat and the community flourished.[202]

The Washington Park Sewage Pumping Station in Providence, Rhode Island is significant under Criterion A, along with the other properties listed under the thematic resource "Public Works and Utilities - Sewage Treatment Facilities in Providence, 1895-1935." The construction

[201] National Register of Historic Places, "How to Apply the National Register Criteria for Evaluation. National Register Bulletin 15."
[202] Héctor Santiago and Luis Pumarada, *National Register of Historic Places Nomination: Alcantarilla Pluvial sobre la Quebrada Manzanares*, (San Juan, Puerto Rico: Puerto Rico Historic Preservation Office, 1990).

of the system is associated with the local response to the residential and industrial expansion taking place within the city.[203]

The Lake Union Sewer Tunnel in Seattle, Washington was deemed eligible under Criterion A "for its association with the development of the city of Seattle and its early infrastructure."[204] The Lake Union Sewer Tunnel was the first of its kind and was significant to the development of the city.[205] In contrast, over 3,000 feet of sewers in Seattle constructed between 1893 and 1963 were not considered eligible under Criterion A as "no significant events are directly associated with the linear structures" as they were "just one component of a larger rebuilding program and are not considered individually significant."[206]

The New Orleans Drainage System was also deemed eligible under Criterion A as a district because of its connection to the urbanization of the city and its role in the genesis of sewerage infrastructure for New Orleans.[207]

The Tallman Island WPCP in Queens, New York, was designed by sanitary engineer Richard H. Gould and was the first plant in the United States to use the step aeration process. Five surviving structures dating from the plant's construction in 1939 were recommended as eligible under Criterion A for their association with biological treatment of sewage in the 1930s and Criterion C for their engineering design. Four other structures from 1939 no longer retained integrity. One structure dating from 1957 was recommended eligible due to its Modern design,

[203] M. H. Bowers, *National Register of Historic Places Nomination: Washington Park Sewage Pumping Station*, (Wellesley, Massachusetts: Louis Berger & Associates, Inc., 1987).
[204] Mimi Sheridan, *Lake Union Sewer Tunnel. National Register of Historic Places Registration Form*, (Sheridan Consulting Group, United States Department of the Interior, National Park Service, 2012).
[205] Seattle Department of Transportation, *Cultural Resources Technical Report for the First Avenue Sewer Rehabilitation. In Seattle Center City Connector Environmental Assessment, Appendix A-6*, (Seattle: Seattle Department of Transportation, 2017), 7-1, 7-2.
[206] Seattle Department of Transportation, *Cultural Resources Technical,* 7-1.
[207] Maygarden et al., "National Register Evaluation of New Orleans Drainage System," 89-91.

which included a spiral staircase enclosed within brick and glass. Other structures dating from 1957 or later were not exceptional and were not considered eligible.[208]

Brick sewers in Gloucester City, Jersey City, Newark, Paterson, and Trenton have been considered significant due to their association with municipal efforts for urban growth and public health.[209] The Lamberton Street Interceptor and Gloucester City Water Works Engine House were also found eligible under Criterion A.[210] Wooden sewers in Hoboken were determined eligible for listing based on their contribution to Hoboken's development.[211] The Kerrigan Avenue sewer in Union City is not individually eligible but would be a contributing element to the overall system, which may be eligible due to its role in decreasing city mortality rates.[212] Passaic Valley Sewerage Commission Newark Bay Outfall Sewerage Works was deemed eligible under Criterion A because of its association with United States public works, and its architectural and technological significance.[213]

Because a functioning sewer system is something that all American cities eventually constructed, they are all associated with the development of cities, urban growth, and public health. As such, not all sewer systems would meet the standard of having "made a significant contribution to the broad patterns of history." Because they are ubiquitous, only certain sewer systems might be eligible under Criterion A because of their association with an early, innovative, or influential design or implementation. These might include the systems in Brooklyn, Chicago,

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[208] Blasland, Bouck & Lee, Inc. and Tams Consultants, Inc, *Environmental Assessment Statement, Tallman Island TI-2/TI-3 Water Pollution Control Plant Plant Upgrade*, (New York City: New York City Department of Environmental Protection, 2006), A-24.
[209] Modica and Walker, *Stage IA Cultural Resources Survey*, 4-17.
[210] Israel, *Report on the Identification of the Historic and Prehistoric Cultural Resources Along Lamberton Street Southerly of Cass Street, Trenton, Mercer County New Jersey*; Howson, *Cultural Resource Inspection of Market and Hunter Street Sewer Reconstruction, Gloucester City, Camden County, New Jersey.*
[211] Raes et al., *Archaeological Monitoring*, 1-1.
[212] Modica and Walker, *Stage IA Cultural Resources Survey*, i – ii, 4-18.
[213] Tomaso, *Phase IA Cultural Resource Reconnaisance, Passaic Valley Sewerage Commission, Newark Bay Outfall Sewerage Works, City of Newark, Essex County, New Jersey.*

Jersey City, and Memphis. In many cities, sewer systems were constructed by following generally accepted practices and using generic or common designs, and therefore would not be eligible under Criterion A.

Criterion B

We have found no previous determinations of sewers eligible under Criterion B. A property found eligible under Criterion B must demonstrate that it is associated with a significant individual, but the National Register recognizes contributions by engineers under Criterion C, as they are "often represented by their works," with their residences and studios as recognizable under Criterion B for the personal connection to their productive life.[214]

Criterion C

Many properties determined to be eligible under Criterion A are also eligible under Criterion C, as they are not only associated with the broad patterns of our history, but also embody the distinctive characteristics "of a type, period, or method of construction or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction."[215] Sewers in some cities could potentially be eligible because of their association with significant engineers or city planners, such as Julius W. Adams, E. S. Chesbrough, Rudolph Hering, Alexander Potter, George E. Waring, Jr., or William Scollay Whitwell.

The Alcantarilla Pluvial sobre la Quebrada Manzanares has significance under Criterion C as it includes the oldest bridge in San Germán and a railroad culvert dating to 1892 and

[214] National Register of Historic Places, "How to Apply the National Register Criteria for Evaluation. National Register Bulletin 15," 15.
[215] National Register of Historic Places, "How to Apply the National Register Criteria for Evaluation. National Register Bulletin 15."

demonstrates a wide range of construction techniques and materials that created a cohesive structure to remove stormwater. Though the structure was constructed piecemeal, it is considered a single structure both because the larger drainage system functions as a single entity and because of the difficulties in tallying significant individual structures due to the numerous shifts in construction techniques and the lack of historical data that would otherwise guide identification.[216]

The Lake Union Sewer Tunnel in Seattle was determined eligible under Criterion C as a "good example of a nineteenth-century brick-lined sewer tunnel with original materials design and workmanship," and the Tallman Island Water Pollution Control Plant (WPCP) in New York City was determined eligible because of its engineering design.[217] The New Orleans Drainage System was determined eligible under Criterion C because of the architectural and engineering challenges unique to New Orleans including the need to have a system that drained land that was located below sea level and conveyed the drained water to a point at or above sea level, handled minor rainfall as well as storm rainfalls, and caused as little pollution as possible to Lake Pontchartrain.[218]

Brick sewers in New Jersey, including the Trumbull Street Sewer in Elizabeth, have been found eligible under Criterion C due to their distinctive construction that is representative of nineteenth century sewers in northeastern United States cities.[219] Parts of the Jersey City brick sewer system were significant feats of engineering related to the construction of the first integrated

[216] Santiago and Pumarada, *National Register of Historic Places Nomination*, 8-4.
[217] Sheridan, *Lake Union Sewer Tunnel*; Blasland, Bouck & Lee, Inc. and Tams Consultants, Inc, *Environmental Assessment Statement, Tallman Island TI-2/TI-3 Water Pollution Control Plant Plant Upgrade.*
[218] Maygarden et al., "National Register Evaluation of New Orleans Drainage System," 79, 92-93.
[219] Dorothy Guzzo, "SHPO Opinion, Trumbull Street Sewer, Elizabeth, New Jersey. NJ State Historic Preservation Office. Letter submitted to Edward Hummel, US EDA, 10 September," (1999).

sewer system in the country.[220] Wooden sewers in Hoboken were considered eligible for listing based on their rarity and their contribution to the development of Hoboken.[221] The Passaic Valley Sewerage Commission Newark Bay Outfall Sewerage Works was deemed eligible under Criterion C because of its architectural and technological significance [222] and the Lamberton Street Interceptor was determined eligible as an achievement of individuals in Trenton's city services and public works, is representative of well-designed brick engineering structures and Trenton's industrial development.[223]

Sewer systems may embody distinctive methods of construction. Brick sewers became widespread and common relatively quickly in the mid-to-late nineteenth century before being almost completely replaced by concrete and other materials. While they are restricted to a narrow time period of 50 to 100 years, for many decades brick sewers were ubiquitous. Therefore, the mere presence of brick sewers during the period of their greatest use, particularly the late nineteenth century and early twentieth century, would not alone make them eligible. Specific sewer components may, however, be eligible under Criterion C if they embody especially high-quality design and workmanship, or innovative solutions to unusual design or engineering problems. In these cases, a whole city sewer system is unlikely to be eligible (with certain exceptions, such as Jersey City and Newark), but specific components may be (such as the Line Ditch in Camden, or the Lamberton Interceptor in Trenton). On the other hand, some city sewer systems may be eligible if the aggregate value of the components raise the significance of the system as a whole, as seen in the Alcantarilla Pluvial sobre la Quebrada Manzanares.

[220] Lembo and Diker, *Stage IA Cultural Resource Survey*.
[221] Raes et al., *Archaeological Monitoring*, 1-1.
[222] McEachen et al., *Cultural Resources Investigation*, 7-31.
[223] Israel, *Report on the Identification of the Historic and Prehistoric Cultural Resources*.

Criterion D

Properties that have yielded, or may be likely to yield, information important in prehistory or history have significance under Criterion D. Bulger and colleagues have stated that the early Jersey City Brick sewers are eligible under Criterion D in the area of Engineering, as the system has potential to yield knowledge about the implementation, construction, and alteration of the 1853 Sewerage Plan.[224] Cultural resource surveys have frequently recommended archaeological monitoring and documentation of historic sewers, which indicates that additional information can be gleaned from them. Previous monitoring efforts in New Jersey have documented some unusual or unique sewer components, including sewers that combine multiple materials, such as brick and stone.

Integrity

To be listed on or eligible for the National Register, the resource must retain its integrity, which is evident in its historic qualities including: location, design, setting, materials, workmanship, feeling, and association.[225]

Location

Intact brick sewers will, by their nature, retain integrity of location. It would be difficult, if not impossible, to move a brick sewer without destroying it. Other types of sewer pipes are more mobile, at least theoretically, and water pipes have been dug up and reused elsewhere. Generally, to maintain integrity of location, the sewer must be in its original location.

[224] Teresa D. Bulger, Philip A. Hayden, Michael J. Gall, and Lauren Lembo, *Stage II Cultural Resources Survey, Jersey City Municipal Utilities Authority, Sewer Phases 1-2 Sewer Rehabilitation*, (Cultural Resources Survey, RGA, Inc., Submitted to Mott MacDonald, 2019), 5-8.
[225] National Register of Historic Places, "How to Apply the National Register Criteria for Evaluation. National Register Bulletin 15."

Design

The aspects of design for a sewer include the size and shape of the pipes, the angle at which they were installed, and their configuration with respect to adjoining pipes. The matrix in which the pipe is installed is part of the design as well, as the bedding and the fill surrounding the pipe provide important structural support. In order to retain integrity of design, these aspects must be present in their original form.

Setting

Since sewers are a largely underground resource, setting is not a vital aspect of integrity. In situ sewers and sewers that are still operational presumably retain their setting.

Materials

A sewer must retain integrity of materials to contribute to the overall eligibility of the system. Repairs to existing pipes that allowed the pipes to continue to fulfill their function would not necessarily reduce the integrity of the resource. When old sewers are replaced, the new pipes are often put in the same place. However, the new pipe is generally made of more modern materials, and it may be a different size or shape. New pipes therefore do not contribute to the overall eligibility of the system. However, while replacement of sections of old pipes will reduce the integrity of a system, it will not necessarily have a significant detrimental effect to make a previously eligible sewer system ineligible.

There are repair techniques for pipes that involve the addition of material. Cured-in-place piping (CIPP) uses a resin-impregnated cloth tube that is inserted into a sewer and hardened into a strong, water-tight pipe that is self-supporting and does not require load on the original sewer. The CIPP resin is not adhesive, thus it does not damage the original sewer, which remains in place. This method was used to reinforce Newark's National Register-eligible brick sewers. Since

CIPP is nondestructive and allows the pipe to retain its original use, its installation is not considered an adverse effect and "future historians will be able to cut out pieces of the CIPP and gain access to the original sewer with little difficulty."[226]

The Washington Park Sewage Pumping Station is demonstrative of the flexibility of material integrity in nominations to the NRHP. The major alterations that were made included the filling in of windows, replacing the original clay tile roofing with composition shingles, and replacing the original pumps in the late 1970s. Since the alterations did not impact the pump stations ability to perform its historical functions in "essentially the same manner" for which it was built, the structure does retain overall integrity.[227] The pump station is a system, and replacing individual components of the larger system does not compromise its material integrity.

Workmanship

Workmanship is defined as "the physical evidence of the crafts of a particular culture or people during any given period in history or prehistory."[228] Workmanship of a property can be defined by its usage of common tradition or a demonstration of innovative construction techniques. Constructing the sewers, especially the brick sewers, took techniques used in above-ground structures and adapted them to below ground pipes. Thus, it is an important consideration for brick sewers. These sewers were assembled by hand, and there were varying construction techniques, including the bond used, the number of courses laid, and so on. Individual craftsmen would have varied in expertise as well, and it is possible that only experienced bricklayers would have worked on specific parts of the sewer pipe. The workmanship might have been impacted by

[226] Brett Hansen, "Newark's Brick Sewers Reinforced with Cured-in-Place Pipe," *Civil Engineering News:* 2005, 27-28.
[227] Bowers, *National Register of Historic Places Nomination: Washington Park Sewage Pumping Station*, 2-3.
[228] National Register of Historic Places, "How to Apply the National Register Criteria for Evaluation. National Register Bulletin 15," 46.

the variations in the quality of the brick, resulting in the use of commercially produced brick sourced from different factories or possibly bricks made on site, as suggested by Aaron Ward's patent for a brick press.

Repairs, by their nature, impact the workmanship of the pipes. Repairs are necessary for the continuing function of sewers, but they must be undertaken in the understanding that the difference between repair work and replacement is often just a matter of degree. Interventions like CIPP respect the original workmanship but do not compromise the integrity. As CIPP does not add a substantial amount of new materials, and it does not interfere with the existing brickwork, the sewer would retain integrity of workmanship.

Feeling and Association

Feeling is not an important aspect of integrity for sewers since they are not meant to be seen.[229] Nineteenth-century sewers are associated with the Sanitation Movement, but that association will be retained if sewers are used for their original purpose. Sanitation infrastructure may also be associated with historic districts in which they were built. There may be different levels of association, for sewers that were built at the same time as their related districts, as part of planned communities, or for sewers that were built after the period of significance of the district, in an established neighborhood. In these cases, consideration should be given to the impact that sewer development had on the neighborhood and to whether sewers were a common part of urban infrastructure or were advertised as a new amenity.

[229] Sewer systems are part of the invisible city, urban infrastructure that keep cities functioning and are out of sight. Components of the invisible city are often seen above ground. For sewer systems this includes manholes and storm drains.

Evaluating the City of Camden's Sewer System

Camden's sewers retain their integrity of location, design, setting, materials, and workmanship. The sewer system can be considered further for nomination, through four separate approaches, including as a city-wide historic district, as specific components that are individually eligible, as a contributing resource to another historic district, and as an MPS.

Considering nominating the City of Camden's sewer system under Criterion A as a city-wide historic district conflicts with previous determinations about city-wide sewer systems. Criterion A determines significance as contributing to the "broad patterns of our history." In most cities, the sewer system had an important role in the history of the city and the development of public health. Based on existing evidence, the Camden sewer system as a whole was not designed as a coherent, city-wide system. This is not detrimental to the significance of the system as the Alcantarilla Pluvial sobre la Quebrada Manzanares was listed on the NRHP under Criteria A and C, even though the system was ad-hoc. Under Criterion A, the Alcantarilla Pluvial sobre la Quebrada Manzanares is significant because the construction of the sewer system mitigated the threat of the local stream flooding the community, and with the threat mitigated the community flourished. Camden's sewer system did not mitigate an environmental threat, though like many other sewer systems it was pivotal in the community flourishing.

Sewer systems in Seattle were determined not eligible since "construction of the downtown sewer lines is not a specific event that marks an important moment in history, but is rather a small component of a much larger historical trend" of "infrastructure improvements initiated after the Great Fire in response to a series of health and public safety crises that had

affected the whole country."[230] Similarly, as Camden grew and new areas were settled, sewers were constructed to respond to that development. Therefore, it is difficult to consider nominating Camden's sewer system under Criterion A as a city-wide historic district.

While data presented here indicate that parts of Camden's sewer system contributed to the early development of the city, it also suggests that Camden was rarely an early adopter nor innovator of sewer technology, including materials used in construction. Materials for the city's clay, concrete, and metal sewer pipes would likely have been purchased from large-scale manufacturers who also supplied many other municipalities. This leaves little room for distinction or innovation. The method of construction of brick sewers leaves more room for distinctive workmanship and design. The Camden Sewer Notebooks do not include information on any idiosyncrasies of brick sewer manufacture, and so more research would be needed to determine if Camden's contractors (who in at least some cases may also have been the designer) did, indeed, use unusual or experimental techniques.

The City of Camden's sewer system represents common and widespread methods of construction. Before the first brick sewer was constructed in Camden, it was a common construction material already used in other New Jersey cities including Elizabeth, Hoboken, Jersey City, Newark, Paterson, and Perth Amboy. The elliptical, egg-shaped, and circular brick sewers were adopted in Camden from innovations previously made in other cities by non-Camden engineers. While Camden's sewer system, as a whole, does not appear to be eligible for

[230] Seattle Department of Transportation, *Cultural Resources Technical Report*, 7-1.

listing on the National Register as a city-wide historic district, it is possible that specific sewer components, like the Line Ditch sewer, are individually eligible (Figure 53).

Figure 53. Line Ditch sewer as it was constructed by Aaron Ward in 1907
Data sourced from the Camden Sewer Notebooks

Nominating specific components that are individually eligible would come under Criterion C, which determines significance as "a type, period, or method of construction or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction." Due to their association with locally significant persons such as Aaron Ward, who constructed significant portions of Camden's sewer system, or because of distinctive methods of construction, such as the Line Ditch sewer, which was described as an engineering marvel at the time of its completion in 1907, the Line Ditch sewer can be considered a specific component that is individually eligible.[231]

In addition to Criterion C, Criterion D would apply to the nomination of Line Ditch sewer. Though no listed examples have been found, Bulger and colleagues have demonstrated that the early Jersey City Brick Sewers are eligible under Criterion D, in the area of Engineering. The Line Ditch sewer was constructed at a time when sanitary engineers were attempting to standardize sewer construction methodologies, relying on already constructed sewers for their recommendations of best practices. At a time when most sewers were constructed on timber bases, or cradles, with concrete or brick for the sewer, Aaron Ward used wooden pilings to secure the sewer in quicksand, in addition to concrete flooring which was poured onto a timber base,

[231] The term "engineering marvel" is not used by the National Register in its explanation of Criterion C. However, the term is used on the NPS website to describe many National Register sites throughout the country, including the Paterson Raceway (New Jersey), the Transcontinental Railroad (Utah), Buffalo Bill Dam (Wyoming), and the Northern Canal Walkway (Massachusetts). The term is also used by those submitting nominations of sites to the National Register of Historic Places, as seen in the nomination of the Cleveland Arcade.; "Aaron Ward Dies at 4-Score Mark," *Camden Courier*.

stone for its walls, and a brick arch. The completion of the Line Ditch sewer reclaimed nearly 100 acres of land fronting the Delaware River, with potential for both residential and industrial use.[232]

Specific components of Camden's sewer system may be contributing resources to another historic district, which would rely on the parameters of the defining characteristics to be considered a contributing resource. Listed historic districts in Camden include the Cooper Street Historic District, Cooper Grant Historic District, Fairview Historic District, and South Camden Historic District. Eligible historic districts include the Camden Circular Buildings Historic District, Cooper Plaza Historic District, Market Street Historic District, Parkside Historic District, and State Street Historic District. Sewer infrastructure may be a contributing element of planned communities like Fairview Village, where the sanitation system was an integral part of the original community design.[233] However, for other listed or eligible historic districts where it cannot be demonstrated that the sewer system was the defining characteristic of the historic district, it would not be a contributing resource.

Originally known as Yorkship Village, Fairview Village was built during World War I to house workers of the New York Shipbuilding Corporation (Figure 56).[234] In 1974, Fairview Village was listed on the NJRHP and NRHP as Fairview Historic District. U.S. Shipping Board's Emergency Fleet Corporation (EFC) and U.S. Housing Corporation (USHC) adopted housing standards from Lawrence Veiller, a housing reformer in the early twentieth century. Included in Veiller's standards was the importance of sanitation not being managed through privies and cellar

[232] "Passing of Line Ditch in South Camden Means Much to that City," *Philadelphia Inquirer*, (Philadelphia: Philadelphia Inquirer, November 1, 1906).
[233] William H.C. Ramsey, "The Water Distribution System of Industrial Housing Projects for Shipbuilders," *American Water Works Association* 7 (1920): 239-263.
[234] All of Fairview Village was sewered at the time of its construction; however, the Camden Sewer Notebooks do not cover all sewer construction in Fairview Village.

water closets, which meant that a comprehensive sewer system had to be planned in conjunction with the design of Fairview.[235]

As part of the planning process of Fairview Village, the water supply was investigated to ensure that it was safe to consume and would be abundant.[236] Additional water supply studies looked to pipe size and material requirements to ensure that the pipes would have longevity and could maintain flow.

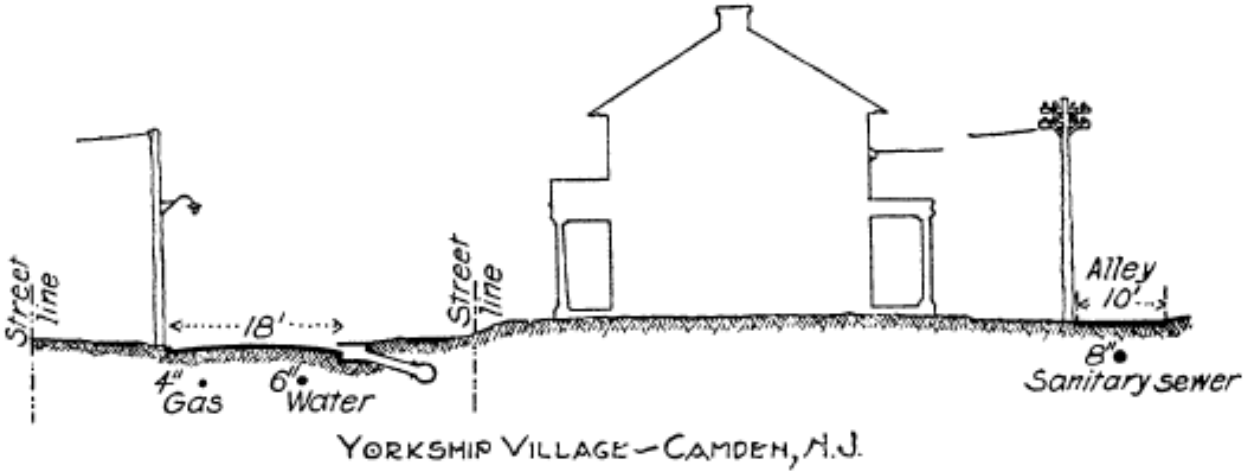

Figure 54. Cross-Section of Fairview Village
Source: William H.C. Ramsey, "The Water Distribution System of Industrial Housing Projects for Shipbuilders," American Water Works Association 7 (1920): 246.

In the cross-section of Fairview Village (Figure 54), the gas and water lines are located on the main roads, with the sanitary sewer system located at the rear of houses in the alley. In a 1920 study of four contemporaneous industrial housing projects for shipbuilders, this set-up is demonstrated as atypical and makes the planning of Fairview Village's infrastructure unique (Figure 55).

[235] Martha E. Heuser, *Camden Historic Survey, City of Camden, Camden County, New Jersey, Volume X-XV: South Section of Camden, Fairview Historic District*, (Cranbury: Richard Grubb & Associates, Inc., 2007), 16.
[236] Ramsey, "The Water Distribution System of Industrial Housing Projects for Shipbuilders," 243.

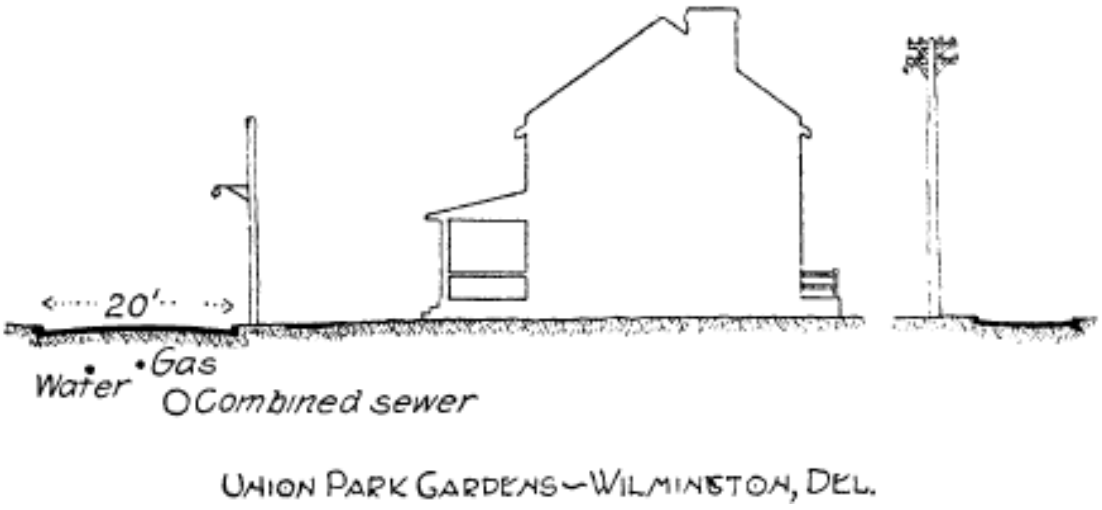

Figure 55. Cross-Section of Union Park Gardens
Source: William H.C. Ramsey, "The Water Distribution System of Industrial Housing Projects for Shipbuilders," American Water Works Association 7 (1920): 246.

Nearly all the historic districts have had their sewer systems constructed within their period of significance, with later additions appearing to fill gaps or reconstruct previous systems (Figure 56). Since national standards required the construction of a sewer system, at a time when privies were still common, in Fairview Village, it is a defining characteristic of the district. However, for other listed and eligible historic districts in Camden, the sewer systems are not contributing resources as they are not the defining characteristics of these districts. For example, South Camden Historic District is listed on the NJ and NRHP under Criteria A and C, for its associations with local events and popular architecture of the late nineteenth into the early twentieth century.[237] The local events that define South Camden Historic District include the annexation of the neighborhood into Camden, which resulted in the transition from wood frame construction to brick construction because of the City of Camden's fire code. Also, the growing industrialization within the neighborhood was significant to its growth. However, neither of these

[237] Martha E. Heuser, *Camden Historic Survey, City of Camden, Camden County, New Jersey, Volume XVI-XVII: South Section of Camden, South Camden Historic District*, (Cranbury: Richard Grubb & Associates, Inc., 2007), 9.

local events correlate directly with sewer systems, making it difficult to establish the sewer system as a defining characteristic of the historic district.

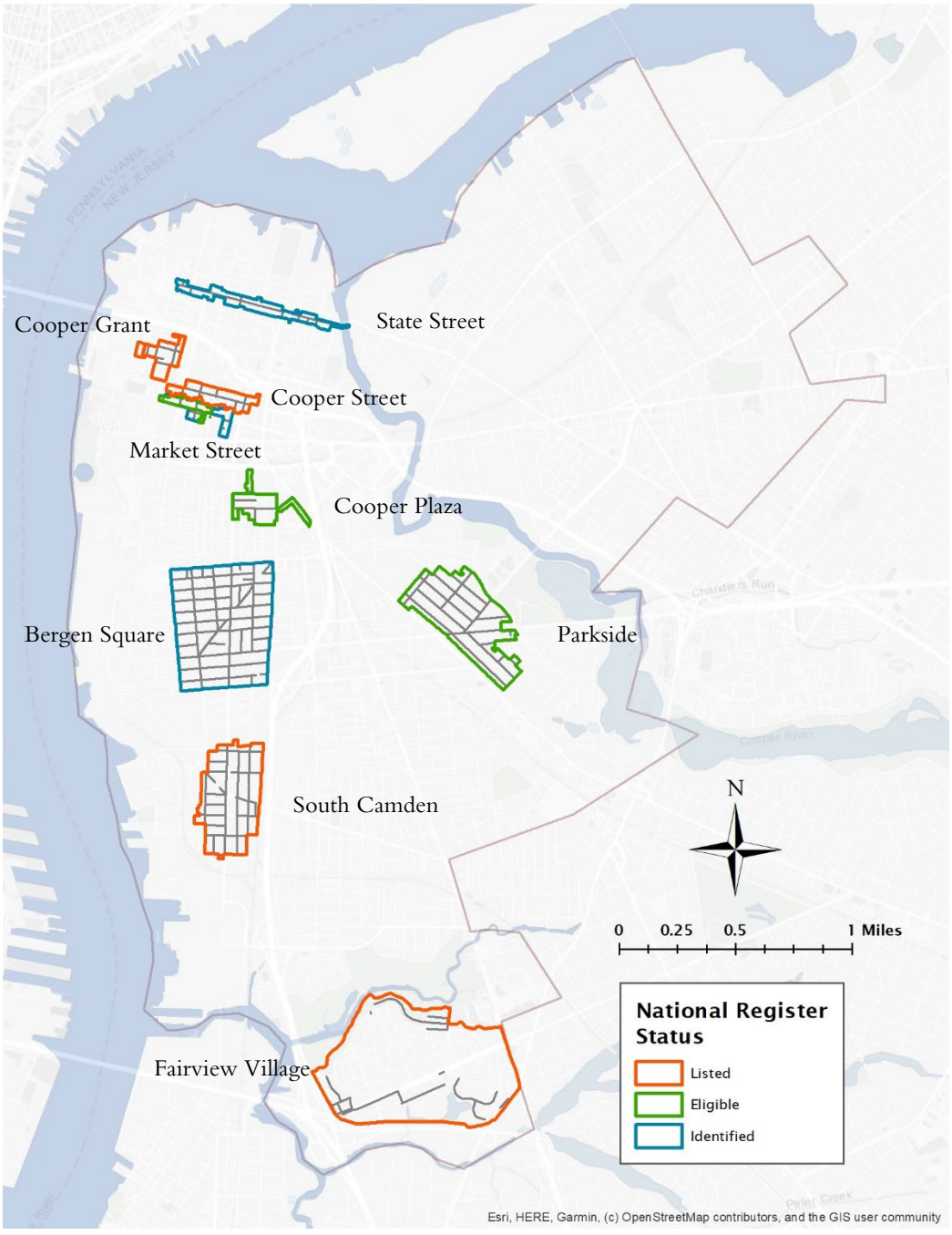

Figure 56. Known Sewer Construction in Select Listed, Eligible, and Identified Historic Districts
Data sourced from the Camden Sewer Notebooks and NJHPO

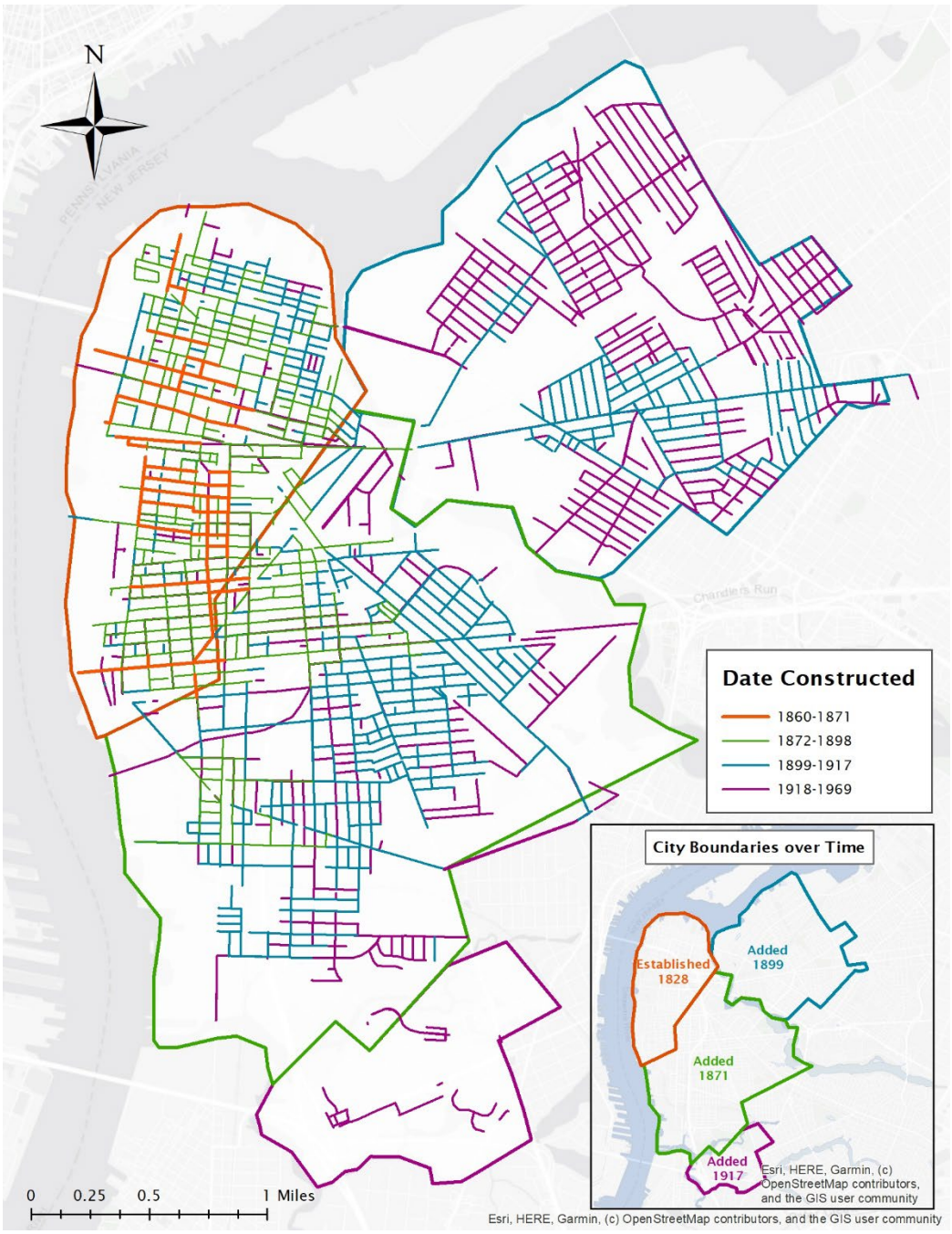

Figure 57. Map of Camden's Brick Sewers, organized by age
Data sourced from the Camden Sewer Notebooks

It is unlikely that Camden's brick sewers would constitute a Camden-specific MPS for the same reasons that the city's sewer system would not constitute a historic district (Figure 57). The creation of a state-wide MPS that encompasses early and notable sanitary and wastewater systems

of New Jersey could potentially include specific parts of Camden's system, as long as they fit the parameters of the historic theme, geographic distribution, and time period. The tentative geographical area would be the boundaries of the State of New Jersey, as early brick sewer infrastructure is found throughout the state. The time period for consideration could be 1845 to 1910, which would encompass the earliest sewer systems completed in New Jersey, most likely to have been made of brick. The latter nineteenth century also saw the transition away from brick as the primary construction material, giving way to early innovation in non-brick sewers. Throughout New Jersey, a limited number of cities are known to have brick sewers. The following survey encompasses data acquired from the *Report of the State Sewerage Commission, to the Legislature, Session of 1900* and the *Twenty-Sixth Annual Report of the Board of Health of the State of New Jersey (1902)* (Table 7).[238]

[238] New Jersey Sewerage Commission, *Report of the State Sewerage Commission to the Legislature, Session of 1900,* (Trenton: MacCrellish & Quigley, State Printers, 1900); New Jersey Board of Health, *Twenty-Sixth Annual Report of the Board of Health of the State of New Jersey, 1902,* (Trenton: The J.L. Murphy Publishing Co., Printers, 1903).

Table 7. New Jersey Cities known to have brick sewers prior to 1900

County	*City*	*Combined or Separate*	*Shape*
Bergen	Hackensack	Combined	Possibly circular, with some egg
Camden	Camden	Combined	Egg
Essex	East Orange	Separate	Possibly circular
	Newark	Combined	Egg and circular
	Orange	Separate	Egg
Hudson	Bayonne	Combined	Possibly circular
	Harrison	Combined	Circular
	Hoboken	Combined	Egg
	Jersey City	Combined	Egg
	Kearny	Combined	Possibly circular
	Union City	Combined	Egg
	Weehawken	Combined	
Mercer	Trenton	Combined	Egg
Middlesex	New Brunswick	Combined	
	Perth Amboy	Combined	Egg
Passaic	Passaic	Separate	Egg
	Paterson	Combined	
Union	Elizabeth	Combined	
Warren	Phillipsburg	Combined	Egg

Each of these systems, and other undiscovered early systems, could be evaluated for significance. As we continue this survey into the other cities in New Jersey that have brick sewer infrastructure, the parameters briefly discussed here have the potential to evolve. If we learn something new and significant, the above conclusions can be re-evaluated in the future.

7. Research Questions

Many questions remain about the sewer system of Camden, the relationship between the sewers and the development of the city. Some specific questions are below and can be answered through research and archaeological monitoring conducted during future projects.

Many scholars during the late nineteenth century and early twentieth century wrote about sewer construction methods and detailed the benefits of certain materials and forms, especially as they pertained to longevity. The diversity of sewer construction methods in conjunction with the data from the Camden Sewer Notebooks leaves unanswered questions about the specific techniques used in Camden's brick sewer construction.

1. In Ogden's 1908 text *Sewer Construction,* he does not recommend the use of hollow blocks as they could result in drainage into the subsoil, whereas using grooved blocks circumvents this problem.[239] Were hollow or grooved blocks used in Camden's brick sewers to separate ground water from sewage?
2. In Jersey City, Whitwell recommended the use of common brick instead of hollow radiated bricks for sewer construction. Was the same done in Camden?
3. Is there a difference in glazing on brick on the bottom vs the upper portions of the sewer? Are there other differences in the types of bricks, mortar, or other materials used?
4. Is there evidence for concrete or wood cradles and support under brick sewers, or of underdrain pipes?
5. Were iron straps used to reinforce the brick pipes?

If monitoring during construction reveals specific techniques from the above questions, those components will need to be re-evaluated for significance. Monitoring during construction will also reveal the internal diameter of the pipe, the thickness of the wall, the shape, the bedding or cradle the pipe sits on, and other relevant features.

[239] Ogden, *Sewer Construction*, 33-34.

The Camden Sanitary Code focused on sanitary solutions to address public health concerns, including the construction of privies too close to water supplies, privy construction to prevent leakage of sewage into the soil. It also recommended material choices and best practices for sewer construction.

1. The Camden Sanitary Code, revised in 1906, strongly recommended the use of good quality hard brick in the construction of the sewers. Since we know that Camden steadily started shifting to concrete in the 1890s, it would be interesting to know when the Sanitary Code shifted their recommendation to concrete for sewer construction.
2. In 1884, Onan B. Gross in his *Report of Special Sanitary Inspector for Camden, N.J., as made to the New Jersey Board of Health* noted that the city lacked funds to complete all necessary repairs. In C.C. Haven's 1897 report on the quality of Camden's sewers, Camden was reported to have had 122 breaks between 1891-1897.[240] Is there evidence of patching or other methods of sewer repair?

According to the Ordinances of the City of Camden, some companies were permitted to construct their own pipes.

1. In 1906, Key Stone Leather Company was permitted to lay a water pipe. In 1907, Camden "authorized and empowered" the PSC to lay down a terra cotta pipe, which was intended for sewer purposes. The pipe was to be no more than 15 inches in diameter, and would be from the Line Street culvert, northeast along Border Avenue through to Starr Avenue, then running east on Starr Avenue until it reached the car barns.[241] Are these pipes still in use?
2. Some factories/businesses (e.g. Victor Talking Machine) built their own water systems or sewers – do these differ from city-built ones and are they still in use?

Answering these questions will provide a nuanced understanding of brick sewer construction in Camden. Broader questions about sewer infrastructure in New Jersey and the United States will be addressed in a separate report. Areas determined to fit the criteria for monitoring include those known to have brick sewers, determined from our mapping of Camden's sewer system, or located in or adjacent to historic districts.

[240] Israel, *Report*, 53.
[241] City of Camden, *Compiled and Revised Ordinances of the City of Camden*, 523, 555.

8. Summary and Conclusion

Historically, sanitary and wastewater systems were vital to the health and development of cities following the Industrial Revolution, even though early cities had no systematic plans for sewage and stormwater management beyond privies, cesspits, and limited piecemeal drainage systems constructed by property owners. Due to the lack of systematic plans, the overcrowded cities did not have clean water or adequate waste removal, and experienced repeated epidemics of deadly diseases like cholera.

The Sanitation Movement grew because of these epidemics and increased awareness that disease and filth were linked.[242] Waterworks projects like the Camden Water Works Company arose to provide cleaner water to the city, but this led to an increase of the amount of water used by homes and businesses and therefore increased the amount of wastewater.[243] The increase in wastewater resulted in local and state governments taking responsibility for regulating and financing comprehensive city-wide sanitary sewer systems. Camden's sewer system, however, was not designed as one comprehensive system.

The earliest municipally owned sewer in Camden was built in 1860, but most of the sewer construction did not begin until Camden was preparing for the cholera epidemic in 1865.[244] Contractors including John Ambruster, and Aaron Ward were hired to construct Camden's sewer system piece by piece. The next major motivation for Camden to construct sewers was the Greater Camden Movement in the 1920s, which sought to consolidate the city with the surrounding municipalities to create an industrial and commercial powerhouse.

[242] Cowen, *Medicine and Health in New Jersey*, 82.
[243] Boyer, *The Public Utilities in Camden*, 4-6.
[244] Cammarota, *Changing Pattern*, 111; New Jersey Board of Health, "Twenty-Third Annual Report of the Board of Health of the State of New Jersey, 1899," 86; Stevenson, "A History of Medicine and Medical Men," 257.

Throughout this entire period, Camden primarily used brick to construct its sewers, with concrete and vitrified clay used for most of the remainder. Later in the twentieth century, concrete and PVC pipe became the most common materials for sewer pipes.

Brick sewers were classified as elliptical and circular, based on measurements in the Camden Sewer Notebooks. The distribution between the two categories is approximately 50/50, with most of the elliptical sewers constructed during our period of focus. The elliptical category may contain numerous shapes, such as egg-shaped, horseshoe-shaped, and so on. The combination of shapes and sizes are common and not unique to Camden, with smaller pipes serving residential and commercial units, larger pipes for interceptors, and elliptical sewers serving to increase the flow for the combined sewer system, as found elsewhere.

As this sanitary and wastewater sewer infrastructure ages, cities like Camden are prompted to replace, rehabilitate, and generally update their pipes. Due to their age, a cultural resources survey is often required to determine their NJ/NRHP significance. Existing surveys of sanitary and wastewater infrastructure throughout the United States inform us that these resources can be eligible under Criteria A and C. If the sewer infrastructure is determined eligible or listed, then agencies must consider project impacts. A majority of the components of the Camden sewer system are not individually eligible, excluding the Line Ditch sewer, unless they are contextualized within a historic district or as part of an MPS, as most of these components are neither innovative nor unique.

Researching the construction of sanitary infrastructure has raised many questions that our current knowledge of Camden is unable to answer. These questions can only be answered by monitoring Camden's brick sewers during construction, and accordingly, we have noted these questions for when the opportunity arises to learn more about Camden's sewer system. Any

answers that come out of monitoring will only strengthen our understanding of the infrastructure below Camden's streets.

This research on Camden will be used by the CR Team of the MFCE as we continue to evaluate projects with historic resources. We hope that other interested parties also find it to be a valuable planning and preservation tool.

To further explore the potential for a state-wide MPS, the next step is to conduct research into the list of brick sewer cities that was generated from the *Report of the State Sewerage Commission, to the Legislature, Session of 1900* and the *Twenty-Sixth Annual Report of the Board of Health of the State of New Jersey (1902)*. Our future research is also an opportunity to ask more questions and answer the broad strokes questions we have about sewer infrastructure.

Our research has raised as many questions about New Jersey's sewer infrastructure as it has answered about Camden's brick sewers. Answering these questions, both those specifically about Camden and those broadly about New Jersey, will be an ongoing process. However, we will develop a greater understanding of bricks as a material, ad hoc and planned sewer construction, and the many motivations that pushed New Jersey residents, lawmakers, and politicians to ensure more and more New Jersey residents had access to sanitary infrastructure.

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Appendix A

Timeline of Major Health Laws in New Jersey & US

Noted below is a brief timeline of some of the major health laws in both New Jersey and the United States.

Year	New Jersey	United States
1866	Sanitary Commission is formed to recommend prevention and mitigation measures	
1877	The State Board of Health is created out of the Sanitary Commission	
	State law passes requiring every municipality to have its own Board of Health	
1880	Sanitary Act	
1882	"An Act to authorize cities to construct sewers and drains and to provide for the payment of the cost thereof"	
1898	Joint Sewer Act	
1899	"An Act to secure the purity of the public supplies of potable water in this State"	
	The Enabling Act "provided for a joint meeting of two or more municipalities for the construction and maintenance of a trunk sewer"	
1900	"An act to authorize cities to issue bonds to obtain money to rebuild sewers"	
1948		Federal Water Pollution Control Act
1965	State Public Sanitary Sewerage Facilities Act, "whereby the State Commissioner of Health is authorized to make grants and loans for the preparation of feasibility studies and reports and the design of public sanitary sewerage facilities…to encourage and support promotion, planning, development and construction of public sanitary sewerage facilities, including sewage collection, transmission, treatment and disposal works on a regional or multi-unit basis."	Water Quality Act
1969		National Environmental Protection Act
1970	Creation of the New Jersey Department of Environmental Protection (NJDEP)	Creation of the Environmental Protection Agency (EPA)
1972		Federal Water Pollution Control Act (Clean Water Act)
1977		Federal Water Pollution Control Act (Clean Water Act) revised

Appendix B

Timeline of First Known Sewer Construction in New Jersey Municipalities

Year	City
1848	Jersey City
1852	Paterson
1854	Newark
1855	Elizabeth & Jersey City
1858	Hoboken
1859	Perth Amboy
1863	Camden
1866	Rahway
1870	Bayonne & Hackensack
1871	New Brunswick
1872	Harrison
1878	Cape May & Flemington
1880	Ocean Grove
1885	Asbury Park, Atlantic City, Long Branch, Orange, & Trenton
1886	Longport
1887	East Orange, Englewood, & Lakewood
1889	Belmar, Palisades Park, Philipsburg, Riverton, Salem City, & Somerville
1890	Passaic City
1891	Burlington, Princeton, & Summit
1892	Delford (now known as Oradell) & Rutherford
1893	Beach Haven, Freehold, Montclair, Ocean City, Riverside, & Washington
1894	North Spring Lake (now known as Spring Lake)
1895	Glen Ridge, Plainfield, Wenonah, & Westfield
1896	Allenhurst, Bogota, Bound Brook, & Pemberton
1898	Avalon, Bridgeton, Cranford, Deal, Red Bank, & South Amboy
1899	Cliffside Park, Collingswood, & Raritan Township (now known as Hazlet)
1900	Haddonfield, Ridgefield Park, & Vineland
1901	Swedesboro
1903	Irvington, Millburn, South Orange, Valisburg, & West Orange
1905	Dover
1907	Morristown
1909	Stone Harbor
1917	Palisades Park
1919	Carney's Point
1926	Metuchen
1957	Penns Grove
1959	Pennsville
1970	Rocky Hill