An Archaeological Survey of the Whiteport Cement Works

Dennis E. Howe

The ruins of an American hydraulic natural cement manufacturing company that operated in Rosendale, Ulster County, New York, provide the platform for a study of the beginning and development of an important predecessor of the enormous, modern cement industry. The accomplishments of Canvass White and his brother Hugh White are summarized with a description of early-19th-century methods for making cement. The archaeological survey recorded industrial surface remains within a larger area of ruins that represent the hamlet of Whiteport, New York, a company town. (Discussion of the nonindustrial ruins, which are known to include at least 30 dwellings, a school, a railroad station, a post office, and a store, is not included here.) The recorded industrial remains represent 14 structures or structure complexes constructed between c. 1850 and c. 1895 by the Newark and Rosendale Lime and Cement Company, which continuously produced natural hydraulic cement at the site (c. 1838–1902) from when it purchased the works of Hugh White until the market for natural cement collapsed. Included is a synthesis of the Newark and Rosendale Company's mill organization, manufacturing processes, transportation infrastructure, and cooperage. Whiteport was essentially abandoned soon after the company ceased making cement in 1902 and was never developed with later construction, which helped make it a valuable archaeological site for the study of the structures and artifacts of a very important historic American industry.

Introduction

No material is more important to modern architecture and civil engineering than concrete. Concrete's binder, hydraulic Portland cement, is the most consumed manufactured material in America today, indeed in the world.[1] Portland cement was not manufactured in quantity in America until the 20th century, yet hydraulic cement was a key component in the construction of canal systems, military installations, bridges, and public works through much of the 19th century when engineers and architects relied on a predecessor, American natural hydraulic cement, also generally known as Rosendale cement. The Rosendale cement industry collapsed at the beginning of the 20th century after the publication of standards and specifications that resulted in the adoption of Portland cement by most building codes.[2] Documentation of the above-grade archaeological remains of a Rosendale cement mill complex at Whiteport is presented here along with a synthesis of the manufacturing processes applied there, which began in the 1830s and continued until 1902. A brief history of the natural cement industry is also included. This focus on the Rosendale region near the Hudson River supplements the work of Thomas Hahn and Emory Kemp (SIA), who researched natural cement mill remains along the Potomac River in the early 1990s.[3] While some of the historic context published here may cover ground already studied by Hahn and Kemp, this article concentrates on the origins and growth of an industry that began with Canvass White who in 1820 patented his hydraulic cement manufacturing process. Manufactured from unique limestone found in New York, he used the new cement in the mortar of the masonry locks of the Erie Canal (see figures 1, 2).[4]

In modern times, a growing need within the historic preservation and restoration community for the most appropriate and traditional masonry materials has awakened a renewed interest in Rosendale cement.[5] Stimulated by this interest and as an extension of my research into historic concrete structures, I became involved in the archaeological study of the cement-manufacturing ruins in Whiteport, a hamlet near the town of Rosendale, Ulster County, New York, at the request of Michael Pavlov, the present-day owner of the property who wishes that the Whiteport archaeological remains be used for education and research.[6] This article documents the results of new research that can be useful for understanding the historic predecessor of modern cements.

Natural Hydraulic Cement

By definition, hydraulic cement is a limestone-based material that can be used in mortar and will set under water. Mortar is a mixture of cement and sand, which may be applied to conventional brick and stone

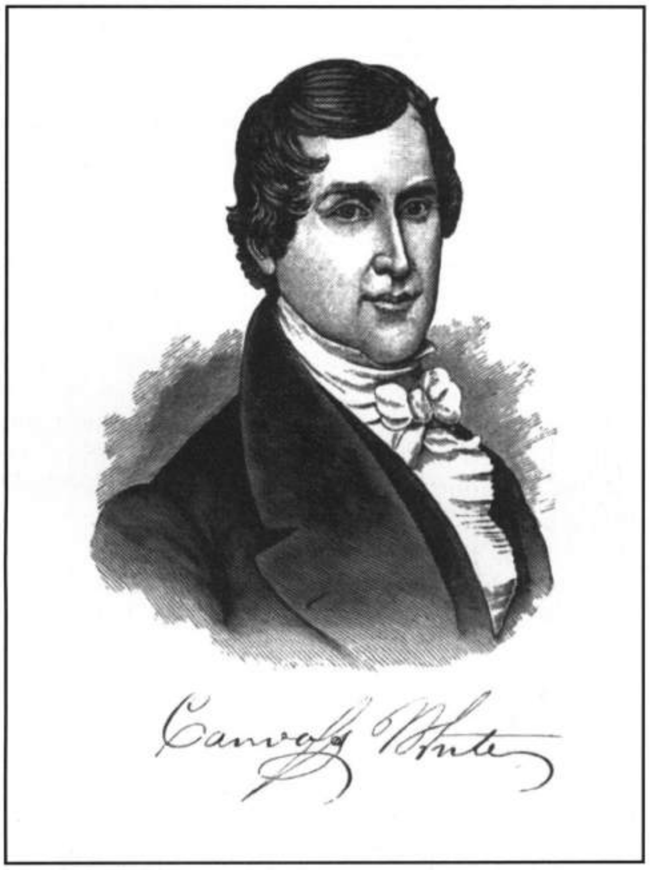
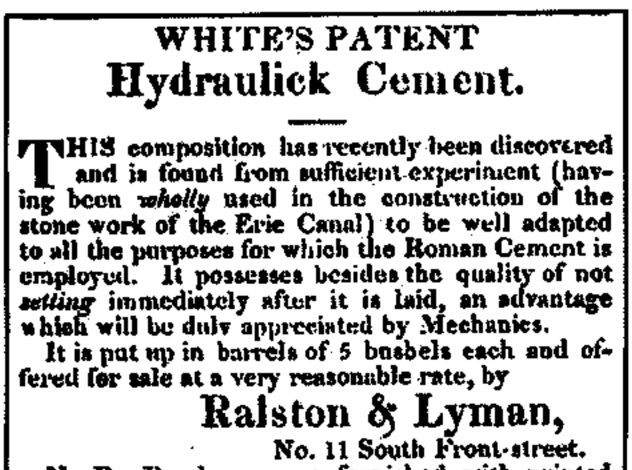


Figure 1. *Canvass White.* Courtesy of the Century House Historical Society, Rosendale, New York.



WHITE'S PATENT
Hydraulick Cement.

THIS composition has recently been discovered and is found from sufficient experiment (having been *wholly* used in the construction of the stone work of the Erie Canal) to be well adapted to all the purposes for which the Roman Cement is employed. It possesses besides the quality of not *setting* immediately after it is laid, an advantage which will be duly appreciated by Mechanics.

It is put up in barrels of 5 bushels each and offered for sale at a very reasonable rate, by

Ralston & Lyman,
No. 11 South Front-street.

N. B. Purchasers are furnished with printed directions for its use.

april 12 dtf

Figure 2. *1822 advertisement for White's cement in Philadelphia.* Courtesy of the Century House Historical Society; *Poulson's American Daily Advertiser, 24 July 1822.*

masonry or combined with aggregate and poured into a mold to produce concrete. Not all limestones can be made into natural hydraulic cement. The Rosendale rock is a dolomite, which is composed of carbonates of calcium, silica, and small amounts of magnesium, alumina, iron oxide, and other compounds. When heated, the carbonates release carbon dioxide and form lime. Most researchers working in the late-19th century agreed that the ratio of carbonates to silica is the critical factor for the production of hydraulic limes and cements. The best natural hydraulic cement is produced from a clastic limestone composed of a critical ratio of about 60% carbonate of lime (calcium carbonate) to 35% silica (clay), with 5% represented by other minerals.[7] Naturally occurring rock with this ratio is relatively rare. The Rosendale rock was deposited during the Silurian period (400 million years ago) beneath the waters of ancient seas in shelly facies at a cratonic margin.[8] In this margin, shells and secretions deposited from sea creatures combined with siliceous mud and clay runoff from the land. Rock formations suitable for natural cement had been found and applied in dozens of North American locations throughout the 19th century as market demand and the potential for economic gain grew, but the Rosendale formations proved to be the most extensive and reliable. Rosendale cement mills provided nearly half of the 19th-century market demand.

In contrast, Portland cement is produced by combining ground stone containing calcium carbonate with ground stone containing clay (such as shale) that was mined from different geological contexts. Portland cement is made hydraulic with the necessary lime to clay ratio. The manufacturing process for Portland cement is more complex than for natural cement and became commercially competitive after the introduction of horizontal rotary kilns in the early 1890s. Some late-19th-century authors who may have been biased toward the natural cement industry often referred to Portland cement as "artificial cement."[9]

Historic Context

Inexpensive hydraulic cement was a critical element for the construction of masonry locks on transportation canals. Rather than importing very costly hydraulic cement from Europe to apply to building the Middlesex Canal, completed in 1803 between Charlestown and Middlesex Village near Lowell in Massachusetts, engineer Loammi Baldwin had volcanic ash (called trass) shipped from the West Indies. He combined the trass with lime to produce a hydraulic pozzonaic cement much like that which had been used in Roman aqueduct construction more than 2,000 years before.[10] As construction of the Erie Canal was begun in 1817 under the leadership of engineer Benjamin Wright, the need for an "American" hydraulic cement intensified. Wright encouraged a number of people to find a suitable material, including White, a bright young engineer in his employ (figure 1). White believed that a natural stone for making hydraulic cement existed in America, making Baldwin's solution on the Middlesex Canal unnecessary on the Erie Canal.

White's research in Great Britain and America helped him recognize the characteristics of a suitable stone, which he identified in deposits near Chittenango, New York. With Wright's encouragement and with assistance from Andrew Bartow, White experimented successfully with methods for limestone's manufacture into cement. In 1820 a U.S. patent was awarded for making cement that involved three operations: (1) quarrying, (2) burning the rock at the correct temperature for the correct length of time (that is, calcining it), and (3) grinding the burned rock to a fine powder. The technology and apparatus that White and Bartow applied were borrowed from other earlier activities. They quarried the rock with pick and shovel, as it had been for agricultural lime production, and calcined in limekilns using wood-fueled fires. The reduction of calcined rock lumps that emerged from the kiln was accomplished with water-powered trip-hammer mills (or possibly modified fulling mills) and by hand hammering. Gristmills that were alternately applied to grain and cement milling further reduced the calcined rock into a fine powder.[11]

The new "Hydraulick" Cement (figure 2) was put to use in canal construction as early as 1819 (before the U.S. Patent Office granted White's patent on 1 February 1820). Information about the new cement was exchanged quickly and freely, and soon several other contractors began to supply hydraulic cement for canal construction. It was impossible to control the patent. Even after White received a second patent in February 1821, the number of entrepreneurs making and selling cement increased. The validity of his patent was strongly debated, not only in court but also among the canal commissioners, the canal contractors, and within the New York State Assembly. "On Feb. 11, 1825 the Joint Committee on Canals and Internal Improvements in the [New York] Assembly negotiated a compromise. In return for discharging his judgment against the petitioning contractors and granting free use of his cement formula, Canvass accepted the sum of $10,000."[12]

Upon completion of the Erie Canal in 1823, White's engineering skills were in great demand. During the next 10 years, he was employed by or was a consulting engineer for at least a dozen canal and public works projects. With increasing competition in the business of making cement and with more and more requests to apply his engineering talent, White needed help managing the production of the cement. For that help he called on his brother Hugh White, whose interests and training contrasted with and complemented his own (see figure 3). While C. White was developing his engineering reputation, H. White, eight years his junior was

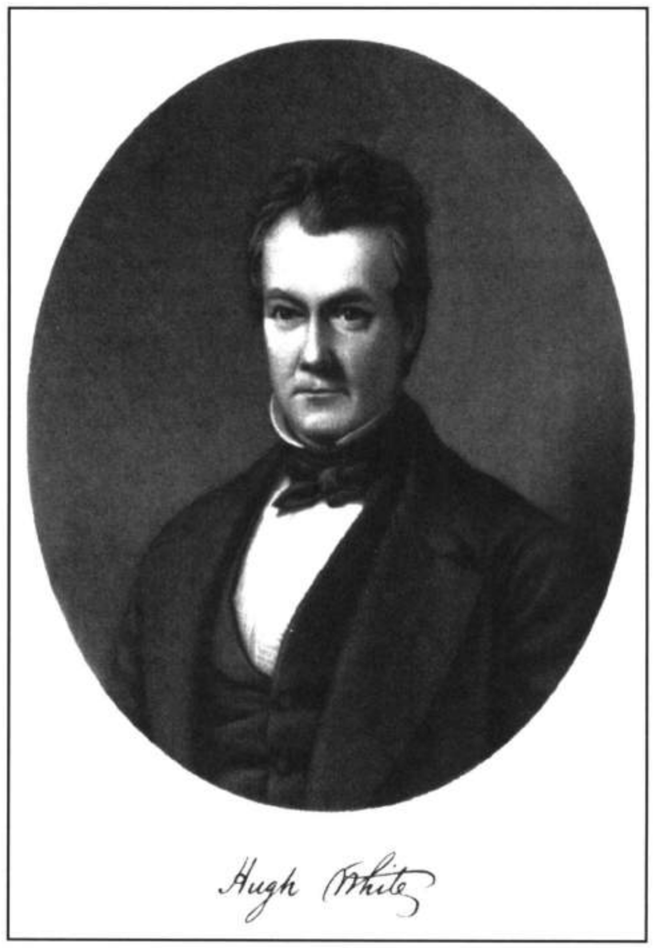


Figure 3. *Hugh White.* Courtesy of the Waterford Historical Society, Waterford, New York.

becoming skilled in business. Together they would successfully manufacture hydraulic cement from New York limestone and begin several other new manufacturing businesses at the falls in Cohoes, New York.[13]

With the untimely death of C. White in December 1834, H. White assumed total management responsibility of the Cohoes enterprises. Honoring his brother's agreements, H. White continued to manufacture cement and profit from its rapidly growing market demand. He was involved in many other enterprises as well, including the Albany and Cohoes Railroad Company, the Cohoes Savings Bank, the Cohoes Bridge Company, the Cohoes Water Works, and the Cohoes and Waterford Horse Rail Road Company. H. White was elected to the U.S. House of Representatives in 1844, then re-elected twice, finishing in 1851. He died in 1870.[14]

Beginnings of Rosendale Cement and the Establishment of Whiteport

In 1825, about the same time as H. White was moving into the cement business at Chittenango on the Erie Canal, James McEntee, an assistant engineer for the construction of the Delaware and Hudson Canal, discovered limestone suitable for hydraulic cement on the property of Jacob Low Snyder in High Falls, a hamlet on Rondout Creek near Rosendale, in Ulster County, New York (see figure 4). In a process similar to that used by C. White for the Erie Canal in 1818, McEntee took the limestone he discovered to a local blacksmith and had it burned. Then the limestone was pulverized and mixed with water, finally hardening into strong hydraulic cement. The discovery meant that the locks of the Delaware and Hudson Canal being constructed at High Falls could be mortared with local hydraulic cement rather than with material shipped from Chittenango. A local entrepreneur, John Littlejohn, received a contract to produce this cement. To calcine the rock, he built a "pot kiln," commonly used by farmers and fueled by wood to burn lime for agriculture (see figure 5). He took his burned stone to Simon De Puy's gristmill in High Falls to be pulverized. Soon other local entrepreneurs were producing cement to sell for canal construction. Pot kilns popped up all along Rondout Creek, and local gristmill owners had a cash-flow bonanza grinding the burned rock into powder. This entrepreneurship was made possible by the policy of the Delaware and Hudson Canal management to divide the work into small segments. Many of the early Rosendale cement entrepreneurs earned some money and then dropped out of the business when the canal was completed. Their quarries and works were taken over by larger, well-capitalized companies. The Rosendale area became so well known for its product, all American natural cement became known as "Rosendale."[15]

Anticipating a cement contract with the Croton Aqueduct project in which his late brother had played an important planning role, H. White purchased property in the town of Hurley (now the hamlet of Whiteport) on the Greenkill, a few miles north of High Falls, with the intention of applying the mills there to cement grinding.[16] The Croton aqueduct would ultimately supply New York City with much-needed clean water. Jacob Jarvis engineered its construction. He had worked with C. White on the Erie Canal and had been employed by Wright on several other projects. C. White had surveyed possible aqueduct routes for the New York City aqueduct commission and had headed a company with Wright to construct the aqueduct in 1825. Political wrangling in the city's leadership and incessant disagreements delayed action until Jarvis was made chief engineer of the aqueduct project late in 1836. Jarvis's detailed plans and specifications for the 47-mile-long closed-masonry aqueduct reveal a strong reliance on American natural hydraulic cement in the mortar. The entire length was waterproofed with a concrete lining. Concrete was also used in the Croton Dam and the footings for the Harlem River Bridge.[17] H. White likely realized that a great deal of hydraulic cement would be needed. The mills and other works of the place, which would ultimately bear his name, were closer to the aqueduct project than Chittenango and Cohoes and would prove to be more productive and efficient.

H. White contracted quarrymen to open several quarries in the Rosendale area and burn the stone. His company furnished the fuel, which was screened anthracite shipped on the Delaware and Hudson Canal from Pennsylvania and delivered to the kilns. To grind the calcined rock, H. White employed the mills he had purchased on the Greenkill as well as contracted with other scattered gristmills. For shipment, the barreled cement was carted on wagons 3 miles to Eddyville, a Delaware and Hudson Canal port on Rondout Creek near its confluence with the Hudson River.[18]

In 1848 the Croton Aqueduct project neared completion. With increasing demands on his time for the

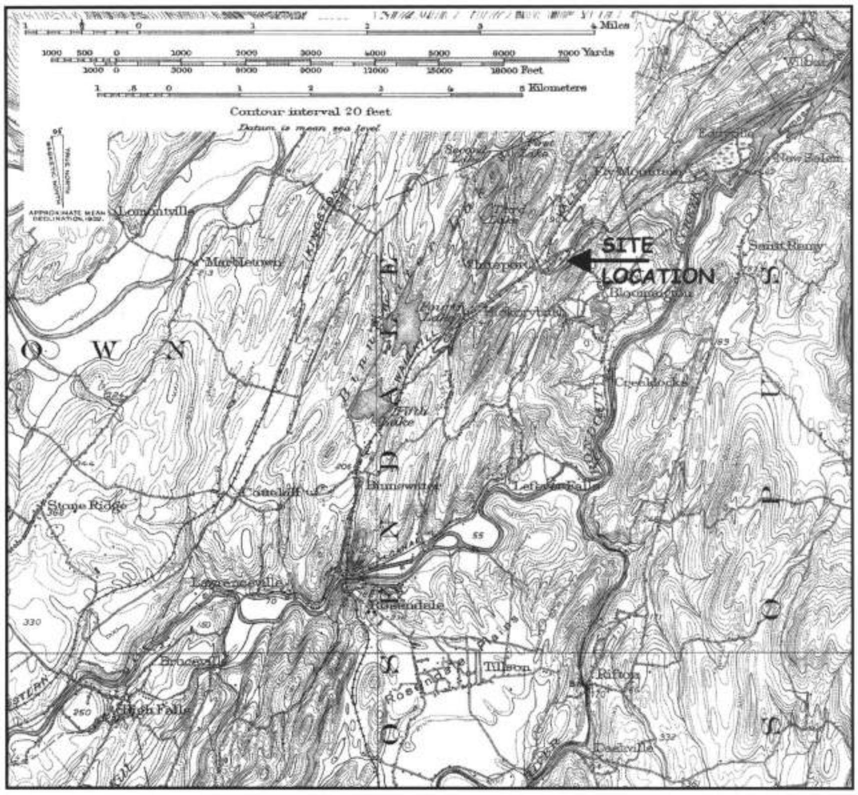


Figure 4. *The Whiteport site in the Rosendale cement region, High Falls to Eddyville; the D&H Canal follows Rondout Creek, which flows from lower left to upper right.* Cropped and reduced 1903 USGS *Rosendale, New York*, 15-minute quadrangle map.

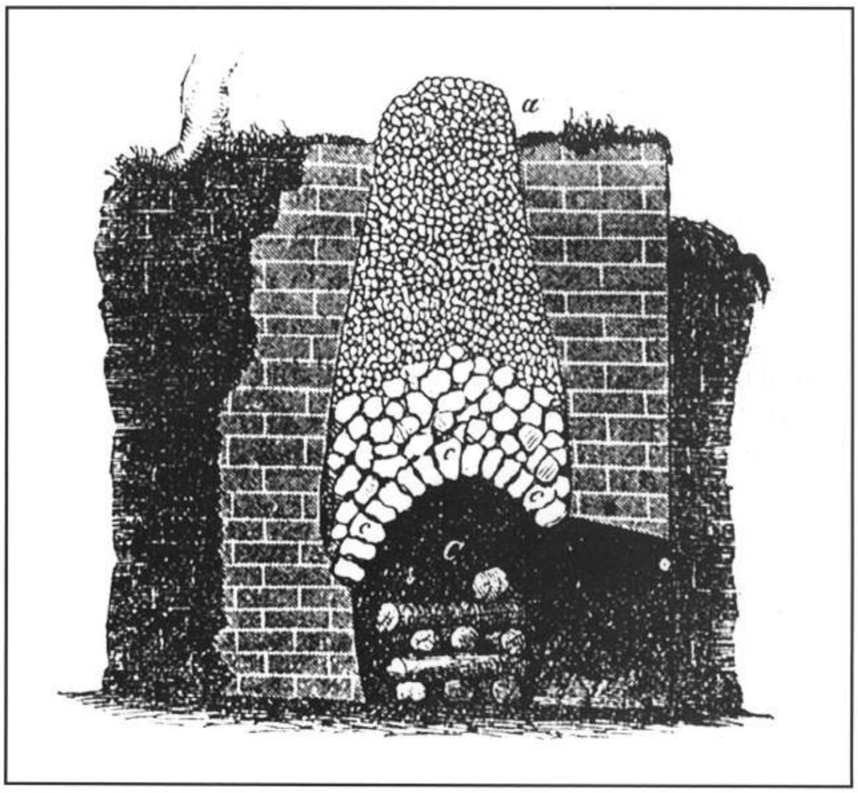


Figure 5. *An early wood-fired limekiln; a dome of larger limestone chunks is built over the fireplace to support the load of rock to be burned.* Cross-section by Q. A. Gillmore in *Practical Treatise on Limes, Hydraulic Cements and Mortars* 1874, p. 139 (see n. 9).

management of the Cohoes enterprises and his service in the U. S. Congress, H. White chose to sell the Whiteport works to a small group of New Jersey investors. They named their company the Newark and Rosendale Lime and Cement Company (N&R L&C) and invested $120,000 to upgrade the mills and facilities. The new works destroyed the original gristmill-based works. In 1850 a 3½-mile plank road was constructed through the N&R L&C Whiteport mill to the port of Eddyville. The improvements in infrastructure and new mills enabled the company to increase production from 450 to 1,000 barrels of cement per day. (The N&R L&C would also establish works in the hamlets of Hickory Bush and Rondout—see figure 4.) Frederick Doremus was hired as the superintendent in 1852 after a succession of short-term managers. He continued to manage the company into the 1880s, when his son Edmund succeeded him and continued in charge until the Whiteport works were shut down.[19] In 1869 a horse-drawn railroad replaced the plank road, cutting hauling expenses by 60%, and served as the company's transportation backbone between its quarries, mill, and Eddyville dock facilities throughout the next 23 years, even as steam-powered railroads came to dominate the nation's transportation system. Regular railroad freight service was never provided to Whiteport.[20]

With F. Doremus in charge, the community of Whiteport grew considerably under the influence of the N&R L&C, as suggested by the 1853 Brink and Tillson *Map of Ulster County*. It illustrates at least 16 structures, including a school and a store. By 1872, the hamlet of Whiteport and its neighboring hamlet, Hickory Bush (where some Newark and Rosendale facilities were located), had a population of about 1,500. The company employed about 180 men and fired 17 kilns. Its mill contained "twelve runs of three-feet stones," powered by a 50 hp waterwheel and two 100 hp steam engines.[21] Figure 6 provides a plan of Whiteport in 1875.

Archaeological Survey

The purpose of the survey was to identify, record, describe, and determine the age of the surface ruins that represent the industrial component of Whiteport. The survey was conducted between April 2005 and June 2006 during several two- and three-day visits to the site. A theodolite was used to establish a baseline and measure angles from points on that baseline to the various features. Most distance measurements were accomplished using tape. A visual reconnaissance located many features that were matched up to the identified structures shown on historic maps.[22] Individual features were measured, recorded by sketches and notes, and photographed. No excavation was conducted. Surface features were plotted onto a recent property survey plat and converted to an axonometric projection with the help of three-dimensional measured sketches produced in the field (see figure 7). Due to constraints of time and costs, only the ruins of

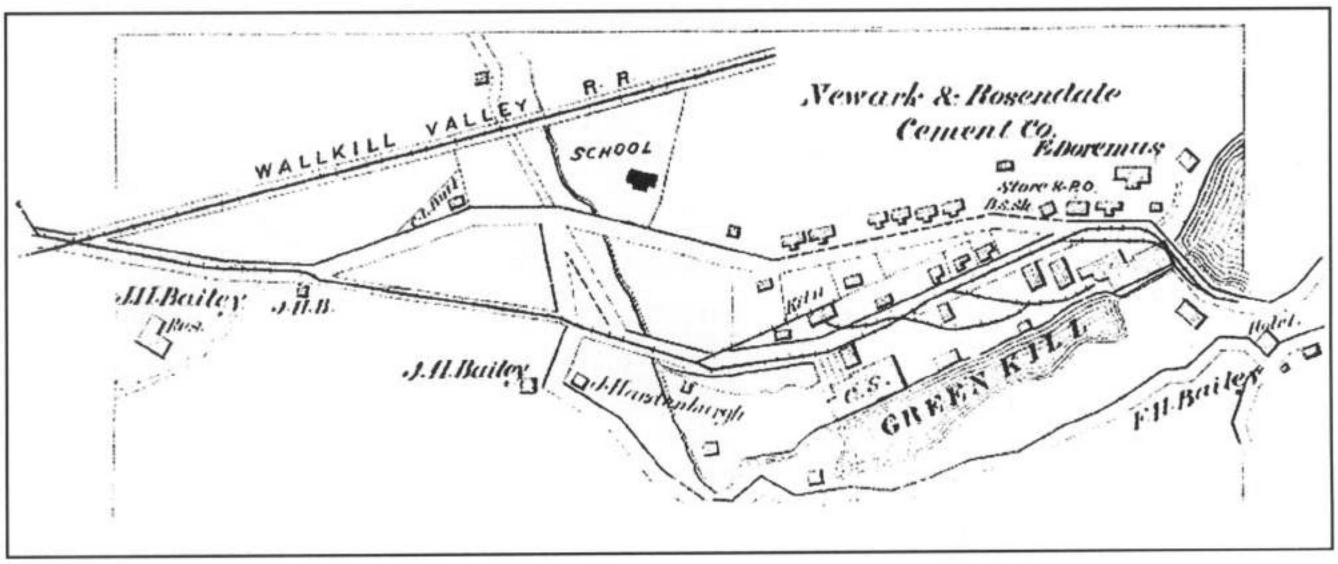


Figure 6. *A plan of Whiteport.* Courtesy of Michael Pavlov; F. W. Beers, *County Atlas of Ulster, New York*, 1875 (see n. 24).

industrial structures shown on historic maps were recorded during the survey, even though many remains of domestic structures were recognized.

The baseline was laid out along the edge of the modern paved drive, which had been constructed over the bed of the Hickory Bush and Eddyville horse-drawn rail line and earlier plank road. This baseline, used as the north-south line for the archaeological site recording, is actually about 40 degrees easterly of magnetic north. Compass references in this text are related to the archaeological baseline, unless they are quoted from historical documents.

All of the features that were recorded can be attributed to the N&R L&C that operated on the site from 1848 until 1902. No features were recognized that could be attributed to the earlier cement manufacturing mills of H. White and others. The industrial features recorded by this survey are illustrated in figure 7 and described below.

Feature 1. Kilns

Feature 1 is a battery of four limestone kilns (see figures 8–11) of the continuous operation type, constructed with vertical shafts that were lined with refractory brick. Each shaft is an approximately 16-foot-long cylinder measuring 8 feet in diameter at the top. Beginning about 10 feet above the bottom of the kiln structure, the shaft tapers down to 3 feet in diameter, forming a neck that curves toward the front of the structure as a discharge port (figure 11). The kiln shafts are supported by a mass of masonry in two adjacent structures. The outside walls of the kiln structures are of coursed rubble. Some joints exhibit mortar, which was probably added after the original construction. The space between the kiln shaft and the outside walls is filled with stone rubble. Each of the masonry structures is 24 feet high, 38 feet wide, 28 feet deep and built into the side of a steep natural hill. Extending into the front of each of the two masonry structures is brick vaulting that provided workspace for discharging the calcined limestone (figure 10). These kilns are typical for the Rosendale area and conform to the description given by Albert Bleininger in 1904.[23] A long earthen incline that once supported a railroad for the horse-drawn carloads of rock and coal extends southerly 460 feet from the top of the kilns, parallel and to the west of the modern roadway.

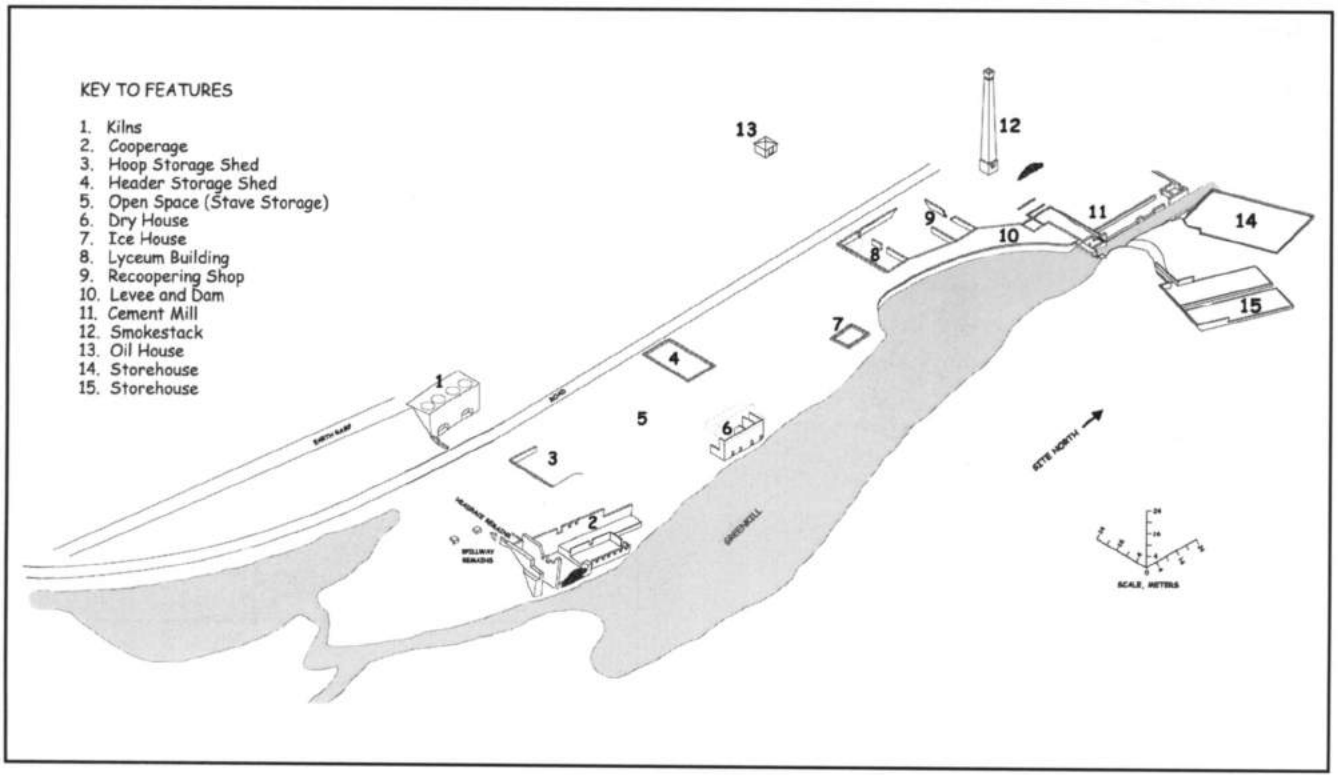


Figure 7. *Industrial remains of Whiteport as surveyed fall 2006.* Map by author.

Figure 8. *Feature 1, a kiln battery, viewed southwest.* Photo by author.

Figure 9. *The cylindrical refractory brick lining of kiln in Feature 1, viewed from above.* Photo by author.

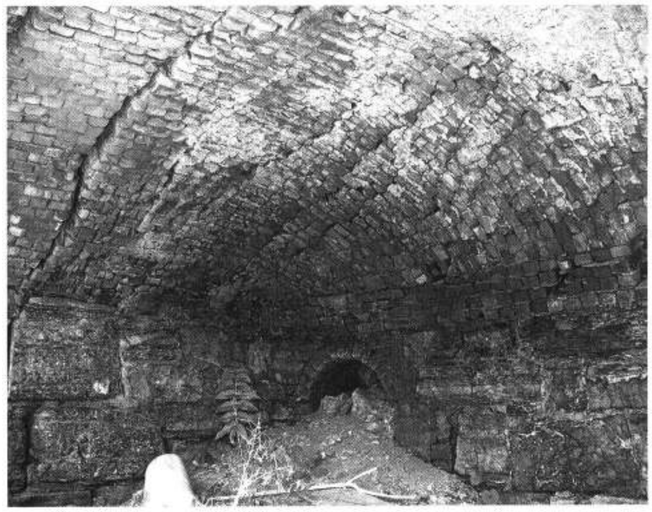


Figure 10. *A discharge port and brick vaulting of a kiln in Feature 1.* Photo by author.

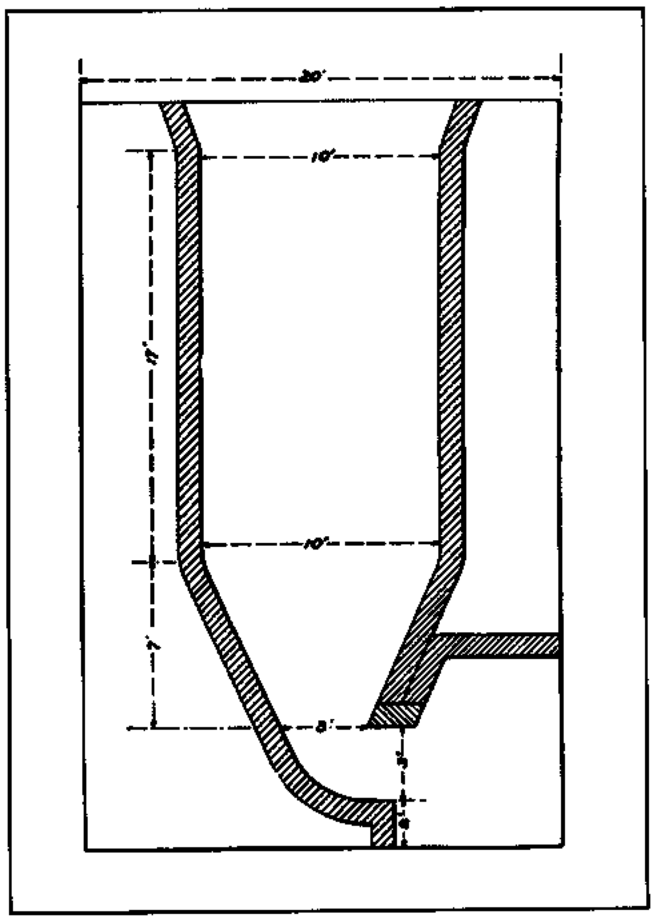


Figure 11. *Cross-section of a typical kiln.* Figure 20 from Albert Victor Bleininger, "The Manufacture of Hydraulic Cements," *Geologic Survey of Ohio,* Bulletin No. 3 (1904): 188.

It is thought that earlier kilns were constructed c. 1836 at this location by H. White's workers. Later, at least one of the extant structures of Feature 1 was built c. 1858. An 1875 historic map exhibits kilns in this location,[24] and it is believed that those kilns are the same that are recorded in this survey. The different vault heights and the approximately 5-degree angle between the faces of the two structures suggest that they were built at different times. It is thought that the northern structure was built first, perhaps at a time when the plank road serviced the rock and coal wagons, and that the southern kiln structure and its long ramp was put up in 1869 when the horse-drawn railroad was installed. As described earlier, workers charged the kilns from the top with alternate layers of rock and anthracite, in a ratio of 100 pounds of rock to 10 pounds of coal. Calcined material was removed from the discharge port by other workers under the vault at the bottom.

Feature 2. Cooperage

Feature 2 is identified on historical maps and other documents as a cooperage.[25] The feature is a ruin composed of the masonry remains of contiguous structures constructed in three episodes. The first, southernmost component of this feature has walls of coursed, roughly squared stone that enclose an area approximately 40 by 45 feet. Some standing portions of this structure are 15 feet high (see figure 12). Extending west-east at the southern end of this structure is a wheel pit, 16 feet wide by 14 feet deep, also constructed of coursed, squared stone. The two other structural ruins extend approximately 70 feet northward, aligned with the first structure's eastern and western walls (see figure 13). The structure was built into the slope rising from the Greenkill so that the second floor would have been at ground level on its west side. A 1900 insurance policy describes the structure as a "stone and frame cooperage building 40 × 45 feet, and frame addition 44 × 70 feet."[26]

The cooperage was one of the structures installed by the N&R L&C when it made its large investment in the early 1850s, although Gilchrist suggests that H. White may have developed a cooperage for his operation, but it would not likely have been as extensive a structure.[27] The Newark and Rosendale Company mechanized barrel making, applying newly invented machinery driven by a water-power system. Southwest of the stone structure, a dam was built on the Greenkill to create a pond with a stone-lined headrace, constructed easterly from the pond to the wheel pit in which was installed a 50-hp overshot wheel. (The surveyor observed that the headrace was filled with soil and rubble.) According to a 1901 inventory, the wheel measured 24 feet in diameter and 6 feet wide. The iron axle of the wheel was seen in the bottom of the wheel pit during the survey. About 1870, a 500-hp steam engine was applied to the cooperage and was supplied by a boiler serviced with a 60-foot tall brick stack.[28]

Through the 1890s, the cooperage was little used, while the recoopering shop (Feature 8, also designated as a cooperage in some documents) was very active.[29] Bags were being employed for packing and shipping cement by the company beginning about 1890. Most of the shipments of the Newark and Rosendale Company cement were probably carried to markets and customers by canal barge and steamship. A 1902 inventory document stated the company owned and operated two steamships and eight canal barges. Since the preferred packaging for water transport was barrels, the company probably continued its reliance on barrels, even as other manufacturers were adopting bags.[30]

Feature 3. Hoop Storage Shed

Feature 3 is a mortared-rubble, L-shaped foundation built into the earthen bank, measuring 55 by 32 feet (see figure 14). The structure is open to the north, and its eastern wall is an earthen berm. The southern and western masonry walls are 5 feet high. It was roofed, with "eaves level with surface" of the ground.[31] The feature probably had no superstructure, and historical documents indicate it was used to store barrel hoops. Its construction date is not known.

Feature 4. Header Storage Shed

Feature 4 is a low rubble foundation measuring 20 by 58 feet. A temporary, modern, framed-plywood storage building is set on cylindrical concrete piers above a portion of the feature. The original building on this feature was probably constructed in the 1890s as suggested by the 1901 insurance policy, which refers to it as "new frame shed, 20 x 63 feet occupied for the storage of headings."[32] It is not known if the foundation feature supported an earlier building. It was noted that the large, flat open area of about a half-acre between Feature 3 and Feature 4 was devoted to "piles of staves." North of the header storage shed, a quarter-acre was also devoted to stave piles.[33]

Figure 12. *The inside of the remains of the cooperage (Feature 2), viewed south.* Photo by author.

Figure 13. *The wheel pit of the cooperage (Feature 2) with the axle of the waterwheel lying at the bottom, viewed west.* Photo by author.

Figure 14. *The remains of the hoop storage shed (Feature 3) with the kiln battery (Feature 1) in the background, viewed southwest.* Photo by author.

Feature 6. Dry House

Feature 6 is a poured-concrete, rectangular structure built into underlying bedrock on the bank of the lower millpond, north of the cooperage remains (see figures 15, 16). It measures 50 by16 feet in plan, and the wall facing the pond is 16 feet high. The bedrock functions as the structure's western supporting wall. The east (pond-facing) wall exhibits four round-arch doorways cast into the concrete. Each of the doors opens into a separate chamber created by concrete partitions. The concrete walls are about a foot thick and exhibit the poor bonding of multiple small-volume pours. Rubble and waste were included in the aggregate. There are no passageways through the partitions, with the exception of round ports about 1 foot in diameter. The pond-facing wall also exhibits rectangular sockets arranged horizontally near the top that are thought to have supported a shed roof. An earth-filled space of only 6 feet separates the wall from the edge of the pond.

The historic use of the single-story feature is unclear. It is identified as a dry house by the 1892 and 1898 Sanborn Fire Insurance Company maps, but no reference has been found that suggests what was dried in the structure. The millpond may have been a factor in the building's use as suggested by the four doors opening to the narrow space between the building and the pond. This narrow space has no recognizable access from above on the steep bank into which the structure is built. The Greenkill was not likely to have been used for transport because there are no locks at falls and dams. The structure was listed as a storage building, rather than a dry house, in a 1901 N&R L&C inventory.[34]

The structure was constructed before 1892, possibly as an architectural demonstration or experiment using Whiteport's cement in its concrete. The 1875 Beers map illustrates an unidentified building in the same location, but it is not known if the building is the same structure. It may be considered too early for such a poured-concrete structure, although there are some early examples of concrete structures such as the Ward house in Port Chester, New York, built between 1873 and 1878.[35] A modern workshop has been constructed on the feature by the property owner who intended it to protect the historic concrete from further weathering damage.

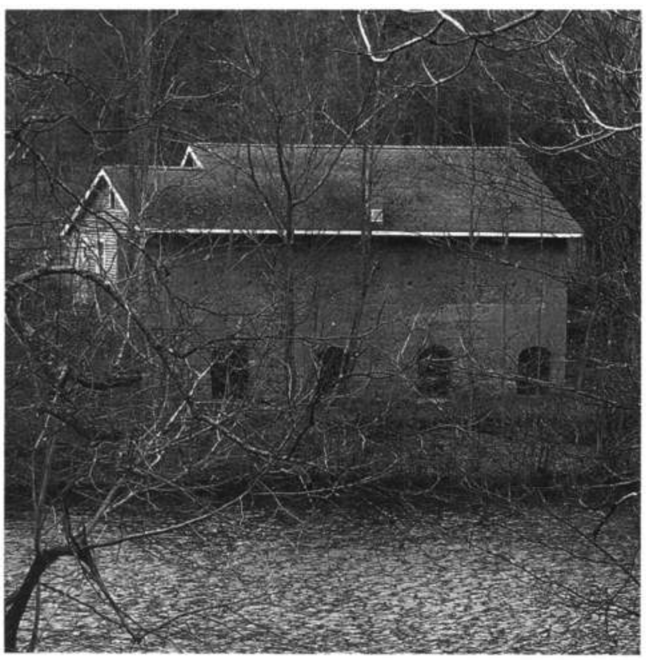


Figure 15. *The dryhouse (Feature 6), viewed west across the Greenkill, is a poured-concrete structure on which a modern workshop was built.* Photo by author.

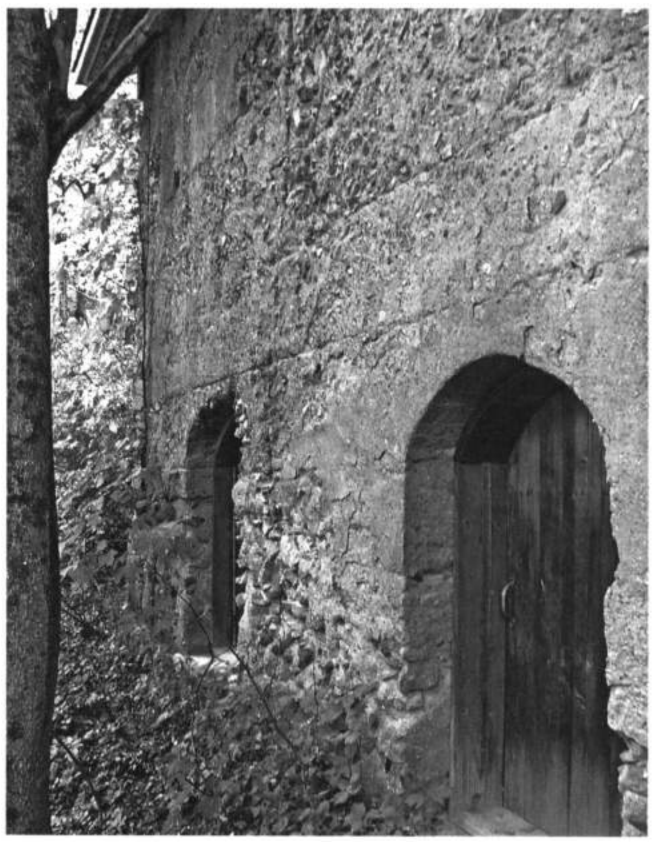


Figure 16. *Detail of concrete on east side of Feature 6, viewed south.* Photo by author.

Feature 7. Ice House
Feature 7 is a low, rectangular rubble foundation measuring approximately 18 by 15 feet. It is identified as an icehouse on the Sanborn Fire Insurance Company maps and the 1901 valuations inventory of the N&R L&C [36] An insulated building, it was used for the storage of ice that was harvested from the millpond during the winter. Before the development of refrigeration, ice was an important commodity in the 19th century. According to Gilchrist,

> the icehouse itself was usually constructed of spruce, hemlock, or white pine with a cedar shingled roof. The outside was painted white ... [and] two outside walls created a space which would be filled with sawdust, charcoal, shavings or some other insulating material. The inside of the house was usually divided into rooms with drains across the floor.[37]

Feature 8. Lyceum Building
Feature 8 is a coursed-rubble masonry, rectangular foundation. Measuring 68 by 28 feet, the foundation walls are approximately 8 feet high. The east wall is also a component of the levee (Feature 9), and the north wall exhibits two passageway openings. With the exception of the north wall, the foundation is mostly below grade. The structure that was supported by this foundation is identified as a lyceum, that is, a community center. The 1892 and 1898 Sanborn Fire Insurance Company maps indicate that it was a single-story "hall used as church, band, etc.," and a 1900 insurance policy identifies it as a "one and one-half story frame, shingle roof building, 30 × 60 feet, occupied for storage and lecture room." The 1901 "Masonry 1st & 2nd Class" inventory indicates that the lyceum had a chimney and was plastered. The building appears on the 1875 Beers map without identification. It is not known if the building was originally intended for industrial use, as suggested by its location, or if it was always used as a community center.[38]

A small barn, 18 by 16 feet, was constructed on the southwest corner of this foundation about 1910 and was extant at the time of the survey.[39] Being much smaller in plan than the lyceum, the north and east walls of the barn are supported by posts.

Feature 9. Recoopering Shop
Feature 9 is a coursed-rubble foundation exhibiting masonry technique similar to Feature 8. It was probably rectangular in plan, measuring approximately 60 by 30 feet. The western wall and part of the southern wall are no longer extant, and a 6-foot section of the north wall has been breached by modern activity. As in Feature 7, the east wall is also part of the levee retaining wall. It is about 8 feet high. The building is identified by the Sanborn Fire Insurance Company maps of 1892 and 1898 as being a recoopering shop on the first floor and a store on the second floor. In the 1900 insurance policy, the structure is described as a two-story frame, shingle-roof building, 30 by 70 feet, having the same purpose as the Sanborn maps suggest, revealing that it is referred to as a cooper shop on some documents.[40]

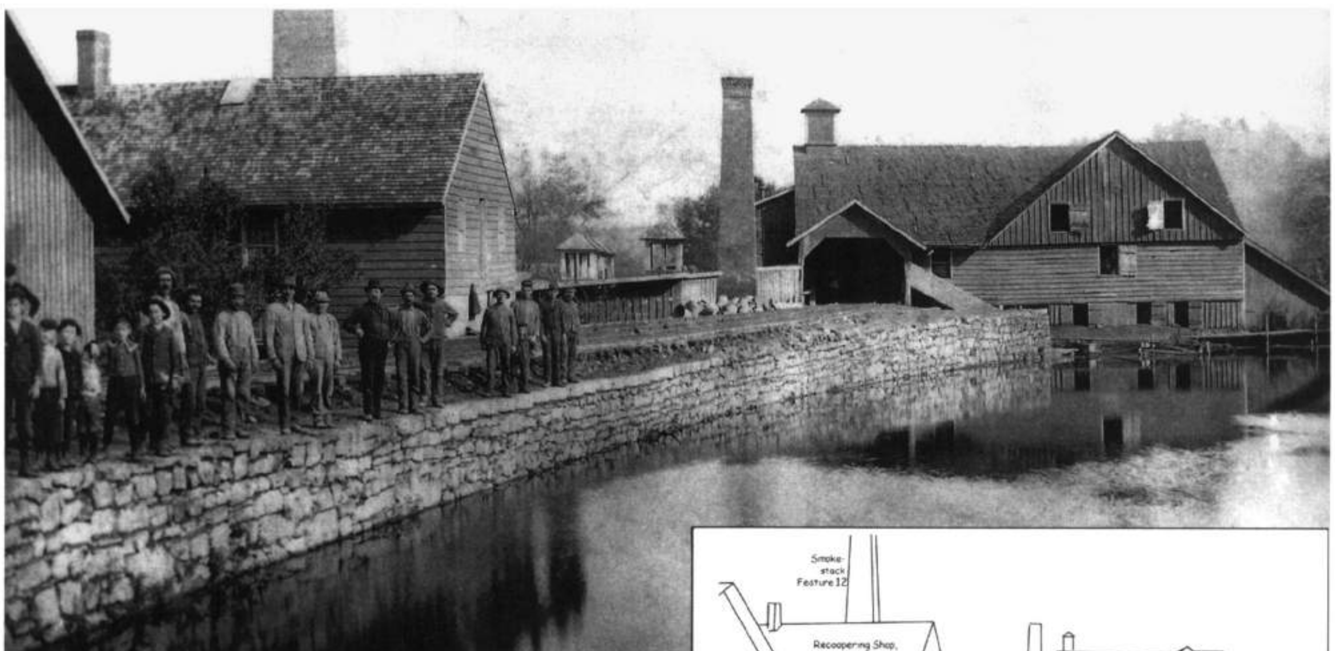
This building supplied the cement mill with barrels that were recycled from the staves, hoops, and heads of returned barrels. As large numbers of empty barrels were returned, the N&R L&C shut down the original cooperage (Feature 2), discontinuing the manufacture of new barrels, and concentrated on repair of returned stock. The structure appears, but is not identified, on the 1875 Beers map.[41] The original construction date likely coincided with the early-1850s construction of the levee, dam, and cement mill, and it may have functioned as a carpenter shop or millwright's shop. About half of the building can be seen behind the workers standing on the levee in the only known photo of the Newark and Rosendale Company works.

Feature 10. Levee and Dam
Feature 10 is an earthen levee extending south to north 174 feet, 16 feet wide, with coursed-rubble masonry walls for shoring and erosion resistance, terminating at an east-west stone dam. The levee and the stone dam at its northern terminus created the millpond that once provided the waterpower potential for the cement mill, Feature 10. The masonry wall is 8 feet high on the west side of the levee (see figures 17, 18, 19).

The dam, 16 feet high by 30 feet wide by 4 feet thick, was built with coursed, squared-stone blocks. It was constructed with a downstream buttress that, with the parallel eastern cement mill wall, formed a wheel pit and provided outboard support for the overshot waterwheel that was installed to provide power to the mill during the early years of its operation. The dam has seen repair work, and the opening for the headrace above the wheel pit was filled with masonry when waterpower was abandoned about 1870, and the mill was converted to steam engine power.[42] After 1870 the millpond continued to have economic value as a source of ice.

Figure 17. ***The levee, Feature 10, viewed northerly (compare with figure 19).*** **Photo by author.**

Figure 18. ***Southeasterly view of the levee (Feature 10) in an area between features 8 and 9. A stairway of recycled millstones is seen in the levee wall in the background, and a broken millstone is seen in the foreground. Broken and worn millstones were observed to have been recycled as building material in many of Whiteport's structural features.*** **Photo by author.**



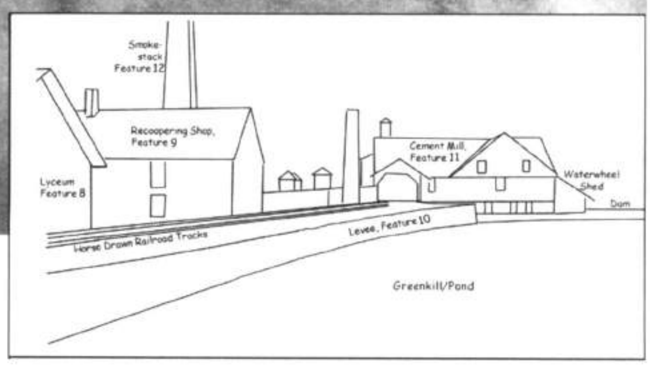


Figure 19. ***The only known photograph of the Newark and Rosendale Lime and Cement Company works at Whiteport, viewed north with drawing features identified by the author. The date of the photograph is not known but thought to be sometime near the end of the 19th century.*** **Photo provided by Michael Pavlov.**

The levee also provided a causeway to the mill along its top surface that once supported two sets of railroad tracks for horse-drawn cars (figure 19).[43] When the cement mill was operating, the calcined rock was moved from the kilns over the rails along the top of the levee to a receiving area at the south end of the cement mill. The levee and dam were probably originally built in the early 1850s when the Newark and Rosendale Company was developing its works.

Feature 11. Cement Mill

Feature 11 is a complex of masonry foundations and walls identified by historical maps as the cement mill and its supporting infrastructure. Much of the western portion of the masonry foundations has been removed or obliterated by 20th-century development or scrounging of material (see figures 20, 21). However, the eastern sections adjacent to the tailrace and the Greenkill are extant. According to the Newark and Rosendale Company masonry inventory of 1901, the valuations list of 1901, and the 1898 Sanborn Fire Insurance Company map, the mill complex consisted of a series of two-story buildings aligned south to north along the Greenkill below the dam, beginning at the levee terminus with the dam and covering a rectangular area measuring about 55 by 150 feet.[44] The remains of these buildings consist of walls and foundations of coursed-rubble masonry and squared-block masonry, varying in height from 2 to 16 feet. The combined steam plant and engine room was a rectangular brick structure, 57 by 45 feet, located west of the extant mill remains, between Feature 9 and the extant brick smokestack, Feature 12. The steam plant building housed four 125 hp boilers on brick settings.[45] While the foundation perimeter of the steam plant was not recognized during the survey, the boiler bases were recognized in the form of a pile of brick and 10 steel mounting posts. Abutting the steam plant to the south was a single-story frame building that served as a carpenter shop, measuring 63 by 43 feet in plan.[46] The eastern wall of this building was also the retaining wall of the levee, and it once had a rectangular brick smokestack, 30 feet in height, built against the levee wall. Some of the brickwork of that smokestack is incorporated into the levee wall.

The cement mill was probably constructed about 1850, with some of structures recognized in the survey being added before 1875. The carpenter shop probably also dates to about 1850. The steam plant was installed in the late 1860s.

Feature 12. Smokestack

Feature 12 is a smokestack that served the steam plant of the cement mill (see figure 22). The smokestack has a base measuring 12 by 12 feet and is square in plan through its entire height of 90 feet on the outside and is cylindrical on the inside. Its extreme height was necessary to provide a powerful draft to aid combustion of coal and to carry off the gases that resulted.[47] Modern communications media use images of smokestacks to associate industry with air pollution, but an entirely different view was taken in the 19th century

Figure 20. *The dam spillway* (left) *and the wheel pit* (right) *with mounted waterwheel axle on the east side of the cement mill (Feature 11), viewed south.* Photo by author.

Figure 21. *Foundation walls of the cement mill (Feature 11), viewed upstream along the tailrace (southeast).* Photo by author.

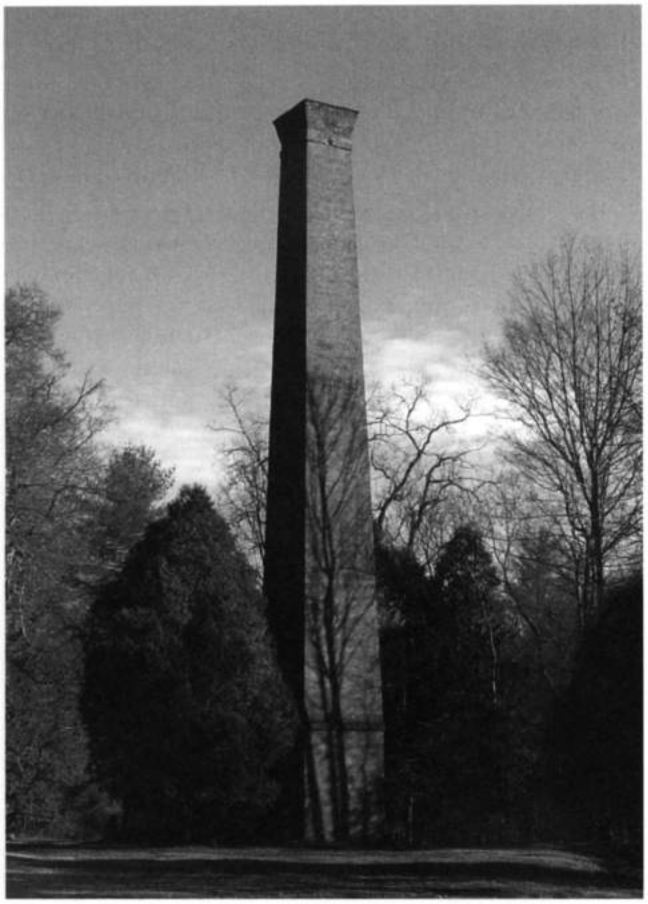


Figure 22. *Smokestack (Feature 12), viewed north.* Photo by author.

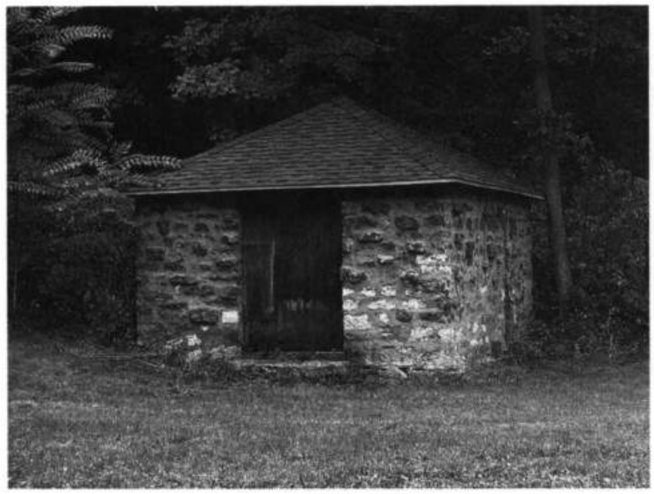


Figure 23. *The oil house (Feature 13), viewed westerly.* Photo by author.

when images of very prominent smokestacks, often belching smoke, were used to advertise prosperity and economic success as symbols of technological progress.[48] The stack is Whiteport's most prominent feature and probably has been since its construction in the 1860s. It certainly symbolizes progress in prime-mover technology that provided a huge increase in number of machines that could be applied by the Newark and Rosendale Company.

Feature 13. Oil House

Feature 13 is a coursed-rubble masonry building, 13 by 13 feet with a hip roof (see figure 23). Identified on historical documents as an oil house without other indications of its purpose, it is assumed that the building was used for storage of flammable liquids. Its small size and lack of windows supports such an assumption. The oil house is not shown on the 1875 Beers map.[49]

Feature 14. Storehouse

Feature 14 is an earthen platform measuring 120 by 60 feet, enclosed with a coursed-rubble masonry wall. The wall also functioned as the foundation of a framed single-story building having a "composition" roof, identified as a cement storehouse by some documents. A bridge over the Greenkill connected the storehouse to the mill.[50] A characteristic of the cement manufacturing business was the necessity for large roofed spaces that provided a dry area for stockpiling thousands of barrels, some empty but many filled with cement, as well as cloth and paper bags also filled with cement. (Of interest is that three filled cloth bags or four filled paper bags equal one barrel, and a cement barrel occupies about 5.5 cubic feet of space.)[51] This storehouse, with its long northern wall facing the railroad line to the port at Eddyville, was constructed in the 1869.[52]

Feature 15. Storehouse

Feature 15 is an earthen platform measuring 120 by 70 feet, enclosed with a coursed-rubble masonry wall. The wall also functioned as a foundation for the frame storehouse that once sat atop the platform. The platform has a unique 5-foot wide slip through its center. When the storehouse was being used, the slip contained a railroad track so that the horse-drawn cars could be moved under cover for convenient loading or unloading (see figure 24). The height of the storehouse platform was probably equal to the distance from the track to the rail car's cargo bed. A 90-foot-

Figure 24. *The slip between the two platforms of the storehouse (Feature 15) that once held the horse-drawn railroad tracks; this is the northern end of the feature, viewed north.* Photo by author.

long arcade, which was carried on a bridge over the Greenkill and passed through a 9-foot-wide cut in the ledge on the east bank, connected the storehouse with the mill. This feature was constructed sometime between 1892 and 1898.[53]

Synthesis of the Whiteport Manufacturing Process

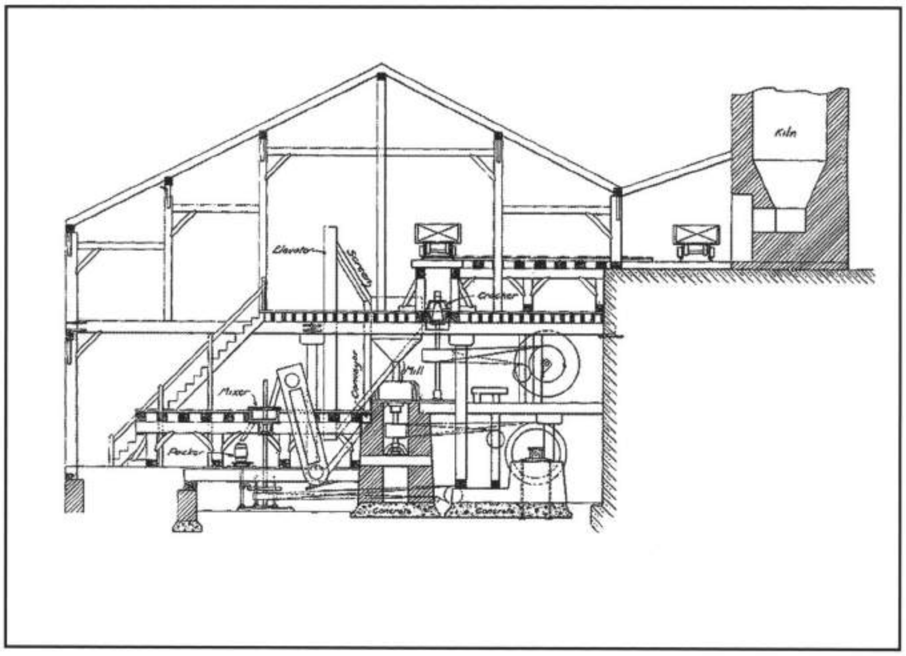
It is possible to synthesize the cement manufacturing process most likely used by the N&R L&C by combining the interpretation of the plan of the archaeological features representing the industrial components of Whiteport with historical documents and the various witnessed descriptions of the cement-making process applied to other works. The process begins with the quarrying of the useful formations of limestone from beds owned by the company to the south of the survey area. Rosendale limestone beds are extensive. In addition to the four kilns at Whiteport, the company also operated many more kilns located nearer to the quarries. At Whiteport the raw rock was carted up the earthen ramp on rails to the top of the battery of kilns (Feature 1 in figure 7). Also carted up this incline would have been coal, which had been shipped by canal barge to the company's port facilities in Eddyville located to the north of Whiteport. The received coal was carted from Eddyville on the plank road and later on the horse-drawn railroad to Whiteport storage areas called "coal pockets" near the kiln ramp. The coal was drawn up the ramp as needed in a ratio of 1 to 10 with the rock.[54]

Workers at the top of the kilns dumped the rock from the carts and shoveled the proper amount of coal into the top openings of the kilns. (Note that Feature 1 is a battery of four kilns; see figures 8, 9 and 11.) Kilns were fired from March to December and kept continuously hot throughout the period, then allowed to cool during cold winter months.[55] (Presumably repairs to the kilns would be accomplished during the winter shutdown as would major millwright work.) The kilns were heated to a temperature of 950° F to 1000° F, and the rock remained in the kiln cylinder for 12 hours, becoming calcined as carbolic acid (carbon dioxide and water) was released as vapor from the top of the kiln.[56] Another group of laborers working under the vault at the bottom of the kilns shoveled the calcined rock from a relatively small opening (figure 10) and loaded it into horse-drawn railroad cars. The workers who removed the calcined rock applied a quality control inspection, as described by Heinrich Ries and Edwin Eckel that resulted in "returning under burned stone to the top of the kiln and discarding over burned rock."[57] The carloads of properly, or "normally" burned rock were drawn over the levee (Feature 10) to the cement mill (Feature 11) (figures 17, 19). In the mill (see figures 25–28),

> the normally burned rock is taken to the "cracker" room, where it is crushed in crackers to fragments and grains, varying from dust to hickory nut size. These [crackers] are made from cast iron, and consist of a frustum of a solid cone called the core, working concentrically within the inverted frustum of a hollow cone, both having on their adjacent surfaces suitable grooves and flanges for breaking the stone as it passes between them. From the crackers the crushed cement is carried by means of an elevator and conveyor to a sieve 11 feet long and 10 inches wide, and about 50 meshes per inch. 25% to 27% passes this sieve. That which does not pass the sieve goes to horizontal stone mills, where it is ground between millstones, after which the two lots of fine material are mixed ... .[58]

During much of the time that it operated, the N&R L&C mill applied seven crackers for reducing the roughly soccer-ball size chunks of rock that were delivered from the kilns to peanut-sized chunks that would be accepted by the grinding stones (figure 26). The mill employed 12 3-foot diameter mills, and 1 3.5-foot diameter mill (figure 27). As previously pointed out, the mills were similar to those used to make flour from grains. While early cement mills, such as those operated by H. White, were nothing more than gristmills

Figure 25. *Cross-section of a typical natural cement mill, illustrated by Albert Bleininger in 1904. All the machinery is driven by a pulley and belt system whose main drive pulleys are located in the lower right area of the structure. The moving belting connects the power to a cracker, a mill, a mixer, a packer, elevators, and conveyors. A typical elevator was composed of belt loop with attached buckets. Conveyors were either long augers or flat belt loops. Figure 28 provides a schematic representation of the material handling system.* Drawing from Albert Victor Bleininger, "The Manufacture of Hydraulic Cements," *Geologic Survey of Ohio*, Bulletin No. 3 (1904): 195.



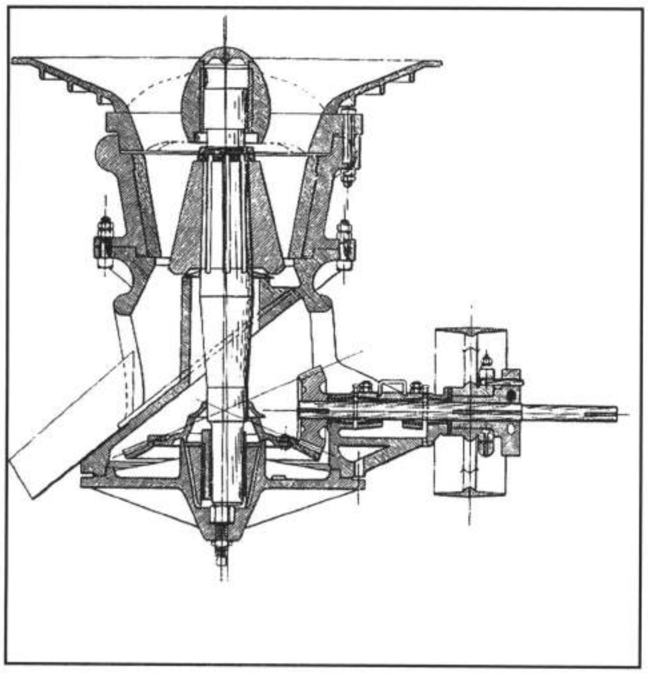


Figure 26. *Cross-section of a cracker that reduced lumps of burned limestone to a small size for a grinding mill such as seen in figure 27.* Drawing from Albert Victor Bleininger, "The Manufacture of Hydraulic Cements," *Geologic Survey of Ohio*, Bulletin No. 3 (1904): 258.

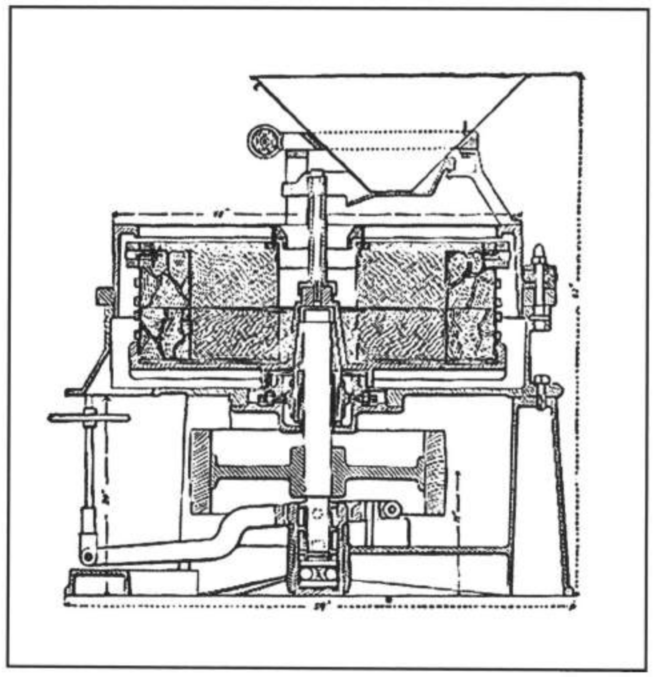


Figure 27. *Cross-section of a Sturtevant cement-grinding mill equipped with emery stones.* Drawing from Heinrich Ries and Edwin C. Eckel, "Lime and Cement Industries of New York," *Bulletin of the New York State Museum* 44, no. 8 (1901): 689.

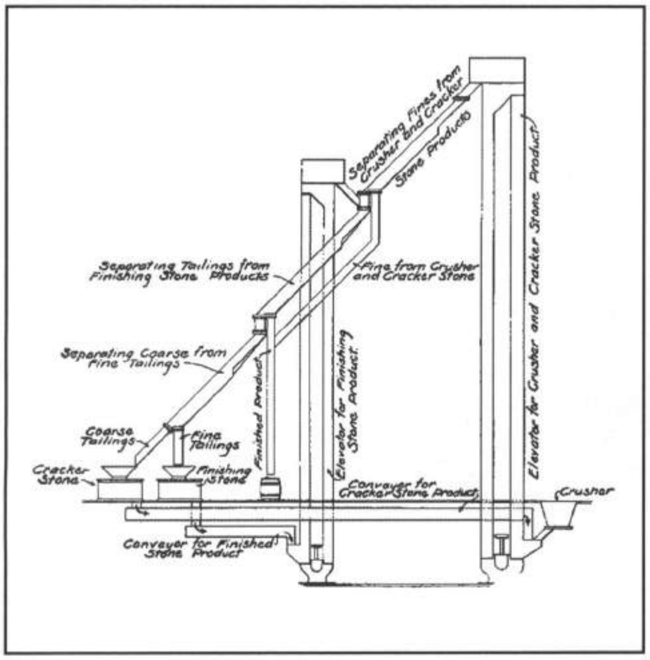


Figure 28. *Berthellet reduction and processing system that was likely applied to the Newark and Rosendale mill. The process begins at lower right where rock enters the crusher. The crusher's output moves up the right elevator to the top, then the rock moves downward, diagonally to the left. Material passing through a 50-meshes/inch screen falls into the lower incline plane and through the finished product "slide" to the barrel. The remaining material slips downward to the cracker or the finishing stone, depending on particle size determined by a second screen. The cracker breaks the stone to a size accepted by the finishing stones, and its output is carried left to right on a conveyor and returned to the elevator* (right). *The output of the finishing stone is conveyed to the left elevator, where it is screened and either directed to the barrel or re-enters the cycle for further processing. In theory, all of the chunks of rock entering the crusher will end up in the barrel as powder that has passed through a 50-meshes/inch screen.* Albert Victor Bleininger, "The Manufacture of Hydraulic Cements," *Geologic Survey of Ohio,* Bulletin No. 3 (1904): 190.

configured with the fixed or "bed" stone at the bottom and the revolving or "running" stone at the top, later mills developed specifically for grinding cement were configured with the fixed stone at the top and the running stone at the bottom. Presumably this change of position aided maintenance, which involved deepening the channels in the stones as they wore down under the abrasion of the limestone. It was noticed during the survey that dozens of fragments of worn-down millstones were reused as building stone (figure 18).

No written descriptions of the organization of the N&R L&C mill were located during the archival research nor were any photos of the inside of the mill found. It may be assumed, however, that most cement mills were organized and run in similar ways. Bleininger provides a system drawing and a section drawing of typical natural cement mills [figures 25 and 28]. He wrote:

> An ingenious system of screening has been perfected by Berthellet in which all of the crushed material makes a complete circuit, the fine material being constantly removed and the coarser particles being carried along with the fine grindings from the buhr mill, since they insure better working of the screens. The grindings from the finishing mill are usually screened and delivered to the hopper, from which chutes take the cement to the packing room. Usually the rock cement is not stored, but shipped at once. This of course, is a matter depending on the composition of the cement rock. Very basic cements must be stored.[59]

Barrels were essential to the natural cement industry in the 19th century when shipments were transported in open vessels, which exposed their cargos to moisture. The early works of H. White did not include a cooperage to manufacture wooden barrels into which his cement was packed for shipment. Acquiring enough barrels was challenging. In a letter to his wife, Maria, dated 26 April 1838, H. White wrote,

> I arrived here this morning safe and sound but found matters going rather dull, first the vessel by which we expected 6 or 700 empty barrels has not arrived, consequently we are disturbed and obliged to let the cement run upon the floor. The kills [sic] are rather cool; therefore we do not make as much cement as usual.[60]

Later in the letter, H. White instructed his wife to direct an assistant to secure 1,500 more barrels, 1,000 of which were to be shipped to Whiteport and 500 to be stockpiled in his Waterford pasture. The N&R L&C recognized the need to develop its own barrel manufacturing capability to control costs and ensure the availability of the containers to meet orders in a timely manner. The company constructed a large cooperage that was likely equipped with the many different cooperage machines that were being invented and introduced at the time (figures 7, 12, 13).[61]

The Newark and Rosendale Company built a huge number of barrels. For example, in 1858 the company produced 119,822 barrels. In 1871 the company was packing 800 barrels of cement per day. During the last 10 years of its operation (1892–1902), the company was shipping more than 150,000 barrels of cement annually.[62] By the mid-1880s, so many barrels were being returned to Whiteport that the cooperage production was reduced and soon stopped. (The return of barrels was encouraged with a deposit that the manufacturer refunded.) The company operated a recoopering shop (Feature 8) where barrels were repaired or rebuilt. Large amounts of space were required for the stacking of staves as well as storage of headers, hoops, and empty barrels. The empty barrels returned for deposit refund were likely brought in through the Eddyville port facilities (see figure 29).

Inventory records show that the company operated a testing laboratory.[63] As early as the 1840s, purchasers of hydraulic cement were providing written specifications that defined their expectations as to the quality and performance of the cement being manufactured for them, requiring the cement manufacturer to certify certain tests. A typical artifact of 19th-century cement testing is the hourglass-shaped cast briquette, used for testing tensile strength of hardened cement. The briquettes are common in the collections of Rosendale's Century House Historical Society as well as with private collectors throughout the Rosendale area (see figures 30, 31). The N&R L&C laboratory, defined as a small, stone structure that was 15 by 17 feet in inventory records, was not recognized by the survey. It is assumed that the laboratory was among the buildings making up the mill complex (Feature 11). As the industry grew, the purchasers became more specific about how cement should be tested, indicating in their purchase orders such attributes as fineness, setting time under a variety of conditions, resistance to shear, compressive strength, tensile strength, and other attributes. For many years there were no standards, and specifications varied. As one example, performance specifications written by U.S. Army engineers were written for individual districts without regard to other districts' documents, resulting in different sets of manufacturing specifications for the Army. It was not until the mid-1880s that testing methods were beginning to be standardized by the American Society of Civil Engineers and not until the 1890s that the American Society for Testing Engineers, a university-based group, established testing standards as known today.[64]

Conclusions

The Whiteport archaeological site provides the opportunity for research and learning. Research to define the historic context demonstrates that Whiteport was associated with events that made a contribution to patterns of American history as well as to the lives of people who are significant in the technological and industrial past.

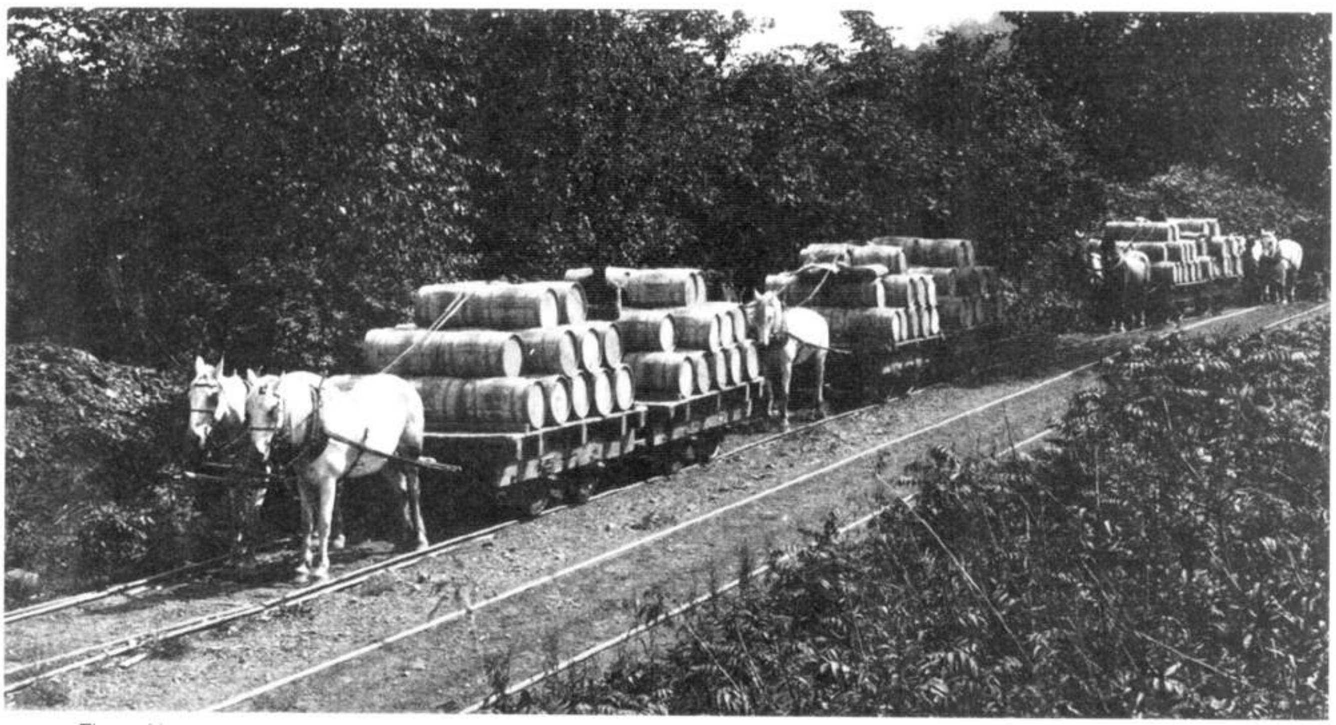


Figure 29. *Loaded with barrels of cement, cars on the Hickory Bush and Eddyville Railroad, which is the horse-drawn railroad that served the N&R L&C Co. from 1869 until 1902.* Photo courtesy of the Century House Historical Society, Rosendale, New York.

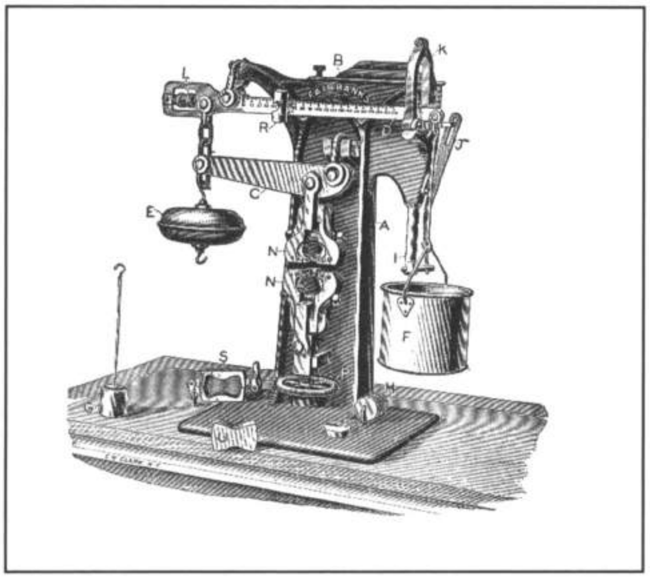


Figure 30. *Fairbanks cement briquette* (U) *test apparatus, which would reveal the weight (or tension) at which the briquette breaks in half. The apparatus is basically a balance scale that can measure tension on a briquette placed in the gripper* (N) *with a combination of weights* (E and F), *using a sliding scale-reader* (R). Drawing from Uriah Cummings, *American Cements* (Boston, Mass.: Rogers & Mason, 1898), 177.

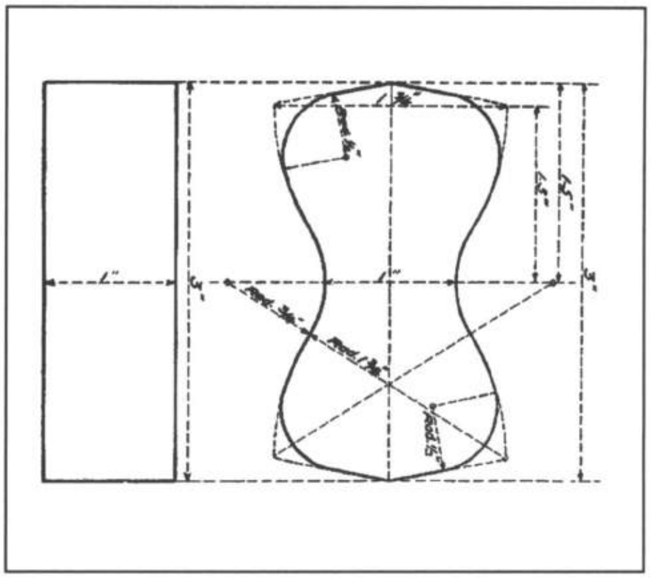


Figure 31. *Standard cement tensile-strength test briquette. The center area measures 1 inch square and is the smallest cross-sectional area, thus the weakest portion of the molded form.* Drawing from Albert Victor Bleininger, "The Manufacture of Hydraulic Cements," *Geologic Survey of Ohio*, Bulletin No. 3 (1904): 375.

Although the machines applied to the manufacture of natural cement are no longer onsite, the infrastructure of the ruins provides evidence of the cement-making process applied there. For example, the survey has made it possible to interpret physical space requirements necessary for the successful operation of a cement mill, revealing that much more space than was expected by this surveyor was required for coopering.

Documentary research in support of the survey, which was limited in scope, has found useful descriptions of the structures that made up the works at Whiteport in collections of the Century House Historical Society. More intensive documentary research promises much detail, perhaps including details of machinery and systems.

The survey did not investigate the remains of the homes or other buildings that made up the "company town" that developed. Much work remains to be accomplished on that aspect of Whiteport, with an ultimate goal to learn about the lives of the people who made this industry work. Researchers may examine Gregg Andrews's *City of Dust*[65] to learn about the town of Ilasco, created when the Atlas Company began producing Portland cement in Hannibal, Missouri, in 1906, just as Whiteport with its more than 1,000 inhabitants was being abandoned. Andrews's work is an extensive and useful anthropological and historical study of a 20th-century cement company town. He had the advantage of being able to interview witnesses. As we know of no living witnesses of the 19th-century town of Whiteport, archaeology is required to provide a more complete story. This survey should be regarded as a kind of context statement in support of the significance of the site, and it may be a beginning of important new research into Whiteport's unique group of people who lived more than a century ago, made cement, and contributed to American culture.

Acknowledgments
I am indebted to many people who helped to make this article possible. First and foremost, I am grateful to Michael and Arikka Pavlov for inviting me to do the survey and for extending their hospitality to me. I am impressed with their resolve to make Whiteport a place of learning. I am extremely thankful to Marjorie

Robbins for her essential assistance with field and archival research and for intelligent proofreading. I am indebted to Gordon DeAngelo of Chittenango, New York, for his help in the search for the origins of cement manufacturing there and for the many useful copies of materials that he extracted from the Chittenango Landing Canal Boat Museum collection. I thank Dietrich Werner, president of the Century House Historical Society and curator of their collections, for his assistance and sharing of knowledge. The citizens of Rosendale are fortunate to have Dietrich remind and inform them of the important history of their town. I thank the helpful librarians at the Rosendale Public Library and the librarians at the New York City Public Library's historic map and microfilm sections. I am grateful to Bruce Utter of the Waterford Historical Museum, housed in Hugh White's home, for making the museum's collection of Hugh White material accessible to me. I am most grateful to the folks who took the time to read a draft of this article and provide comments that helped improve the final version, including Stanford Prichard, Victoria Bunker, David Starbuck, James Garvin, and Patrick Martin.

Notes

1. See Alexandria Goho, "Concrete Nation," *Science News* 167, no. 1 (1 Jan. 2005): 7, 8, 11.
2. *The Report of Board of Engineering Officers on Testing Hydraulic Cements with Specifications for the General Case* was published in 1901 by the Government Printing Office in Washington, DC, and the ASTM published the first natural cement standard in 1904. The historical development of commercial standards and specifications and the acceptance of written protocols are fully discussed by Amy E. Slayton in her introduction to *Reinforced Concrete and the Modernization of American Building* (Baltimore, Md.: Johns Hopkins Univ. Press, 2001), 1–19.
3. Thomas F. Hahn and Emory L. Kemp, *Cement Mills along the Potomac River* (Morgantown, W.Va.: Institute for the History of Technology and Industrial Archaeology, 1994).
4. See Gerald Bastoni, "Episodes from the Life of Canvass White Pioneer American Engineer," *Proceedings of the Canal History and Technology Symposium* 1 (30 Jan. 1982), ed. Lance E. Metz (Easton, Pa.: Canal History and Technology Press, 1982), 50–95.
5. See Michael P. Edison, "The American Natural Cement Revival," reprinted in *ASTM Standardization News* 34, no. 1 (Jan. 2006): 3–4 or see <www.astm.org/snews/january2006>.
6. Dennis E. Howe, "Concrete in the Archeological Record: How Old Is It?" *The New Hampshire Archeologist* 43/44 (2003/2004): 119–57.
7. The ratio can vary by about ±12%. For various definitions of 19th-century cements, see Frederick P. Spaulding, *Hydraulic Cement: Its Properties, Testing, and Use* (New York, N.Y.: John Wiley & Sons, 1898); Uriah Cummings, *American Cements* (Boston, Mass.: Rogers & Mason, 1898), 19–22; Heinrich Ries and Edwin C. Eckel, "Lime and Cement Industries of New York," *Bulletin of the New York State Museum* 44, no. 8 (1901): 641–968; and Albert Victor Bleininger, "The Manufacture of Hydraulic Cements," *Geologic Survey of Ohio*, Bulletin No. 3 (1904): 25–391. In summary, as compiled by author, these cements are described as follows: *Quicklime* (nonhydraulic) is nearly pure carbonate of lime produced by heating limestone, which possesses the property of slaking, producing heat (and creating a paste) when treated with a sufficient quantity of water. It may be called "fat lime" when nearly pure and "meager lime" when inert impurities are present. When used in mortar, quicklime sets air-drying and will soften when subjected to water. *Hydraulic lime* is produced by heating limestone that contains 75%–80% calcium carbonate and 25%–20% clay (silica and minor compounds). Hydraulic lime may slake, producing heat, but mortar made with it will set under water, albeit slowly. *Roman cement* is produced by heating limestone containing 50%–70% calcium carbonate and 50%–30% clay. Roman cement will not slake, and mortar made from it will set under water. *Natural hydraulic cement* is produced by heating Dolomite (containing 34%–70% calcium carbonate) and clay with 20% or more aluminous impurities.
8. See, for example, Robert Dott, Jr., and Roger Batten, *Evolution of the Earth*, 3d. ed. (New York, N.Y.: McGraw-Hill, 1981), 52, 244.
9. All texts published after Quincy A. Gillmore's *Practical Treatise on Limes, Hydraulic Cements, and Mortars* (New York, N.Y.: D. Van Nostrand, 1874) that I consulted referred to "artificial cement." Defined, for example, by C. D. Jameson, *Portland Cement, Its Manufacture & Use* (New York, N.Y.: D. Van Nostrand, 1898): "In what follows the term Portland cement means always an artificial cement as distinguished from natural cement" (p. 198).
10. Hydraulic cement technology was not widely known after the fall of Rome but was revived in Europe in the 18th century. See Daniel L. Schodeck, "The Middlesex Canal," *Landmarks in American Civil Engineering* (Cambridge, Mass.: MIT Press, 1987), 6–13, 10–12 (mortar discussion). Also see Mary Stetson Clarke, *The Old Middlesex Canal* (Melrose, Mass.: Hilltop Press, 1974). Pozzolanas are discussed by many texts: I used M. S. J. Gani, *Cement and Concrete* (New York, N.Y.: Chipman and Hall, 1997).
11. See Bastoni, "Episodes" (n. 4).
12. ibid.
13. Arthur H. Masten, *History of Cohoes, New York* (Albany, N.Y.: Joel Munsell, 1877) 50–65; Nathanial Bartlett Sylvester, *History of Saratoga County New York* (Philadelphia, Pa.: Evwerts & Ensign, 1878), 338–39; also see Bastoni, "Episodes" (n. 4).
14. See Sylvester, *History* (n. 13).
15. Ann Gilchrist, *Footsteps across Cement: A History of the Township of Rosendale, New York* (Rosendale, N.Y.: A. Gilchrist, 1976), 42–43. For early kiln descriptions, see Victor R. Rolando, *200 Years of Soot and Sweat: The History and Archaeology of Vermont's Iron, Charcoal, and Lime Industries* (Burlington: Vermont Archaeological Soc., 1992), 207. For early manufacturing processes, see Gillmore, *Practical Treatise* (n. 9).
16. See Gilchrist, *Footsteps*, 22, 51 (n. 15); Dietrich Werner, "Hugh White's Rosendale Cement," Century House Historical Society *Natural News* (Winter 2001).
17. See Daniel L. Schodeck, "The Croton Aqueduct," *Landmarks in American Civil Engineering* (Cambridge, Mass.: MIT Press, 1987), 203–11, and Emory L. Kemp and Edward Winant, "John Jarvis and the Hydraulic Design of the Old Croton Aqueduct," *Canal History and Technology Proceedings* 22 (15 March 2003), ed. Lance E. Metz (Easton, Pa.: Canal History and Technology Press, 2003), 56–78. Descriptions of the use of mortar and concrete are

described by George H. Rappole, "The Old Croton Aqueduct," *IA: The Journal of the Society for Industrial Archeology* 4, no. 1 (1978): 15–25; and Larry D. Lankton, "Valley Crossings on the Old Croton Aqueduct," *IA: The Journal of the Society for Industrial Archeology* 4, no. 1 (1978): 27–42.

18. Gilchrist, *Footsteps*, 51 (see n. 15).
19. Dietrich Werner, personal communication, 9 Jun. 2006.
20. Passenger railroad service did not reach Whiteport until after the completion of the steel trestle across the Rondout gorge at Rosendale in 1872, but it was nonstandard gauge and did not provide freight service to Whiteport, even after its conversion to standard gauge in 1877. See Gilchrist, *Footsteps*, 51–55 (n. 15); and A. T. Clearwater, ed., *History of Ulster County, New York* (Kingston, N.Y.: Van Dusen, 1907).
21. P. H. Brink and O. J. Tillson, *Map of Ulster County, N.Y.* (Tillson, N.Y.: Brink and Tillson, 1853); Hamilton Child, *Gazetteer and Business Directory of Ulster County, N.Y.*, 1871–1872 (Syracuse, N.Y.: n.p., 1871).
22. Bleininger, "Manufacture," 187–89 (see n. 7).
23. ibid.
24. F. W. Beers, *County Atlas of Ulster, New York, 1875* (New York, N.Y.: Walker and Jewett, 1875); Sanborn Map Company, Fire Insurance Maps, Whiteport portion, 1892, 1898, 1904.
25. Sanborn, maps (n. 24); and the following documents: Insurance policy, Newark & Rosendale Lime and Cement Company at Whiteport & Eddyville, New York, 12 May 1900 to 12 May 1901, Richard Ross Collection of Papers, Century House Historical Society of Rosendale, N.Y. [hereafter, Ross Papers]; Valuations, Newark & Rosendale Lime & Cement Co., 1901, Ross Papers; and Masonry 1st & 2nd Class, Various Buildings, Newark & Rosendale Lime & Cement Co., 1901, Ross Papers.
26. Ross Papers, insurance policy (see n. 25).
27. Gilchrist, *Footsteps*, 51 (see n. 15).
28. Ross Papers, insurance policy (see n. 25).
29. Sanborn, maps, 1892 and 1898 (see n. 24).
30. Werner, "Hugh White" (see n. 16).
31. Sanborn, maps (see n. 24).
32. Ross Papers, insurance policy (see n. 25).
33. Sanborn, maps (see n. 24).
34. Ross Papers, masonry (see n. 25); Sanborn, maps (see n. 24).
35. See Schodeck, "Middlesex Canal," 276–78 (n. 10).
36. Ross Papers, valuations (see n. 25); Sanborn, maps (see n. 24).
37. Gilchrist, *Footsteps* (see n. 15).
38. Ross Papers, insurance policy and masonry (see n. 25); Sanborn, maps (see n. 24).
39. The construction date for this barn estimated by the author from the observed architectural style and initials with the year "1911" carved into sheathing.
40. Ross Papers, insurance policy (see n. 25); Sanborn, maps (see n. 24).
41. Beers, *County Atlas* (see n. 24).
42. Child, *Gazetteer* (see n. 21); Sanborn, maps (see n. 24); Cecil D. Elliott, *Technics and Architecture: The Development of Materials and Systems for Buildings* (Cambridge, Ma.: MIT Press, 1992), 173–74.
43. The tracks can be seen in the photo, figure 19, and are shown on the map by Beers, *County Atlas* (see n. 24).
44. Ross Papers, masonry and valuations (see n. 25); Sanborn, maps (see n. 24).
45. Ross Papers, valuations (see n. 25).
46. Ross Papers, insurance policy and valuations (see n. 25); Sanborn, maps (see n. 24).
47. Betsy Hunter Bradley, *The Works: The Industrial Architecture of the United States* (New York, N.Y.: Oxford Univ. Press, 1999), 52.
48. Robert B. Gordon and Patrick M. Malone, *The Texture of Industry: An Archaeological View of the Industrialization of North America* (New York, N.Y.: Oxford Univ. Press, 1994), 166–69.
49. Ross Papers, insurance policy (see n. 25) and Sanborn, maps (see n. 24); Beers, *County Atlas* (see n. 24).
50. ibid.
51. *1958 Book of ASTM Standards*, Part 4 (Philadelphia, Pa.: American Society for Testing Materials, 1958), 27.
52. Beers, *County Atlas* (see n. 24).
53. Sanborn, maps (see n. 24).
54. Beers, *County Atlas* (see n. 24); Sanborn, maps (see n. 24); Brink and Tillson, *Map of Ulster* (see n. 21); and Werner, "Hugh White" (see n. 16); Ries and Eckel, "Lime," 834 (see n. 7). The purpose of the D&H canal was for the transportation of coal from Pennsylvania to the Hudson River as pointed out by Robert M. Vogel, *Roebling's Delaware & Hudson Canal Aqueducts* (Washington, DC: Smithsonian Institution Press, 1971), 1.
55. Ries and Eckel, "Lime," 834, 836 (see n. 7).
56. Bleininger, "Manufacture," 187 (see n. 7).
57. Ries and Eckel, "Lime," 834 (see n. 7).
58. ibid.
59. Bleininger, "Manufacture," 188, 190 (see n. 7); Ries and Eckel, "Lime," 834, 836 (see n. 7).
60. Letter from Hugh White (at Greenkill Mills) to his wife, Maria (at Cohoes, N.Y.), 26 April 1838; Michael Pavlov, owner of the Whiteport archaeological site, provided a copy of the letter to the author.
61. See Kenneth L. Cope, *American Cooperage Machinery and Tools* (Mendham, N.J.: Astragal Press, 2003); Kenneth Kilby, *The Cooper and His Trade* (Fresno, Ca.: Linden Publishing Co., 1989). Bags did not come into common use for packaging cement until the 1890s.
62. Estimates by author and data from Child, *Gazetteer* (see n. 21) and Ross Papers (see n. 25).
63. Ross Papers (see n. 25).
64. See Slayton, "Introduction" (n. 2).
65. Gregg Andrews, *City of Dust: A Cement Company Town in the Land of Tom Sawyer*, rev. ed. (Columbia: Univ. of Missouri Press, 2002).