MITIGATION REPORT
FULTON STREET TRANSIT CENTER PROJECT

UNANTICIPATED DISCOVERY OF BRICK FEATURE BENEATH THE CORBIN BUILDING

192 JOHN STREET
NEW YORK, NY

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March 18, 2010

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Management Summary

SHPO Project Review Number (if available): 03PR01106

Involved State and Federal Agencies (DEC, CORPS, FHWA, etc): MTA, FTA

Phase of Survey: II

Location Information

Location: 192 Broadway, corner of John Street, New York, NY
Minor Civil Division: 06101
County: New York

Survey Area (Metric & English)

Length: 2.43m/8'
Width: 2.43m/8'
Depth: (when appropriate) 3m/10'
Number of Acres Surveyed: N/A
Number of Square Meters & Feet Excavated (Phase II, Phase III only): N/A
Percentage of the Site Excavated (Phase II, Phase III only): N/A

USGS 7.5 Minute Quadrangle Map: Jersey City

Archaeological Survey Overview

Number & Interval of Shovel Tests: N/A
Number & Size of Units: N/A
Width of Plowed Strips: N/A
Surface Survey Transect Interval: N/A

Results of Archaeological Survey

Number & name of prehistoric sites identified: N/A
Number & name of historic sites identified: Corbin Building Well - 1
Number & name of sites recommended for Phase II/Avoidance: N/A

Results of Architectural Survey

Number of buildings/structures/cemeteries within project area: N/A
Number of buildings/structures/cemeteries adjacent to project area: N/A
Number of previously determined NR listed or eligible buildings/structures/ cemeteries/districts: N/A
Number of identified eligible buildings/structures/cemeteries/districts: N/A

Report Author(s): AKRF and URS
Date of Report: March 2010

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I. INTRODUCTION

The Corbin Building (1888), located at the northeast corner of Broadway and John Street in Lower Manhattan, New York, has been undergoing stabilization for its incorporation into the Fulton Street Transit Center (FSTC) project. This has included jet grouting in preparation for the underpinning of the Corbin Building's foundations. Underpinning of the foundations is required to support the excavation for the new escalators and elevators that will come up through the sub-basement of the Corbin Building and will provide access to and from the new Transit Center to be constructed adjacent to the Corbin Building.

During the jet-grouting process, a brick feature was discovered beneath an arch support within the sub-basement of the building (see Figure 1).[1] This unexpected discovery was made when the contractor excavated a test pit to determine the potential cause of the loss of grout/grout pressure during the grouting operations. As per the stipulations of the Project's Unanticipated Discovery Plan, the contractor notified the Metropolitan Transit Authority (MTA) and the Cultural Resources Management (CRM) Team. MTA immediately issued a stop work order in the area of the feature. The test pit was backfilled for safety purposes. Following consultation with the New York State Historic Preservation Office (SHPO) and the New York City Landmarks Preservation Commission (LPC), archaeological mitigation occurred in response to this discovery from December 2009 through January 2010, as described in further detail below.

This report is organized commencing with a discussion of archaeological resource potential and the archaeological mitigation plan that was implemented (Sections II and III), followed by a discussion of the investigation of the shaft feature and the results of that investigation (Section IV), with further documentation of the feature and site provided through a brick and mortar analysis, research on the site's development, comparative evaluation of other wells found in New York City, analysis of the topography of the site (Section V), and finishing with an analysis discussion and conclusion (Section VI).

[1] The jet-grouting process is a blind operation where the grout is pushed into the ground from above.

II. ARCHAEOLOGICAL RESOURCE POTENTIAL

Following an initial site visit by the CRM Team on December 9, 2009, the MTA, at the request of the Project Archaeologist (Alyssa Loorya, URS), directed the contractor to open a larger area for inspection and to expose more of the feature. In accordance with OSHA regulations, the contractor lagged and braced the pit and opened an approximate 3’ x 3’ (.91 x .91 meters) area of the brick feature.

The initial investigation concluded that the brick shaft feature pre-dated the Corbin building and that the feature appeared to have been filled with concrete and/or jet grout. This was observed by removing some of the bricks to ascertain what was in the interior of the feature. SHPO and LPC were notified of the discovery and a conference call among OPRHP, LPC, the MTA, the Federal Transit Administration (FTA) and CRM Team on December 17, 2009, concluded with a determination that the feature was S/NR eligible, and as such, a mitigation plan needed to be prepared and submitted for review and concurrence.

At the time of the December 17th call, construction personnel anticipated that the majority of the feature would need to be removed as the feature was located beneath a building footing that needed to be underpinned to provide structural stability for the building. Specifically, the feature was located in the area of the second proposed underpinning pit (underpinning pit #2) in a series of 30 such pits to be dug beneath the building foundations. During the December 17th call, several questions were raised, including to what extent the feature was filled with concrete/grout. If the concrete fill did not extend throughout the feature, it might be possible that the feature contained material remains. Prior to regular municipal garbage collection, it was common practice to dispose of refuse in no longer used shaft features. If cultural materials were recovered from within the feature, they might provide information with regard to the period when the shaft feature was no longer being used for its original purpose, as well as information about the material culture of the period or dietary habits of occupants in the area. There were also questions regarding the construction date and function of the feature and its relation to the 19th century and modern landscapes.

III. ARCHAEOLOGICAL MITIGATION

As per the above referenced conference call, the CRM Team was tasked with developing and carrying out a mitigation plan for the shaft feature, which was approved by SHPO and LPC. Mitigation consisted of four measures: 1) archaeological monitoring during the removal of the feature, 2) archaeological investigation of the contents of the feature, including the concrete/jet grout, 3) additional historic research of the feature and the surrounding area, and 4) the CRM Team remaining on-call during ensuing excavation within the Corbin building's sub-basement.

The underpinning process in the location of the feature consisted of excavating a 6’ x 4’ (1.6 x 1.2 meters) pit (Underpinning Pit #2), which was anticipated to be excavated to a depth of 14' (4.26 meters) below the sub-basement floor, requiring the removal of the majority of the feature. As indicated above, this underpinning pit would be the second of a series of 30 proposed pits that would be excavated along the perimeter of the Corbin building sub-basement.

Construction personnel indicated that all excavation would occur manually and the mitigation plan indicated that this excavation would be observed by an archaeologist. Due to the sensitivity of the operation, it was understood that excavation would not occur beyond the depth required for the underpinning work. As per the mitigation plan, all materials associated with the shaft feature, including the concrete/grout fill, were removed and collected by construction personnel. The materials were removed to and stored in an area away from the construction work for further examination by the archaeologist.

Also as part of the protocol, additional historic research was undertaken to provide context for the shaft feature. This information is included in Section V. “History” of this report.

IV. INVESTIGATION OF THE SHAFT FEATURE

The feature is located immediately beneath the C-4 brick support column and associated inverted arch support (to the east of the column) along the southern wall of the Corbin building (see Figures 2 and 3). As described above, this area had been excavated to explore a problem during the jet grouting operation which in turn had led to the discovery of the feature. The area was then backfilled by the contractor for safety and structural concerns. The contractor subsequently re-excavated the area for inspection by the CRM Team. The initial area excavated for investigation measured approximately 3’ by 3’ (.91 x .91 meters) and extended 2’ (.6 meters) below the column footer (see Photo 1 of Figure 4). This was expanded to a 6’ by 4’ (1.6 x 1.2 meters) area, and an additional 3’ (.91 meters) of depth, that exposed an approximate 55” by 50” (1.39 x 1.27 meters) section of the circular mortared brick feature (see Photo 2 of Figure 4).

Excavation for the bracing of Underpinning Pit #2, where the feature was located, began in January 2010. The underpinning pit was located beneath foundation column C-4 of the Corbin Building extending west from the area excavated for inspection of the feature. The underpinning pit measured 6' (1.6 meters) wide and would extend approximately 4’ (1.2 meters) horizontally beneath the foundation column.

As opposed to what was discussed during the December 2009 conference call, the project engineers subsequently determined that the excavation for the support column would not impact the majority of the feature as originally anticipated. Instead, the underpinning pit was required to extend 10' (3 meters) below the foundation slab (i.e. concrete floor) and 8' (2.4 meters) below the 2' (.6 meters) thick concrete aggregate footing beneath the column (See Figure 5, which shows the area of the feature as originally exposed and the section of the feature removed to excavate the succeeding underpinning pit). During the excavation of the underpinning pit, another portion of the exterior of the brick feature, consisting of an additional 40" (1 meter) of the feature’s circumference, was exposed (see Photo 3 of Figure 6).

Ultimately the excavation would only impact a relatively small portion of the feature. Of the approximate 95" (2.41 meters) circumference of the feature that was exposed, only 40" (1 meter) required removal to allow for the underpinning. The depth of the section that was removed from the feature consisted of the entire 9" (22cm) length of the brick and from 1" - 4" (2cm - 10cm) of interior material (see Figure 7). Removal occurred in 1' segments to allow for shoring (i.e., horizontal lagging) of the area to avoid collapse. The surrounding soil consisted of the fine, silty sand that is the natural sub-soil of the area. As excavation approached the water table, the soil would liquefy, requiring immediate shoring to comply with OSHA regulations.

It was not feasible to expose the upper surface of the feature, as it was located immediately beneath the building footer. Opening up this portion of the feature, on which the footing rested, could have potentially undermined the structural stability of the footing. As such, it is not possible to determine if the feature was capped with no deconstruction or if a portion of it was removed to construct the foundation of the Corbin Building (or previous buildings on the site) and pour the footings. Removal of the upper bricks confirmed that the interior of the shaft feature was filled with a concrete aggregate along with jet grout that had been inadvertently inserted during the blind grouting operations. The concrete aggregate material appears to be similar to the material that comprises the Corbin Building's footings (Glavan 2010).

Jet grout moderately impacted the feature in small areas of the upper portion of the feature and at the bottom of the concrete/jet grout fill. However, this consisted of a thin surface less than 1" (2cm) thick. Concrete and jet grout filled the feature to a depth of 57” (1.44 meters) below the footing. The remainder was filled with soil, the same fine, silty sand that surrounded the exterior of the feature. The final 30" (.76 meters) of the excavation area was situated within the water table prior to dewatering[2]. Even with the dewatering operation the area was substantially wet.

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[2] Dewatering has been ongoing for several weeks in preparation for the underpinning and construction of the Transit Center foundations.

The bottom of the brick feature was reached at a depth of 98" (2.48 meters) below the existing footing. A circular wooden base, known as a curb, which served as a platform on which to lay the bricks, was exposed at the bottom of the excavation (see Photo 4 of Figure 8). This base was constructed of two layers of overlapping sections of wood that were nailed together with square cut nails (see Photo 5 of Figure 8). Similar circular wooden curbs have been found associated with well features at other sites in the city and are discussed further below in Section V. "History." At the bottom of the feature, the same fine, silty sand that surrounded the exterior of the feature was observed. Unlike the majority of the feature which was composed of mortared bricks, the bricks in the lower 30" - 36" (.76 - .91 meters) of the feature were un-mortared.

The bricks of the feature are known as compass or key bricks, purposefully tapered to form a circular structure (see Table 1 below and Photo 6 of Figure 9). The bricks of the feature are fairly large and are soft. They measure 2 ¼" (6cm) thick, 8 ½" (22cm) long, and taper in width measuring 6" (15cm) at the wide end and 4 ¼" (11cm) at the narrow end. They range in color from orange to dark red with pebble inclusions. They are notably different from the bricks used for the construction of the Corbin Building which are smaller and have a more uniform appearance.

Table 1
Corbin Building Key Brick Measurements

Sample	Weight	Length	Narrow end width	Wide end width	Thickness	Comments
Brick 1	2680 g	21.5 cm	8.5 cm (incomplete)	15.5 cm	6 cm	orange with pebble inclusions, patchy gray mortar adhered, some patches of charring
Brick 2	2960 g	21 cm	11.5 cm	15.5 cm	5 cm	orange with pebble inclusions, moderate gray mortar adhered, some patches of charring
Brick 3	2700 g	22 cm	11 cm	15 cm	6 cm	dark red, cracked, some deformity, moderate gray mortar adhered, moderate charring
Brick 4	2880 g	22 cm	11 cm	14.5 cm	5.5 cm	orange, slight deformity, moderate gray mortar, some patches of charring
Mortar	1600 g					light gray with coarse grit and larger stone inclusions

As per the archaeological mitigation plan all excavated materials were recovered for further examination by the archaeologists. These materials included the brick that formed the feature, concrete, grout and interior soils within the feature. An examination of the 150 sandbags of material recovered from the excavation identified three pieces of pottery and one pipe stem in addition to the brick, mortar and concrete. The pottery consisted of two pieces of tin-glazed tile and one shard of Chinese import porcelain; the pipe stem had a bore hole diameter of 4/64^{ths} (see Photo 7 of Figure 9). The artifacts are described in Table 2, below.

Table 2
Artifacts

Entry#	Artifact Count	Group	Class	Material	Typology	Object	Surface/ Decoration	Decorative Element	Colors	Pattern	Begin Date	End Date	Comments
1	2	Household	Ceramic	Earthenware	Tin-glazed	tile		Painted	Blue	Unidentified	1625	1800	
2	1	Household	Ceramic	Porcelain	Chinese Import	Hollow-ware		Painted	Blue	Unidentified			
3	1	Personal	Ceramic	Clay	White Ball Clay	Pipe			White				4/64

As there was no significant concentration of artifacts it does not appear as though this feature was used for any form of trash disposal. Due to the characteristics of the concrete aggregate found within the feature, which is similar to that of the Corbin Building footings, it appears that the feature was filled when the footings of the Corbin building were poured. Based on the exterior measurements this circular feature has an exterior diameter of 7' 7" (2.3 meters) and an interior diameter of 6' 3" (1.9 meters).

BRICK AND MORTAR ANALYSIS

Building Conservation Associates (BCA), the project's historic preservation consultant, examined a brick sample and concluded that the bricks appeared to be hand formed and that the mortar consisted of a mud or clay base with a small quantity of lime. A mortar sample was sent to Highbridge Materials Consulting, Inc. for petrographic analysis. This report is summarized below and included as Appendix A of this report.

> The sample is identified as a sanded lime mortar with a relatively low sand content. The material is soft, friable, and porous and is consistent in texture with a non-hydraulic lime mortar. While the hand sample is soft, there is evidence to suggest some minor hydraulic component.
>
> The lime matrix has a high capillary porosity and is virtually all carbonated. Microscopic shrinkage cracks are relatively common and these are typical of lime mortars particularly those with a low sand content. Aside from the typical matrix characteristics, the lime is identified based on the presence of undispersed lime grains. Some of the lime grains contain microtextures that have survived the calcination process. These are consistent with textures found in marine shells. Furthermore, unburned and partially burned shells are dispersed throughout the matrix. The lime is therefore interpreted to have been burned from a shell rather than rock source.
>
> Fine-grained particles consisting of silty clay are detected as well. However, these are not interpreted to be part of the sand. Clay was sometimes added to lime mortars for economy but this does not appear to be the case here either. Some of the clay particles are associated with a vesicular glass suggesting that the clay was calcined. Calcined clay may have been used here as a pozzolan or hydraulic addition.
>
> In some cases, the clay is found adherent to unburned or partially burned shell fragments suggesting that the clay and lime had been mixed prior to incorporation in the mortar. There are two ways this might have been performed. The first is that the clay and lime had been mixed prior to calcination in order to produce an artificial hydraulic lime. The second possibility is that the clay was calcined separately and added to the lime to produce a pozzolanic reaction during curing. This latter possibility is favored by the author.
>
> The aggregate is a fine to medium grained siliceous natural sand containing quartz and feldspar with other trace components. The quartz grains typically have a natural iron oxide coating. The sand is sharp textured with most grains subangular in shape. The aggregate is observed in low abundance.
>
> Finally, the mortar does not contain evidence for significant deterioration in service. Microscopic cracking is present but these are considered to be early shrinkage cracks typical of lime mortars with a low sand content. The mortar is almost fully carbonated but this is a desirable consequence of lime mortar curing. Some recrystallized carbonate is found along one bed surface but this is minor. Ettringite (a sulfate mineral) is found in low abundance within air-voids. While not a typical secondary product in lime mortars, there may have been some sulfate present in the added clay resulting in this mineralogy. The only other likely reason for the presence of ettringite would be the presence of portland cement-based mortars adjacent to or very near this lime mortar sample.

Dr. Allan Gilbert of Fordham University, a noted archaeologist and expert on bricks and brick making in the New York metropolitan region, also visited the site to inspect the feature. A sample of the brick was sent to him for examination.

Dr. Gilbert stated that key (compass) bricks were commonly used in the construction of wells. Based upon the breadth of his knowledge and experience, as well as comparative brick samples in his collection, Dr. Gilbert dated the feature to the early-nineteenth century.

Dr. Gilbert's and Highbridge Materials Consulting Inc.'s conclusions provide a date range for the possible construction of the feature. John Walsh, Senior Petrographer and President of Highbridge Materials Consulting, Inc., believes that the shell in the mortar composition could suggest a colonial date. Dr. Gilbert believes the feature to date to the early nineteenth century. According to Dr. Gilbert, “shell by itself isn't sufficient evidence for a colonial date, and there were still shells for burning in the 19th century” (Gilbert 2010). His interpretation is based upon a consideration of factors including the brick shapes, and the fact that the mortar is so thoroughly lime as opposed to a higher shell concentration.

V. HISTORY

In order to assist in the evaluation of the feature beneath the Corbin Building, early maps of Manhattan have been examined, other historical sources consulted, and analyses undertaken to reconstruct the topography and physiography of the area prior to the Corbin Building's construction.

THE HISTORY OF THE SITE

In the mid-seventeenth century, the Corbin Building site and nearby vicinity was part of the bouwerie or plantation owned by Secretary of the Province, Cornelis Van Tienhoven who received it as a grant from Governor William Kieft in 1644. Van Tienhoven's bouwerie was bounded on the west by Broadway, east by the East River, Ann Street to the north and Maiden Lane on the south. After Van Tienhoven's disappearance and presumed death in 1667, the property devolved to his wife Rachel and after her demise, to her children (Stokes 1967, I:237 and IV:256). The grant was confirmed by British Governor Nicolls. The executors of Rachel Van Tienhoven's estate, Peter Stoutenburg and Jan Vinge (her son-in-law), conveyed what remained of the property to Jan Smedes, a cartman, in 1671 (Collections of the NY Historical Society 1914: 9-10 in NYCLPC 1991:13). This deed described the acreage as "a certain farm or Bowry" that included a house, barn, orchard, cornfield and pasture (Ibid). However, the property was immense and it is difficult to say where these structures might have been. In addition, the Castello Plan of 1660 shows the area as an empty field. At this time, the property was roughly bounded by Broadway, on the west, Fulton Street to the north, Maiden Lane to the south and William Street on the east (Haff Associates, Inc. 2005:8).

In two separate deeds, dating 1673 and 1675, Smede transferred his property to four shoemakers and/or tanners: Conraet Ten Eyck, Caarsen Leursen, Jacob Abramse, and Jan Herberding (Harpendinck and various other spellings) (Stokes 1967, I:237). The land was subsequently known as the Shoemakers' Field or Pasture. It is possible there were leather- working industries on this vast expanse of property. "Tanning vats are mentioned in a deed dated 1696 (Liber Deeds XXVIII:136) but their exact location in unknown" (NYCLPC 1991: 13). A planning document prepared for the Collegiate Church Corporation by Haff Associates, Inc. (2005:9) states that the owners of the Shoemakers' Field constructed tanning pits in the "marshy area near the Maiden Path (Maiden Lane), where there was a brook that ran down into the East River. These pits functioned as vats that held chemical mixtures in which hides were soaked as part of the tanning process" (Ibid). Tanning was no longer permitted within the city limits after November 1676. The Shoemakers' Field was outside the city limits at the time (Ibid:16) but there is no evidence that tanning vats were ever constructed on the Corbin Building property. Most tanning vats were relatively shallow and/or above ground (Pappalardo, personal communication, 2/22/10). They certainly would not have been un-mortared which would have allowed seepage, nor would they have extended into the water table.

Although the Shoemakers' land was originally divided equally among four shoemakers and tanners, Heiltje Clopper, widow of another shoemaker/tanner, owned a parcel adjacent to the property and added her land to theirs. In 1696, the group divided the parcel into 164 standard lots for rental and building development (Stokes 1967, I:237; Plate 24; Liber Deeds XXVIII:128-46) (see Figure 10 *A Map or Chart of a Certain Tract of Land commonly call'd The Shoemakers Land (Etc.)* depicting 1696). The property consisted of about seventeen acres. John Harpendinck was the most prominent member of the Shoemakers' Guild, a wealthy man and "a great pillar of the Dutch Reformed Church" (Stokes 1967, I:237) and it is believed John Street was named for him. Upon his death in 1723, he bequeathed his 39 lots in the Shoemakers' Field to his wife with the stipulation that after her death, the lots would fall to the Reformed Protestant Dutch Church (Haff 2005:11). His widow, Mayken Harpendinck died in 1724. These 39 lots were reduced to 21 through consolidation and as of 2004, four of the twenty-one were still held by the church as a source of their endowment (Ibid:9). The Corbin Building today at 192 Broadway/11John Street, consists of Block 79, Lot 15, which corresponds to Harberdinck's Lot 163.

Structures might have been located on the Corbin Building property by 1730 but the Lyne-Bradford Plan does not depict the exact location of these structures; rather it only shows a darkened band which suggests buildings were present. Drawn five years later, Mrs. Buchnerd's vernacular Plan of 1735 only shows structures present on the Broadway side of the Block. The 1813 *Plan of the City and Environs of New York* by David Grim, depicting the city in 1742-44, indicates that five structures were present along the Broadway side of Block 79 between John and

Fulton Streets and two structures were located along John Street toward the Nassau Street side of Block 79. The 1766/7 Ratzen Map (Stokes 1967, I: Plate 41) clearly illustrates the newly constructed John Street Theatre erected in 1767 (see Figure 11), and the first playhouse of note in New York City, as east of, and therefore outside the footprint of the Corbin Building property. The new Theatre was rather unsightly, constructed of wood and painted red (Stokes 1967, III:984). It stood about sixty feet back from the street and had a "covered way of rough wooden material from the pavement to the doors" (Stokes 1967, IV: 779). According to Stokes (1967, III:984), the Theatre was on the site of Nos. 15-21 John Street and an alley between Nos. 15 and 19 John Street marked the approach to the lot on which the Theatre stood (Ibid). According to Stokes, in 1767, "a reader of the *Magazine of American History* (Vol. XXVI:396, 476-77 in Stokes 1967, IV:779) wrote that the John Street Theatre stood on Lots 70, 71 and 72 of the divisional map of the Shoemakers' Pasture" (Ibid) (see Shoemakers Land Map above, Figure 10). This information also suggests the Theatre was not on the Corbin Building property.

The Theatre closed its doors in 1774, probably due to troubles associated with the impending Revolution but it reopened during the British occupation, as the Theatre Royal, from 1777 until 1781. After the War, it was renamed the National Theatre and a wing was added to the west side of the building. George Washington attended a performance of "School for Scandal" along with the Vice President, Governor, members of Congress and other notables at this time. The theatre was demolished in 1789, rebuilt and reopened in 1791 and it played its last performance on January 13, 1798.

There was once a bronze tablet stating that George Washington attended performances here. This plaque, "dedicated by the Maiden Lane Historical Society" was fixed to the building that once stood at 15 John Street" (Ulmann 1923:237).

The 1776 Holland Map illustrates a structure on the project site. It is possible it depicts the Theatre but Holland places it flush with John Street and Stokes (1967, III:984) say the Theatre was set back from the street.

The 1797 Taylor Roberts Plan also shows the Theatre as the only structure on the block. No structures are illustrated on the 1803 Goerck-Mangin Plan, however, as early as 1803, Jonathan Little, a merchant with a business at 165 Water Street, is residing at 15 John Street suggesting at least one structure was extant on the John Street side of the block within the Corbin Building property (Longworth 1803:197). Tax assessment records dating to 1808 indicate the present-day Corbin Building property was occupied by houses, shops and stables (A summary of the tax assessment records is provided in Appendix B of this report). At that time, Nos. 1 and 3 John Street were occupied by three stables owned by John Strineham, George Stanton, and Jonathan Little. Little and his wife also owned a house and lot at 15 John Street. Stanton owned a boarding house at 10 John Street across the street but his stable was on the Corbin Building property. At No. 7 John Street, were "shops and lots" owned by John Bloodgood, a coachmaker, who was listed at that address as early as 1802 (Longworth 1802:149). A house and lot at No. 13 John St. was owned by George Lovett and it is possible this was his residence because a James Lovett, possibly his son, was also listed at this address and the 1810 assessment, indicates that James Lovett is the owner of the property.

In 1810, there was an assessment for a house and lot owned by Edward Bacon at 192 Broadway. The New York City Directory for 1806 puts his dry goods store at 194 Broadway (Longworth 1806). It is possible he lived next to his shop or that one of the addresses is incorrect.

By 1820, widow Ann Bloodgood owned three shops at 11 John Street as did Richard F. Lawrence. Charles Miller was assessed for "rearground" at No. 11 John Street, at which time Jonathan Little and B. Hyde owned a stable at the rear of 11 John Street. It is interesting that by 1835, Sumner & Naylor owned an "alley" and "factory" to the rear of 13, 15, 17, and 19 John Streets. Wright's *Commercial Directory* (1840:186) indicates that Sumner & Naylor had a store that sold "galvanized iron tinned plates for roofing, gutters, leader, etc" on the corner of Broad and South Streets. It is possible the factory for making these goods was located here behind 11 John Street from at least 1835 through 1840.

The 1851-52 Dripps map indicates that by mid-century, the entire Corbin building footprint was occupied by four buildings. Along the western half, one long narrow building tapers at Broadway (192 Broadway/ 1 John Street), and 3 smaller buildings fronting John Street occupy the eastern half of the present-day Corbin Building footprint. The Corbin Building feature appears to be located approximately at the point where the larger building to the west (192 Broadway/1 John St) meets the first of the three smaller buildings to the east (between Lots 7 and 9).

The 1852 Perris map is more detailed and gives the addresses along the John Street side as 3, 5, 7, and 9 John Street for the longer building and 9, 11 and 13 John Street as the addresses of the smaller buildings. Number 9 is listed twice and is probably an error. The 1855 Perris Map gives the addresses for the longer building as 1, 3, 5, and 7 with the three smaller buildings listed as 9, 11 and 13 John Street. The same is true on the 1857 Perris map (see Figure 12).

By 1885, the Robinson and Pidgeon Atlas provides lot numbers: 446 for a triangular shaped structure at the corner of Broadway and John Street (192 Broadway) and 11 John Street as lot number 412. No address or lot number is provided for the next lot to the east, but what is now 15 John Street (previously 13 John) is lot 414. The 1891 Bromley Atlas depicts the Corbin Building footprint as 162.10 feet along the north and south, 49.1 feet on the east, and only 20 feet on the west along Broadway.

In 2006, the land and Corbin Building along with four other properties were acquired for development of the new Fulton Street Transit Center. The properties adjacent to the Corbin Building were subsequently demolished and construction has begun for the Fulton Transit Center foundations.

TOPOGRAPHY OF THE SITE

Research was conducted to determine the elevation of the original ground surface at the location where the brick feature was discovered. The elevation at the corner of Broadway and John Street is currently a little more than 30 feet above sea level. At the corner of Liberty Place and Maiden Lane, less than 300 feet to the southeast, the elevation drops to approximately 20 feet above sea level. A number of cartographic and historic documents suggest that this gradual drop in the topography to the south and east from Broadway in the project site vicinity may have been greater during the 18th and 19th centuries.

The earliest historic map containing topographical information reviewed for this analysis is the 1730 Lyne Map. This map shows a depression extending northwestward from the East River roughly along the path of Liberty Street and Maiden Lane to a point just northwest of the intersection of John Street and Broadway. This depressed area, indicated by tight hatch marks, is very similar to a depression extending the length of Maiden Lane on Viele's 1865 Map (see Figure 13). Viele's Map does not indicate that this linear area was marshland but it has been interpreted as a stream. Hill and Waring's 1899 *Old Wells and Watercourses of the Island of Manhattan* describes a stream as extending along Maiden Lane from the East River to Nassau Street. This work provides a fairly detailed description of the stream's banks:

> In a depression which followed the line of the present Maiden Lane from Nassau Street to the East River, a little stream of sparkling spring water rippled and danced over a pebbly bottom. The southerly bank was steep, but not abrupt, while, on the north, a gentle grassy slope extended from the water to a sharper rise just beyond. The spot presented such facilities for the washing and bleaching of linen that it became a resort for laundry women, and because of this it was first called *Maagde Paetje*, or Virgins' Path *(Old Wells and Watercourses of the Island of Manhattan*, by George Everett Hill and George E. Waring, Jr. in *Historic New York: the First Series of the Half Moon Papers* (New York, 1899), accessed at http://watercourses.typepad.com/watercourses/2008/09/maiden-lane-manhattan.html on January 25, 2010).

A third historic map depicting topographical information in the project site vicinity is the 1766 Montresor Map (Figure 14), which shows tight hatching extending in a band roughly parallel to Broadway in this area. Finally, the Townsend Maccoun Map of the Island of Manhattan drawn in 1909 depicts the landscape as it appeared in 1609 including elevations, streams, marshes, and the original shoreline. This map purportedly is based on early colonial surveys and Viele's 1861 survey. It shows a stream coursing from west to east along present-day Maiden Lane and emptying into the east River. Another stream is shown flowing from north to south near present-day William Street, joining the aforementioned stream near the present southwest corner of Maiden Lane and William Street.

An historic reference to topographical change along John Street can be found in the 1831 Report of the Committee on Streets. The reference states that an individual named S. Cowdrey requested "that the hill in John Street be pitched and regulated as to form a more gradual descent" (Document No. VII, Board of Assistant Alderman, Dec. 19, 1831, Report of the Committee on Streets, on the subject of widening John Street. B. Crane, Clerk). Though the location of the "hill at John Street" is not known and it clearly could have been to the east of the project site, the reference does support the conclusion that topographical change has occurred and is consistent with the Montresor Map (see Figure 14).

Based on these information sources, it seems likely that the original ground surface into which the brick shaft feature was constructed was at a lower elevation than Broadway's current elevation. Though the actual elevation of the original ground surface has not been determined, an estimate of between 25 and 20 feet above sea level is reasonable. Given that the top of the feature remains were discovered at a depth of about 22 feet below current street grade, or at an elevation of approximately 8 feet above sea level, it is reasonable to assume that between 12 and 17 feet of the shaft feature was removed sometime in the past and that it originally extended into the ground a distance of between 20 and 30 feet.

DRINKING WATER AND PUBLIC WELLS IN NEW YORK CITY

During the 17th century, obtaining fresh drinking water in lower Manhattan was an early and immediate concern for the residents of the colony. Local residents used fresh water ponds such as the Collect Pond and shallow wells to obtain water. However, well water near the shore was brackish, often making it unfit for consumption (Geismar 1983, 2005; Koeppel 2000) and nearby industries soon polluted the water in the local fresh water streams and ponds.

New York City's first public well was constructed in 1666 by Governor Richard Nicholls within the confines of the Fort (Koeppel 2000:17). A second public well was opened in 1671 behind the Stadt Huys or City Hall (Koeppel 2000:17). Under the tenure of Mayor Stephanus Van Cortlandt (1677-1678 and 1686-1888) the City's public well system was expanded and neighborhoods were identified to be served by a designated well within their area (Koeppel 2000). The City of New York established a network of public wells in 1686 (Koeppel 2000:18). In 1741, the Provincial Assembly passed a law for the upkeep and construction of public wells.

The Minutes of the Common Council note that a public well was sunk on John Street in 1748 but the records do not indicate where on John Street it was located (MCC 1675-1776: 240). Another was sunk on Dye Street (Ibid). Later that year, the Corporation of the City of New York ordered that the "Neighborhood of John Street and Nassau have also liberty to sink a well at such convenient place as shall be approved" (MCC 1675-1776:435). Wilson's *Memorial History of New York* (1892, Vol. II:283) discusses the water situation in the City at that time, stating that "the water was very poor, and constant attempts were made to sink new wells; thus, in 1748, the corporation contributed to two new wells, one on John Street near Broadway." This is probably the well mentioned in the Minutes of the Common Council above and suggests a well was sunk in the vicinity of the Corbin Building property. However, Wilson's information could not be corroborated. There was also a well on the corner of John and William Streets. This well was filled in 1788 and a new one constructed (MCC 1784-1831:394).

Despite the growing number of wells, the public well system was hard pressed to meet the demands for water as the population continued to grow. Private water works, such as the Manhattan Company, were established toward the end of the eighteenth century promising to deliver 'pure and wholesome' water to city residents via a network of wooden water pipes. In fact, water pipes were laid at the corner of Broadway and John Street in 1824. As part of the plan a large well, twenty-five feet in diameter, was also sunk at the corner of present day Reade Street and Center Street (Geismar 1983:41). Efforts to establish an adequately functioning citywide water system were deficient and the system proved unreliable (Koeppel 2000 and Loorya and Ricciardi 2007:23-26).

Throughout the early to mid-nineteenth century, the Corporation of the City of New York continued to provide funding for the construction of new public wells. It stipulated, however that any public well sunk must be at least 6 feet in diameter, "completely stoned or bricked up," have sufficient water, a "good new" brass chambered pump, and that it be properly covered (MCC 1784-1831:702).

WELLS EXCAVATED BY ARCHAEOLOGISTS IN LONDON, COLONIAL WILLIAMSBURG AND NEW YORK CITY

According to archaeologist Ivor Noel Hume (1969:13), there has been much debate about whether wells are built from the top down or the bottom up, "or to put it another way, whether one dug the hole first and then lined it or built the wall as one dug down" (Hume 1969:13). It is clear that the Corbin shaft feature was constructed using the latter method.

After World War II, many old brick well shafts were excavated by archaeologists in London in association with the redevelopment of areas bombed during the Blitz. Aside from the fact that they were constructed of brick, the wells shared another common trait, a wooden ring or curb at the bottom of the well (Noel Hume 1969:20). The London well rings were fashioned of oak and "made from single thicknesses of timber in two or three sections carefully morticed and pegged" (Noel Hume 1969:20). The wooden ring or curb from the Corbin Building well, however, consisted of "a double board ring" (Noel Hume 1969:20), nailed together with square iron nails. The wood type from the Corbin building well, is unknown, however the ring's construction is similar to a wooden ring from the bottom of James Geddy's well at Colonial Williamsburg constructed in 1762. The ring or curb at the base of the Geddy well consisted of a "double board ring" or curb, nailed together (Noel Hume 1969:20).

"Compass," "key" or wedge-shaped bricks similar to the Corbin well's bricks, were used in the construction of many eighteenth century wells because of the "tightness with which the compass bricks abutted each other" (Noel Hume 1969:27). However, it is interesting that these types of bricks were not used in Colonial Williamsburg after roughly the first decade of the 19th century. The reasons for this are unknown and it is not known if this was also true of New York City as there is not yet a large enough comparative sample of archaeologically-excavated wells.

In general, the Corbin brick feature and other wells that have been studied by archaeologists in the city appear to have been built in the following manner:

"A strong timber CURB is formed on the ground; the brickwork is dug out on the inside and beneath the curb, which allows the whole to sink: the same operation of building up and digging out is continued; and the top covered over or arched over" (Neve 1853 in Noel Hume 1969:19).

"The wooden ring on which the bricks forming the steining or lining of a well are placed, to keep them level as the earth is excavated beneath them, as they descend by their own weight. Plain curbs are generally made of two thicknesses of inch elm board nailed together so as to break joint (Neve 1853 in Noel Hume 1969:19).

Several wells have been excavated by archaeologists in New York City. All seem similar to the Corbin brick feature in that they were constructed from the top down and have a wooden ring at their base. Some were constructed of stone and some of brick. None of the wells were public wells; all were associated with particular family properties or straddled the lot lines. A brief description of these wells follows:

WORTH STREET

A well constructed in 1835 (Feature 4, Lot 20, Trench 2) was uncovered by archaeologists at the Worth Street site. It was built of roughly-hewn sandstone blocks averaging between 0.8 and 1.5 feet in length. Occasional bricks were embedded in the well's lining which was 0.8 feet thick. The interior of this shaft feature was 4 feet in diameter and extended to a depth of 13 feet (-3 below mean sea level). Excavation exposed a profile extending 13 feet into a matrix of stacked fluvial sands.

At the base of the last course of stone, the deteriorated remains of a wooden "ring" were uncovered. As discussed above, the ring or curb was likely used during construction to support the stone lining. The sandstone blocks would have been placed on the wooden ring and the soil excavated from beneath it. The weight of the stones would have forced the ring down to the level where the sand had been removed and this process would have continued until the desired depth was achieved.

SULLIVAN STREET SITE

At the Sullivan Street site in Greenwich Village, a dry-laid sandstone well (Feature 8), approximately 5 feet in diameter and 20 feet deep, was discovered in Lot 35. A "wooden collar" used during the well's construction was visible beneath the lowest course of stones. The lower fill deposit dated c. 1880-1903 and the upper fill contained demolition debris, probably thrown into the well when a road was cut through West Third and West Fourth Streets (Salwen and Yamin 1990:IV-58,59).

BARCLAYS BANK SITE

A well post-dating 1820 at the Barclay's Bank site (Feature 52, Lot 16) was discovered beneath a lot wall between 106/108 Water Street. Constructed of dry-laid, wedge-shaped bricks, it had an inside diameter of 3.0 feet and an outside diameter of 4.15 feet. The well extended 12 feet to river bottom and its lower section rested on a "wooden curb" (LBA 1987: VI-60).

A second well (Feature 48, Lot 19/146 Pearl Street) was approximately 3 feet in diameter, 10 feet deep and constructed of stone. It was located just west of the junction of three lot walls, directly below the wall footings. The feature appeared to have been first used as a well and then, later, a privy (LBA 1987:VI-24-28). It contained a thick layer of night soil with a large quantity of artifacts ranging in date from 1780 until 1820. Below the nightsoil was a lime deposit and a wooden bucket. Feature 48 also had a wooden ring (here called a curb perform) at its base. As previously stated, wooden curbs were used during the construction of the wells. The wooden curb would be placed on the ground surface and then several courses of brick or stone would be laid on top. The ground inside and under the curb would be dug out, allowing the structure to sink and this process would continue until the well shaft was completed (LBA 1987: VI-28). The unstable and wet landfill matrix into which the Barclay's Bank wells were dug suggest this construction method was used, as opposed to digging out the shaft first and then lining it with brick or stone from the bottom up. The wells at the Barclay's Bank site could not have been used for drinking water as the block between Pearl and Water Streets was close to the river and the well water would have been brackish. It is possible the well(s) provided water for specialized activities such as metallurgical work or the water could have been used for firefighting (LBA 1987: VI-28).

VI. ANALYSIS AND CONCLUSIONS

The discovery of the brick shaft feature beneath the foundation footing of the Corbin Building led to several questions including the function of the feature, its construction date and its relation to the original topography of the area. A mitigation plan of archaeological monitoring and documentary research has attempted to answer some of these questions.

A number of characteristics of the feature indicate that it functioned as a well. These include:

1) The depth of the well and its extension into the water table.
2) The circular construction using key/compass bricks, which were typically used for wells.
3) The lower portion of the feature was un-mortared and located within the water table. An un-mortared base is typical of a well as it would allow ground water to penetrate.
4) The presence of a wooden curb beneath the bricks that form the well. This element is part of a construction method used where soil conditions do not allow the shaft to be excavated prior to construction of the brick or stone walls. Wooden curbs have been noted in other wells documented within lower Manhattan

While other possibilities, such as a tanning vat or privy were considered they were soon dismissed. The size of the feature is inappropriate for a tanning vat and its location near the front of John Street makes it an unlikely location for a privy. Furthermore, neither a tanning vat nor a privy would likely be un-mortared and sunk into the water table, as this feature was.

Attempts at dating the feature included petrographic analysis of the mortar, an inspection and interpretation by Dr. Allan Gilbert and map and documentary research. In conjunction, these provide a date range of the turn of the nineteenth century when structures first appear in the immediate vicinity of the Corbin Building and the second quarter of the nineteenth century when John Street was widened. The majority of the well was filled with a concrete aggregate similar to that used to construct the Corbin Building's footers. The few materials found within the well have a fairly wide date-range. Of the four artifacts recovered the tin-glazed tile has the greatest integrity with regard to dating. Tin-glazed tile has a manufacture date range of 1625 - 1800 but the period of use extends beyond 1800.

The construction of the Corbin Building well, including the type of brick and the wooden ring or curb are typical of well construction in the late eighteenth and early nineteenth century (Noel Hume 1969:20). Several wells have been excavated by archaeologists in New York City. All seem similar to the Corbin well in that they were constructed from the top down and have a wooden ring at their base. Though "Compass," "key" or wedge-shaped bricks similar to the Corbin well's bricks, were not used in Colonial Williamsburg after roughly the first decade of the 19th century they continued to be used within New York City. The Barclay's Bank site well, which has been dated to post-1820, was constructed using wedge shaped bricks.

None of the other wells excavated within New York City have been public wells; all were associated with particular family properties or straddled the property lot lines. On average the wells previously documented measure 3' to 5' in diameter. The Corbin Building well is much larger than these wells having an exterior diameter of 7' 7" (2.3 meters) and an interior diameter of 6' 3" (1.9 meters), double the size of the smaller household wells. A well of the size discovered at the Corbin Building could have served a larger property (farmstead or estate), multi-dwelling property or municipal use. However, no documentary evidence was found to either support or refute this opinion.

With the exception of the John Street Theater, the area of the Corbin Building does not appear to have been developed until the nineteenth century. Based on a review of historic maps there have been some shifts in the topography of the area since the eighteenth and nineteenth centuries. It appears that the original ground surface into which the Corbin well was constructed was at a lower elevation than Broadway's current elevation of approximately 30' above sea level.

The top of the well remains were discovered at approximately 22' below the current street grade. This corresponds to approximately 8' above sea level. Though the actual elevation of the original ground surface has not been determined, it is estimated to have been between 25 and 20 feet above sea level, a difference of 5' from present day.

Though it was not possible to expose the upper surface of the well as it was located immediately beneath the building footer, it is likely that the above ground portion of the well was leveled some time prior to or during construction of the Corbin Building. Based on the topographical analysis is reasonable to assume that between 12' and 17' of the well was removed sometime in the past and that it originally extended into the ground a distance of between 20' and 30'.

On January 14, 2010, SHPO and LPC were notified of the results of the archaeological monitoring and the materials that were found in the section of the well that was excavated for the underpinning pit. The CRM Team recommended no further archaeological excavation of the brick feature, since the Fulton Street Transit Center project would have no further impacts on this feature. On January 20, 2010, SHPO and LPC concurred. Therefore, it is the recommendation of this report that no further work occur with regard to this feature.

In accordance with the Archaeological Mitigation Plan (January 2010) the cultural resources team will remain on call should any other unanticipated discoveries occur during excavation of the other underpinning pits and the excavation to construct the escalators and elevators that will provide access to and from the new Transit Center and the Dey Street Concourse.

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3.2.10

Source: United States Geological Survey, USGS
7.5 Minute Topographic Map; Brooklyn & Jersey City Quads, 1975

0 2000 4000 FEET

SCALE

✪ Historic Well

Approximate coordinates of Project Site:
40° 42' 36.76" N, 74° 0' 33.16" W

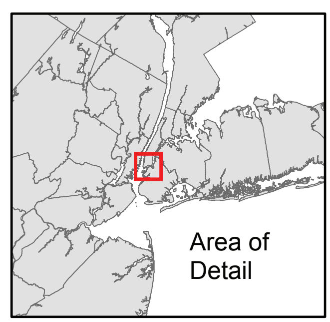


Figure 1
USGS Location Map

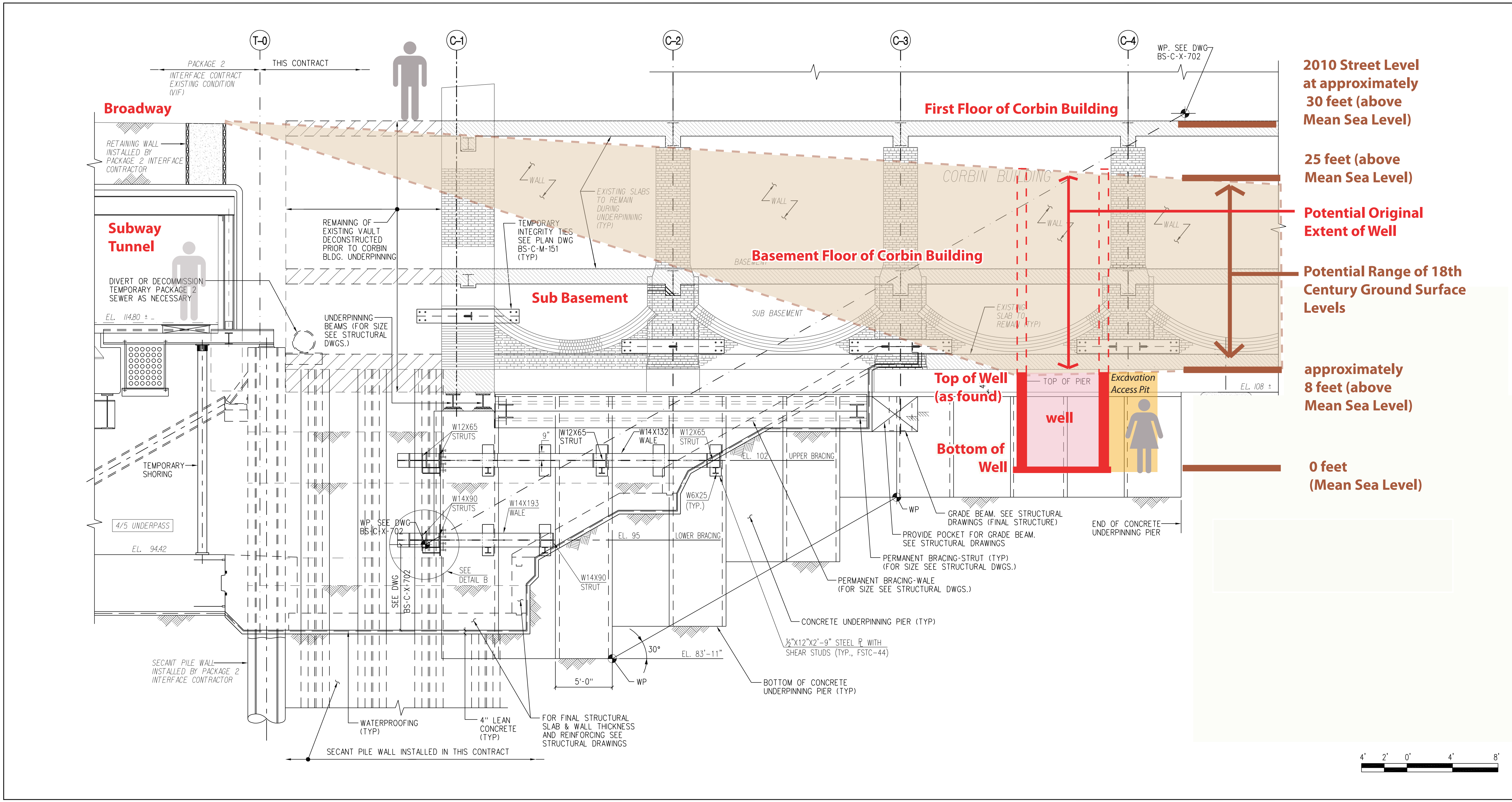


Figure 2

Cross Section (looking North) of Corbin Building Basement and Well Feature

Figure 3
Corbin Building Sub-Basement Plan View and Well Feature

Initial test pit excavated for inspection of the feature. Note that the feature is recessed approximately 2' beneath the foundation and footer **1**

North facade of the well, facing south. Photograph taken from within the initial test pit **2**

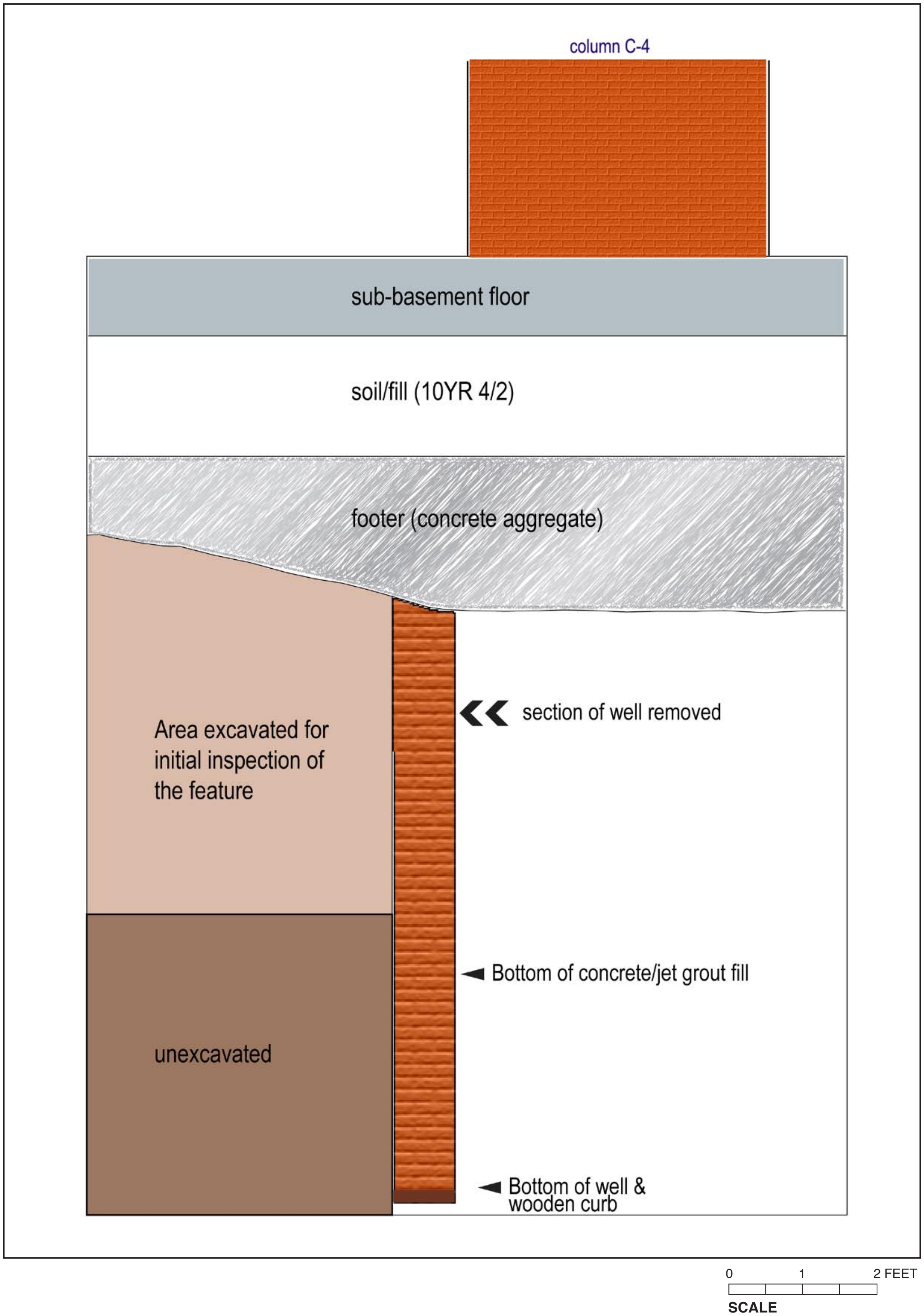
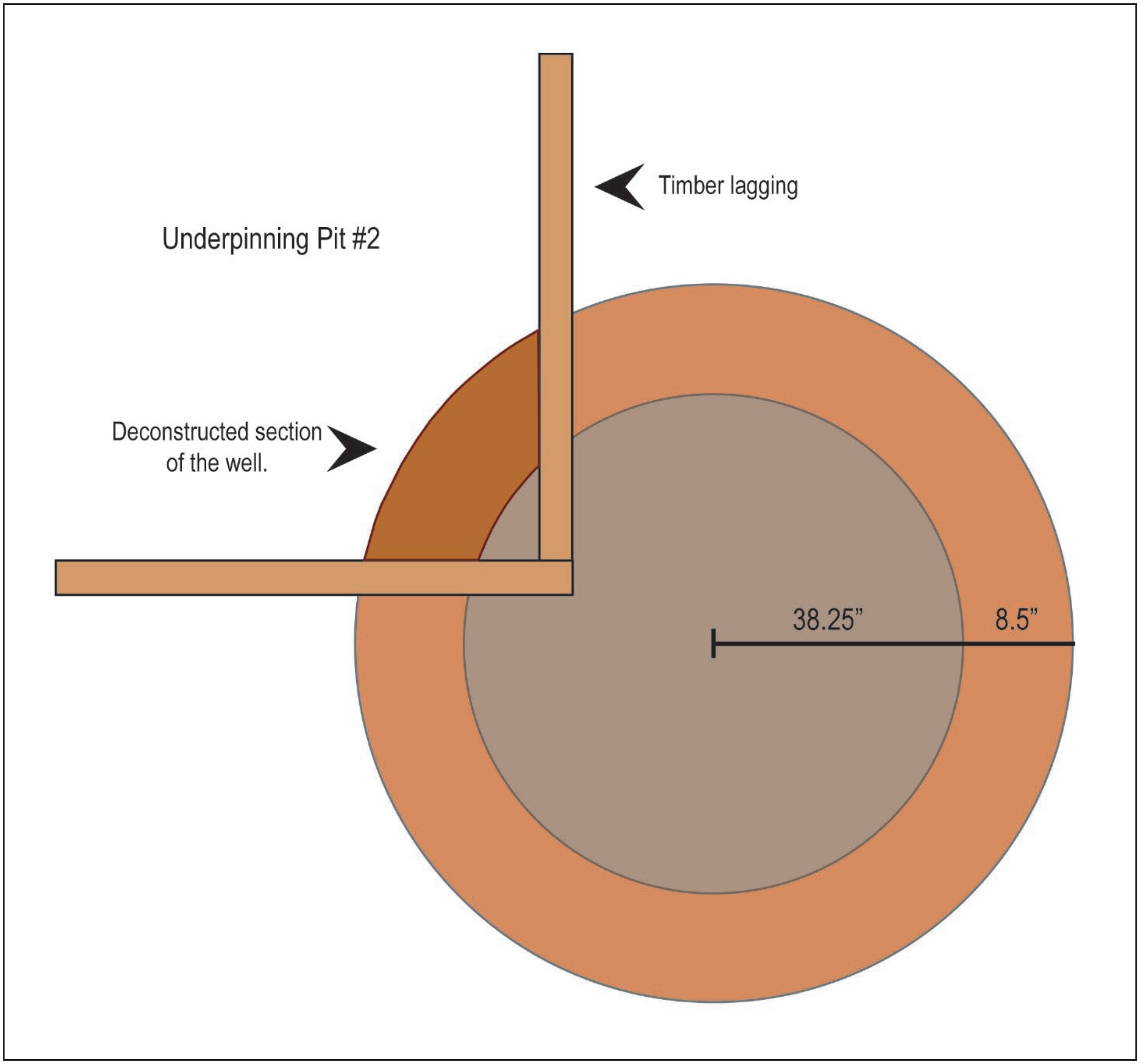


Figure 5
Section Drawing of Exposed Well Feature

North facade of the well, facing west within the underpinning pit **3**

Figure 6

Photograph — Brick Feature Excavation



Not to Scale

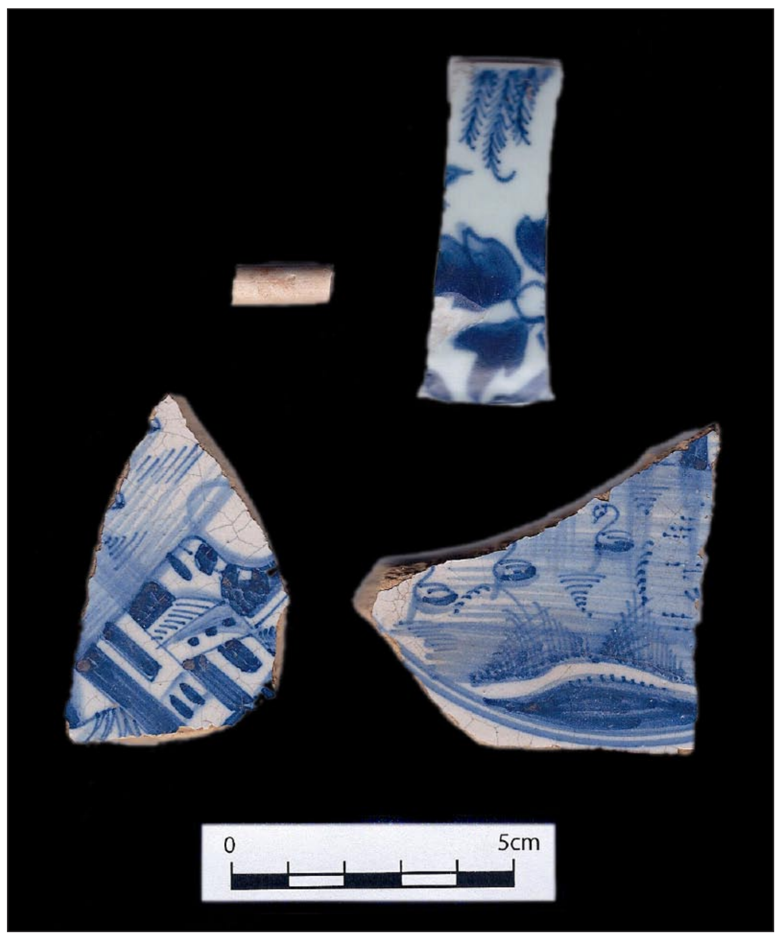
Figure 7

Plan View Drawing of Excavated Portion of Well

Wooden curb of the well, *in situ* **4**

Section of wooden curb after removal **5**

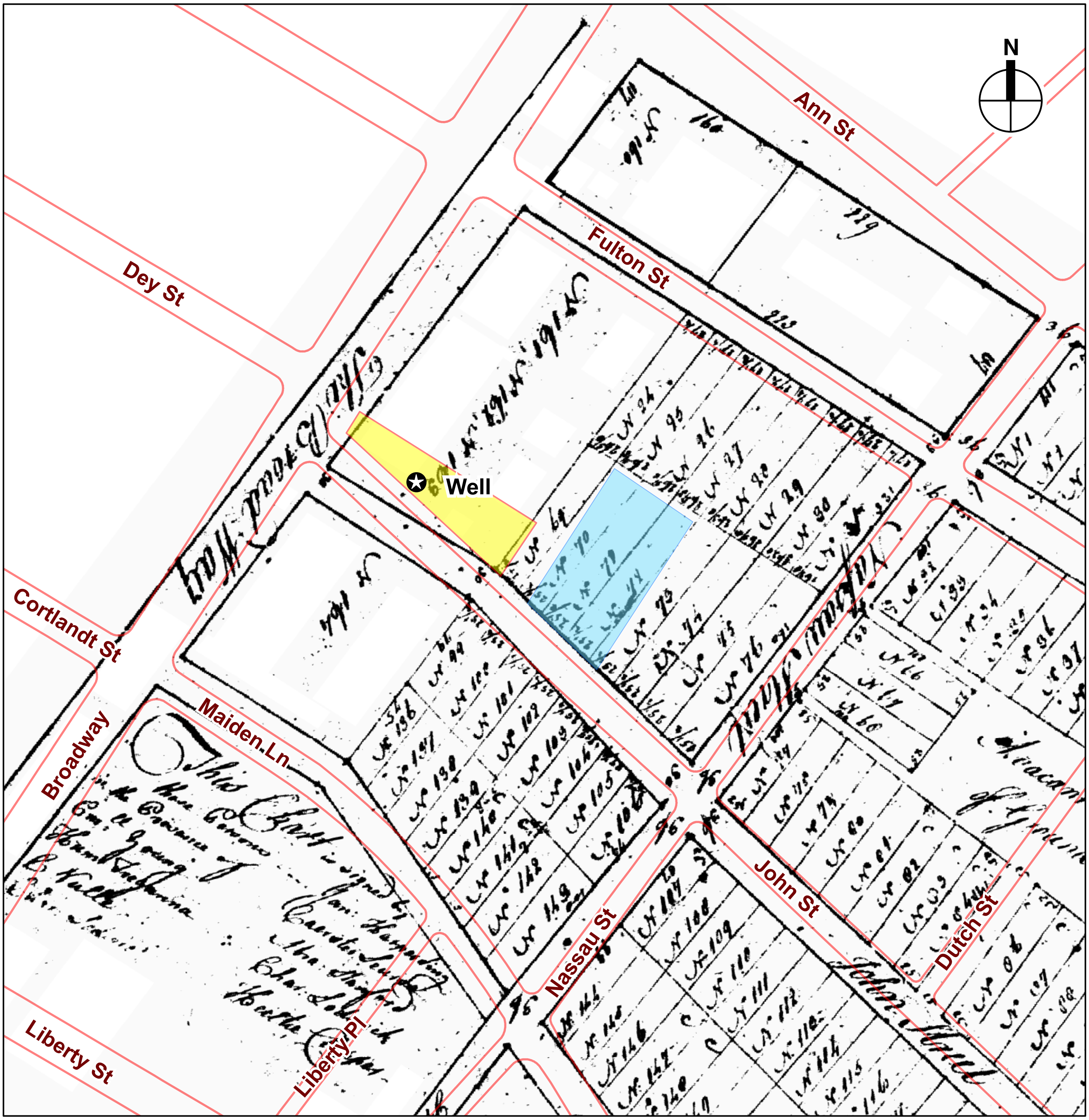
Plan and section view of brick from well **6**



Artifacts recovered from within the well **7**

Figure 9

Photographs — Bricks and Artifacts

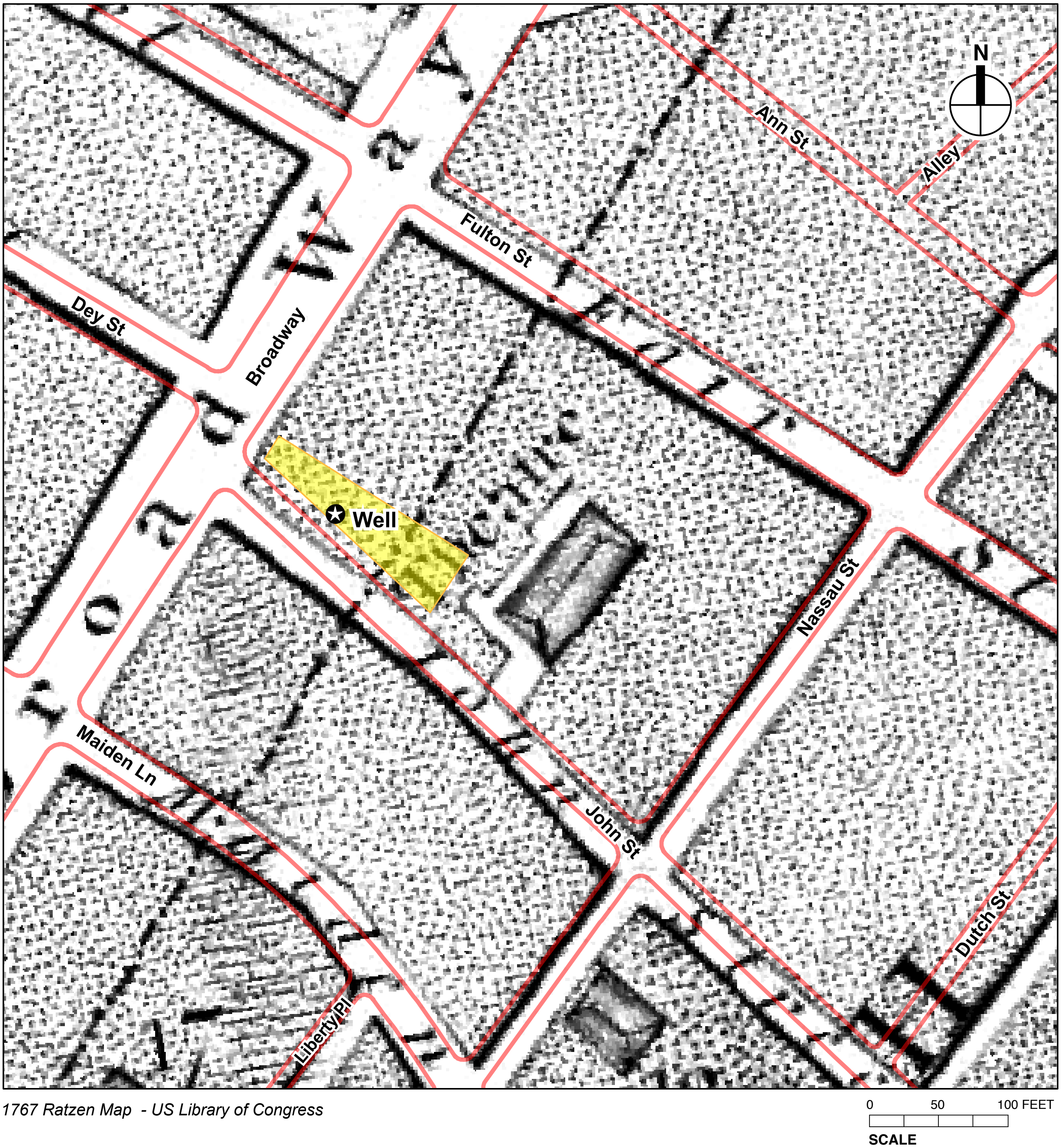


A Map or Chart of a Certain Tract of Land commonly call'd The Shoemakers Land (Etc.) by James Evetts, City Surveyor, depicting 1696

- ✪ Project Site Historic Well
- Corbin Building
- John Street Theatre
- 2010 Streets

Figure 10

1696 Shoemakers Land Map



1767 Ratzen Map - US Library of Congress

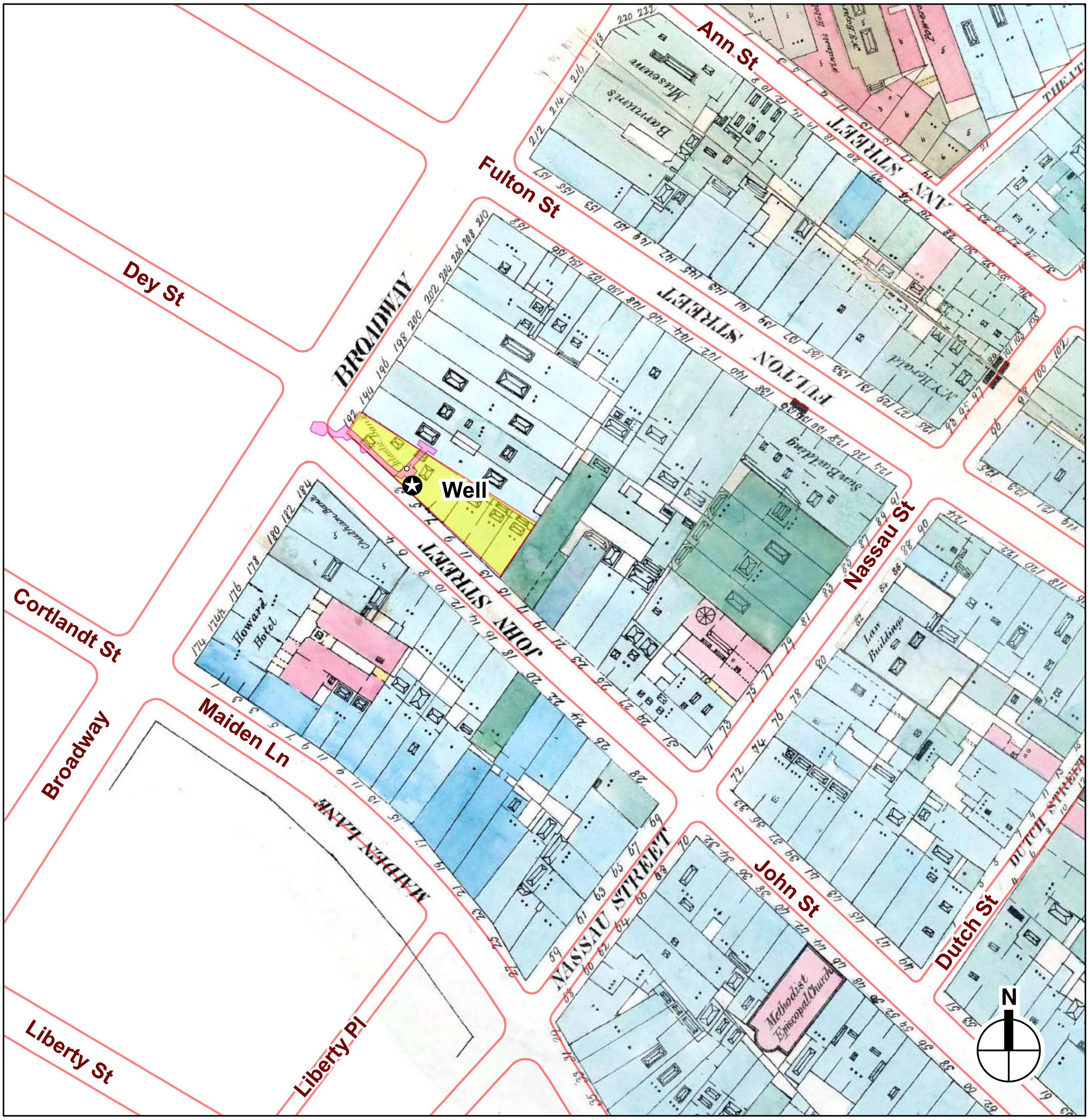
✪ Project Site Historic Well

Corbin Building

2010 Streets

Figure 11

1767 Ratzen Plan



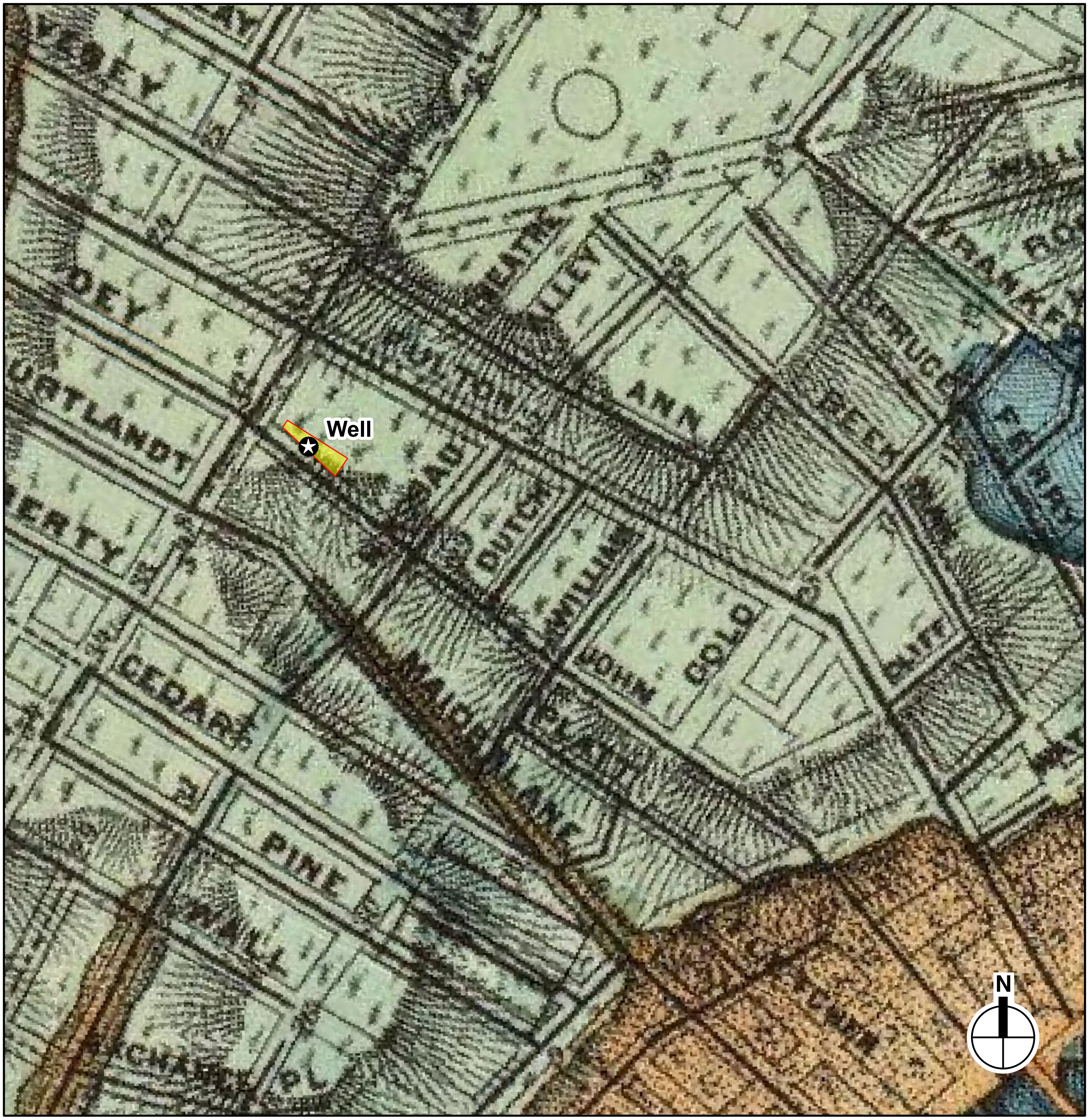
1857 Perris Map

0 100 200 FEET
SCALE

★ Project Site Historic Well
Corbin Building
2010 Streets

Figure 12
1857 Perris Map

3.2.10



1865 Viele Map

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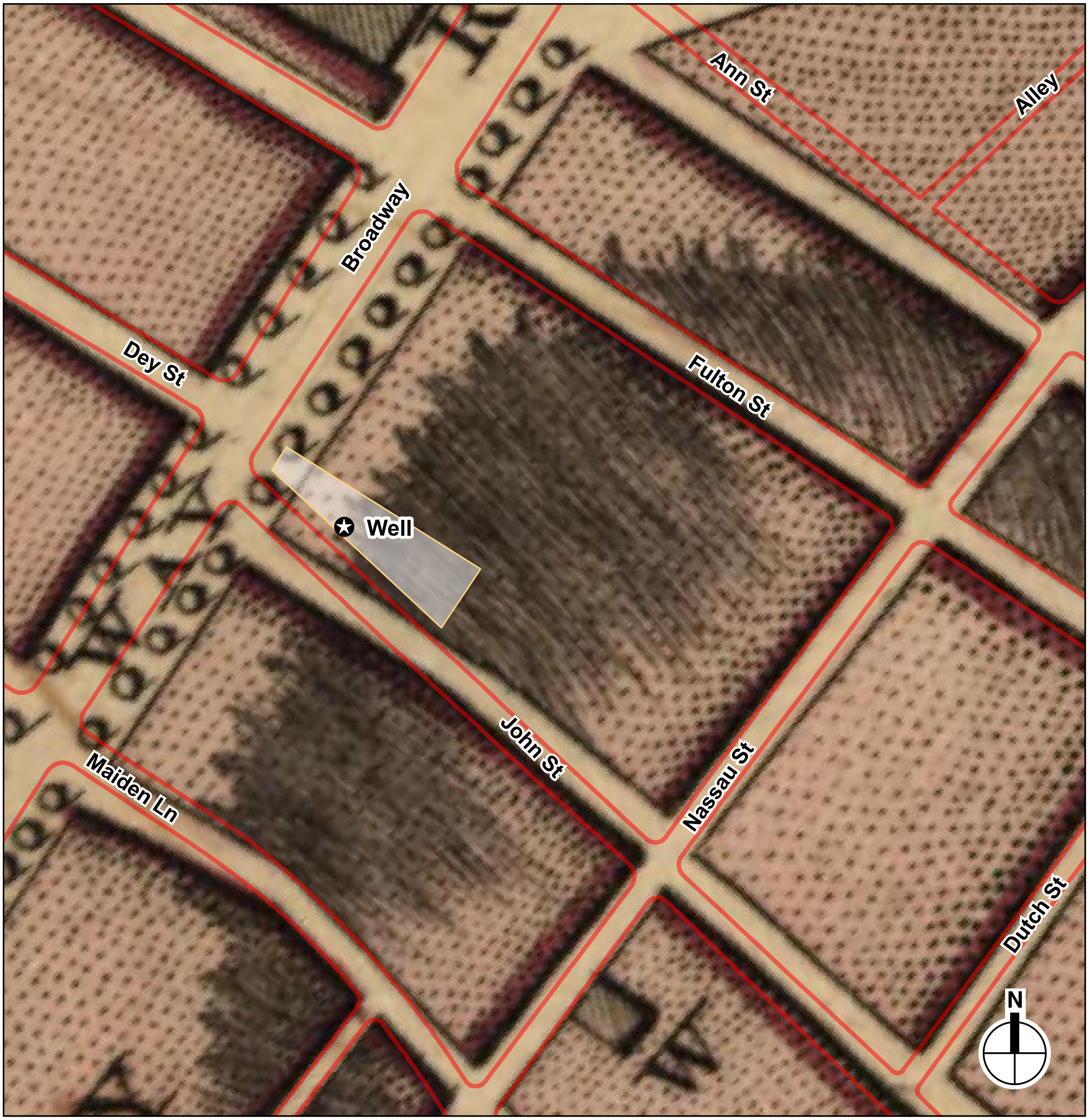
SCALE

✪ Project Site Historic Well

Corbin Building



1766 Montresor Map (published 1775) - US Library of Congress

0 50 100 FEET
SCALE

✪ Project Site Historic Well

Corbin Building

2010 Streets

Figure 14
1766 Montresor Map

APPENDIX A

MORTAR ANALYSIS REPORT

HIGBHBRIDGE MATERIALS CONSULTING, INC.

FEBRUARY 9, 2010

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MORTAR ANALYSIS REPORT

Client:	AKRF, Inc.	**Client ID:**	AKRF001
Project:	Mortar Analysis	**Report #:**	SL0035-01
Location:	New York, NY	**Date Received:**	01/23/10
Sample Type:	Mortar	**Report Date:**	02/09/10
Sampled by:	Client's representative	**Petrographer:**	J. Walsh
Delivered by:	Client's representative	**Page 1 of 12**	

Report Summary

- A mortar sample is examined petrographically in order to identify components and assess material quality.
- The sample is identified as a lime mortar with a low abundance of siliceous natural sand. The material is soft and porous and inconsistent in property with a mortar of any significant hydraulic character.
- Marine shells are identified as the source of the lime and such lime would have been a high calcium, non-hydraulic variety. Bits of unburned shell may be considered as an inert aggregate component.
- Calcined clay appears to have been added as well though the identification is not certain. While the clay could have been calcined with the lime to produce an artificial hydraulic lime, the author favors the interpretation that the calcined clay was added separately as a pozzolan.
- The sand is a siliceous natural sand. Iron oxide coatings along quartz grains likely impart a brownish hue to the aggregate.
- No significant service distresses are identified in the examined sample.
- A more detailed discussion of the findings may be found in the Discussion and Conclusions section on page 4.

1. Introduction

On January 23, 2010, Highbridge received a mortar sample from Mr. John Glavan of Building Conservation Associates, Inc. labeled "Corbin 01". The sample is identified as having been taken from a brick masonry well structure found in an archaeological investigation in lower Manhattan. At the client's request, the sample is examined petrographically to identify components and assess the quality of the material. A quantitative chemical analysis is excluded from the analysis. Also excluded is an acid digestion to recover a graded sand sample.

2. Methods of Examination

The petrographic examination is conducted in accordance with the standard practices contained within *ASTM C 1324: Standard Test Method for Examination and Analysis of Hardened Masonry Mortar*. Data collection is performed by a degreed geologist who by nature of his/her education is qualified to operate the analytical equipment employed. Analysis and interpretation is performed or directed by a supervising petrographer who satisfies the qualifications as specified in Section 3 of *ASTM C856*.

3. Petrographic Findings

SAMPLE ID	**Corbin 01**
GENERAL APPEARANCE	
Sample Type	The sample includes one piece of bedding mortar along with loose powder. The sample weighs approximately 18 g and has dimensions of approximately 1” x 1” with a 1/2” bed thickness.
Surfaces	Bed surfaces are roughly planar and somewhat weathered with a minor abundance of adherent brick residue.
Hardness / Friability	Soft and friable.
Appearance	Freshly exposed paste surfaces have a dull luster and are white to very pale brown in color (Munsell color code approximately 10YR 8/1).
Other Details	Small white lumps are found in hand sample that are identified petrographically as undispersed lime grains. A low abundance of fine coal fragments is also observed. No obvious cracks or secondary mineral deposits are found in hand sample.
AGGREGATE	
Lithology and Mode	Siliceous natural sand in low abundance. The aggregate consists predominantly of quartz with lesser feldspar and trace metamorphic grains. Quartz grains are commonly coated with a thin iron oxide film.
Appearance	A sand extraction was not requested for the sample. Nonetheless, a very small portion of the mortar was digested revealing a brownish toned, translucent sand.
Size and Gradation	The nominal top size is estimated at the No. 16 sieve and the aggregate is moderately well graded. Only a moderate abundance of fines is present from the siliceous sand portion of the aggregate. However, dispersed clays may be present but not resolved petrographically. Furthermore, very fine-grained shell fragments are present at below 75 µm but these should be considered an inert portion of the binder.
Shape	The sand is subangular in shape on average and equant to subequant in aspect ratio.
Distribution	Mostly homogeneous and randomly oriented. However, there are some areas sparser in sand distributed throughout the mortar sample.
Other	No significant microcracking is found in the aggregate. Shell fragments are found in moderately low abundance. However, these may represent unburned bits of lime. Small silty clay lumps are also found but these too may be better grouped with the binder portion of the mortar as discussed below.
BINDER MATRIX	
Hardened Binder Matrix	Homogeneous, mostly nonhydraulic matrix with high capillary porosity and a moderate abundance of discontinuous polygonal microcracks.
Residual Binder Grains	Undispersed lime grains are found in moderate abundance as fine- to medium-grained mostly carbonated particles. Some grains preserve microtextures consistent with a shell source. Unburned or partially burned shell fragments are also found throughout the matrix. Fine-grained, silty clay lumps are also observed. In some cases, there is an association between these and the lime in that some unburned shell fragments contain adherent clay coatings. Within the matrix, some of the clay particles are associated with a vesicular glass and recrystallized aluminosilicates. A low abundance of coal particles is also detected.
Pigments	None detected.
AIR-VOID SYSTEM	
Estimated Air Content	Discounting air space produced by microcracks, the air content is estimated at 4% to 6%.
Consolidation / Distribution	The mortar is well consolidated and the air distribution is homogeneous.
Size / Shape	Voids are generally less than 1 mm in dimension. Voids are generally subspherical in shape.
Secondary Deposits	Some voids are lined or filled with secondary ettringite.
AGGREGATE INTERFACES	
Details	Sand grains are well coated with binder though the binds are soft and sand grains easily dislodged from the matrix. No significant cracks, mineral deposits, or curing variations are found along aggregate interfaces.
SECONDARY REACTIONS	
Carbonation	The mortar is virtually all carbonated. Thin “fronts” of denser carbonation are also interspersed throughout the matrix.
Other	Sparry calcium carbonate deposits are found along one of the bed surfaces. Ettringite is found in some air-voids but is not present within microcracks.
CRACKING	
Details	Discontinuous polygonal microcracks are common throughout the sample.

4. Discussion and Conclusions

The sample is identified as a sanded lime mortar with a relatively low sand content. The material is soft, friable, and porous and is consistent in texture with a non-hydraulic lime mortar. While the hand sample is soft, there is evidence to suggest some minor hydraulic component and this is discussed below.

The lime matrix has a high capillary porosity and is virtually all carbonated. Microscopic shrinkage cracks are relatively common and these are typical of lime mortars particularly those with a low sand content. Aside from the typical matrix characteristics, the lime is identified based on the presence of undispersed lime grains. Some of the lime grains contain microtextures that have survived the calcination process. These are consistent with textures found in marine shells. Furthermore, unburned and partially burned shells are dispersed throughout the matrix. The lime is therefore interpreted to have been burned from a shell rather than rock source. While a chemical analysis was not requested, it is fairly certain that this lime would have been a high calcium, non-hydraulic variety.

Fine-grained particles consisting of silty clay are detected as well. However, these are not interpreted to be part of the sand. Clay was sometimes added to lime mortars for economy but this does not appear to be the case here either. Some of the clay particles are associated with a vesicular glass suggesting that the clay was calcined. Calcined clay may have been used here as a pozzolan or hydraulic addition. It should be stressed that calcined clay is generally difficult to distinguish petrographically. However, the association between glass and clay is difficult to interpret any other way and the calcined clay interpretation is offered as plausible albeit cautiously.

In some cases, the clay is found adherent to unburned or partially burned shell fragments suggesting that the clay and lime had been mixed prior to incorporation in the mortar. There are two ways this might have been performed if the calcined clay interpretation is correct. The first is that the clay and lime had been mixed prior to calcination in order to produce an artificial hydraulic lime. The intention then would have been to form a hydraulic binder by combining the lime and aluminosilicate at high temperature. The second possibility is that the clay was calcined separately and added to the lime to produce a pozzolanic reaction during curing. This latter possibility is favored by the author. The qualitative properties of the mortar in hand sample do not indicate a significantly hydraulic binder as the matrix is quite soft and friable. If the clay were calcined with the lime, some degree of hydraulic character should be noticeable. However, if the calcined clay were added separately and its pozzolanic properties not particularly energetic, a soft and non-hydraulic matrix could still result.

The aggregate is a fine- to medium grained siliceous natural sand containing quartz and feldspar with other trace components. The quartz grains typically have a natural iron oxide coating. While a sand recovery was not requested, a quick digestion was performed on a very small subsample and a brownish-toned aggregate was obtained. The color of the sand is likely influenced by the oxide coatings and consequently the mortar appearance is influenced as well. The sand is sharp textured with most grains subangular in shape. The nominal top size is estimated at the No. 16 sieve. The aggregate is observed in low abundance. While a chemical analysis to estimate proportions was not performed, the sparseness of the sand observed petrographically is consistent with a sand to lime ratio less than 2 : 1 and possibly as low as 1 : 1.

If a rigorous replication is desired, the fragments of unburned shell may be considered as part of the sand. The shell bits behave as inert fragments with sizes that sometimes exceed those of the coarsest sand grains. Any unburned clay particles may also be considered as aggregate. It should be noted that a typical acid digestion will likely dissolve these shell fragments and the clay particles will wind up in the fines that would otherwise be discarded. If such an analysis is performed, the technique should be modified to account for these other components.

Finally, the mortar does not contain evidence for significant deterioration in service. Microscopic cracking is present but these are considered to be early shrinkage cracks typical of lime mortars with a low sand content. The mortar is almost fully carbonated but this is a desirable consequence of lime mortar curing. Some recrystallized carbonate is found along one bed surface but this is minor. Ettringite (a sulfate mineral) is found in low abundance within air-voids. While not a typical secondary product in lime mortars, there may have been some sulfate present in the added clay resulting in this mineralogy. The only other likely reason for the presence of ettringite would be the presence of portland cement-based mortars adjacent to or very near this lime mortar sample.

Respectfully submitted,

John J. Walsh
President/ Senior Petrographer

Appendix I: Photographs and Photomicrographs

Microscopic examination is performed on an Olympus BX-51 polarized/reflected light microscope and a Bausch and Lomb Stereozoom 7 stereoscopic reflected light microscope. Both microscopes are fitted with an Olympus DP-11 digital camera. The overlays presented in the photomicrographs (e.g., text, scale bars, and arrows) are prepared as layers in Adobe Photoshop and converted to the jpeg format. Digital processing is limited to those functions normally performed during standard print photography processing. Photographs intended to be visually compared are taken under the same exposure conditions whenever possible.

The following abbreviations may be found in the figure captions and overlays and these are defined as follows:

cm	centimeters	PPL	Plane polarized light
mm	millimeters	XPL	Crossed polarized light
µm	microns (1 micron = 1/1000 millimeter)		
mil	1/1000 inch		

Microscopical images are often confusing and non-intuitive to those not accustomed to the techniques employed. The following is offered as a brief explanation of the various views encountered in order that the reader may gain a better appreciation of what is being described.

Reflected light images: These are simply magnified images of the surface as would be observed by the human eye. A variety of surface preparations may be employed including polished and fractured surfaces. The reader should note the included scale bars as minor deficiencies may seem much more significant when magnified.

Plane polarized light images (PPL): This imaging technique is most often employed in order to discern textural relationships and microstructure. To employ this technique, samples are milled (anywhere from 20 to 30 microns depending on the purpose) so as to allow light to be transmitted through the material. In many cases, TLI also employs a technique whereby the material is impregnated with a low viscosity, blue-dyed epoxy. Anything appearing blue therefore represents some type of void space (e.g.; air voids, capillary pores, open cracks, etc.) Hydrated cement paste typically appears a light shade of brown in this view (with a blue hue when impregnated with the epoxy). With some exceptions, most aggregate materials are very light colored if not altogether white. Some particles will appear to stand out in higher relief than others. This is a function of the refractive power of different materials with respect to the mounting epoxy.

Crossed polarized light images (XPL): This imaging technique is most often employed to distinguish components or highlight textural relationships between certain components not easily distinguished in plane polarized light. Using the same thin sections, this technique places the sample between two pieces of polarizing film in order to determine the crystal structure of the materials under consideration. Isotropic materials (e.g.; hydrated cement paste, pozzolans and other glasses, many oxides, etc.) will not transmit light under crossed polars and therefore appear black. Non-isotropic crystals (e.g.; residual cement, calcium hydroxide, calcium carbonate, and most aggregate minerals) will appear colored. The colors are a function of the thickness, crystal structure, and orientation of the mineral. Many minerals will exhibit a range of colors due to their orientation in the section. For example, quartz sand in the aggregate will appear black to white and every shade of gray in between. Color difference does not necessarily indicate a material difference. When no other prompt is given in the figure caption, the reader should appeal to general shapes and morphological characteristics when considering the components being illustrated.

Chemical treatments: Many chemical techniques (etches and stains typically) are used to isolate and enhance a variety of materials and structures. These techniques will often produce strongly colored images that distinguish components or chemical conditions.

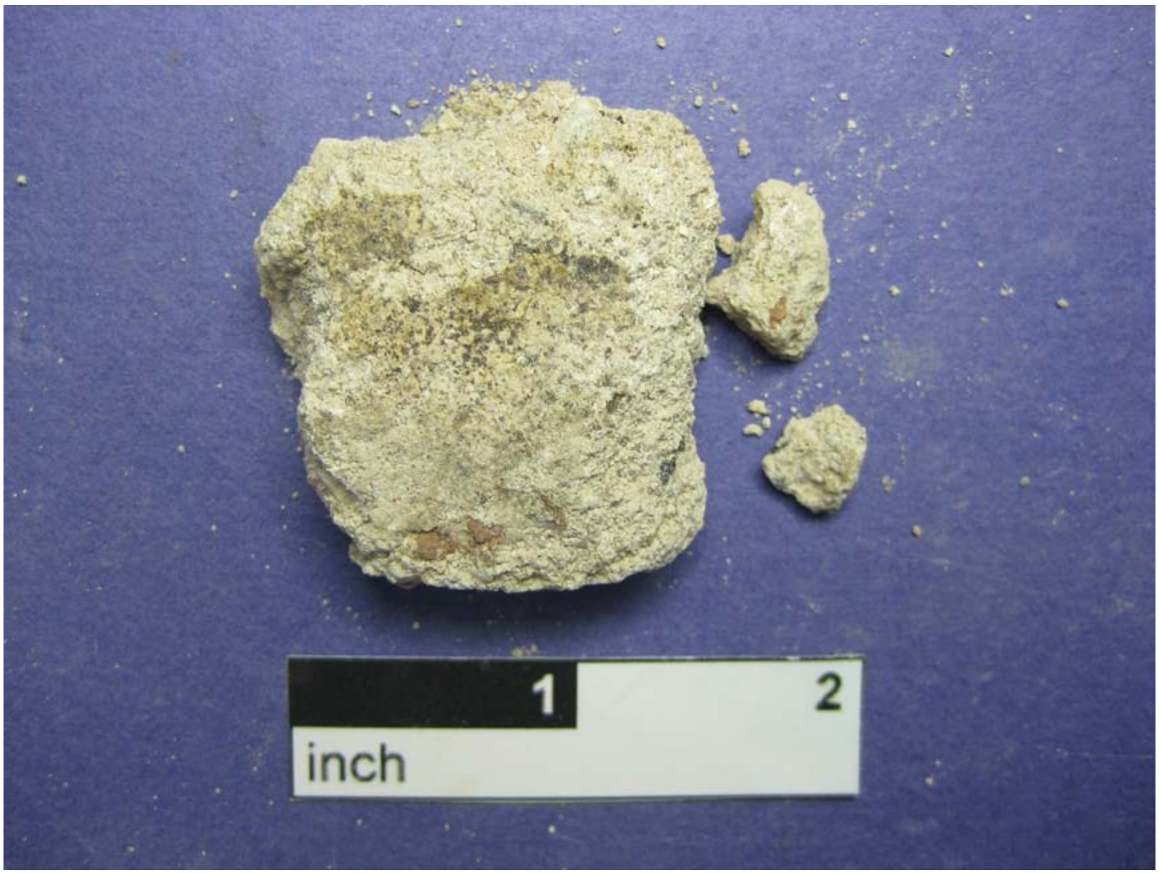


Figure 1: Mortar sample as received by Highbridge for examination.

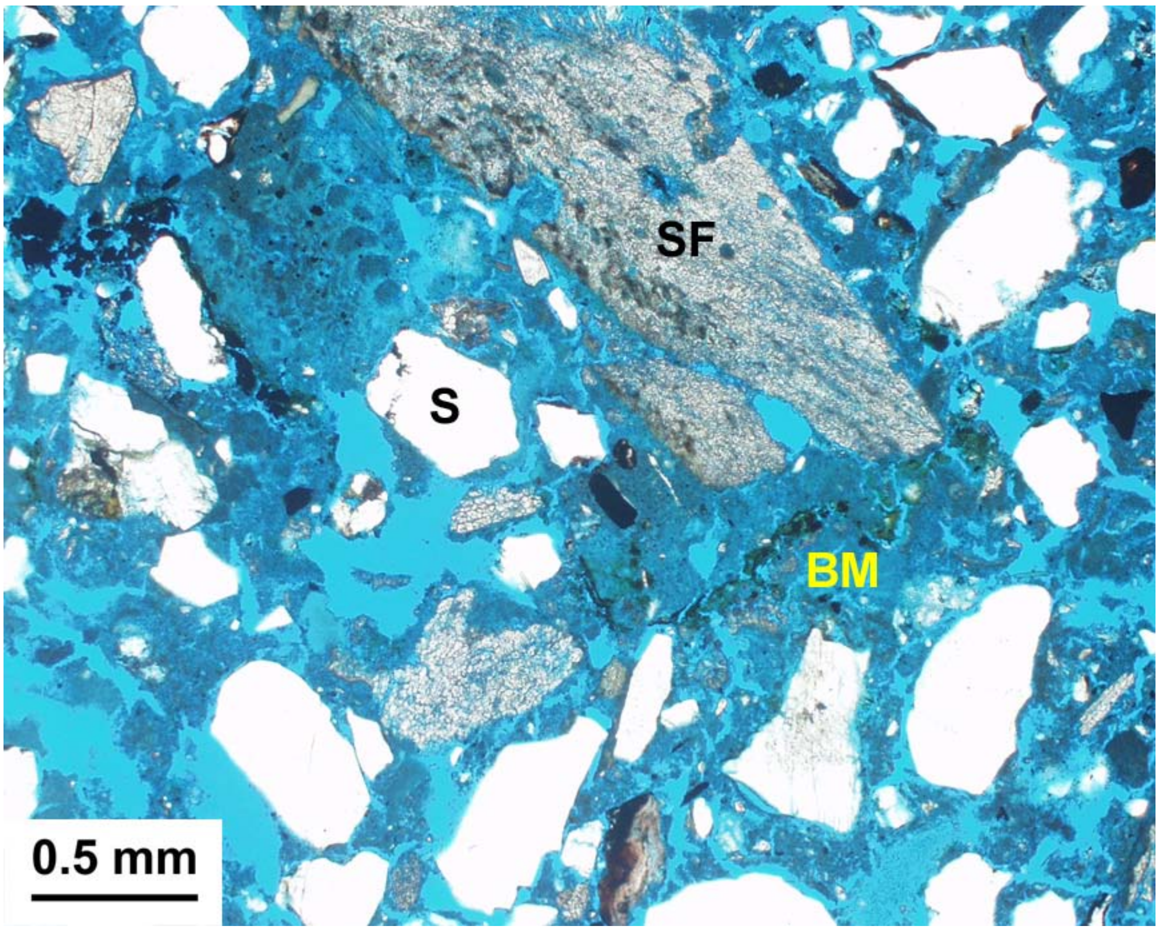


Figure 2: PPL photomicrograph illustrating the overall microstructure of the mortar sample. The binder matrix (BM) has a high capillary porosity as indicated by the absorption of low-viscosity, blue-dyed epoxy used in the sample preparation. Sand grains (S) are well coated with binder and are sparsely distributed throughout the matrix. Shell fragments (SF) represent unburned portions of the lime binder but may be practically considered as an aggregate component.

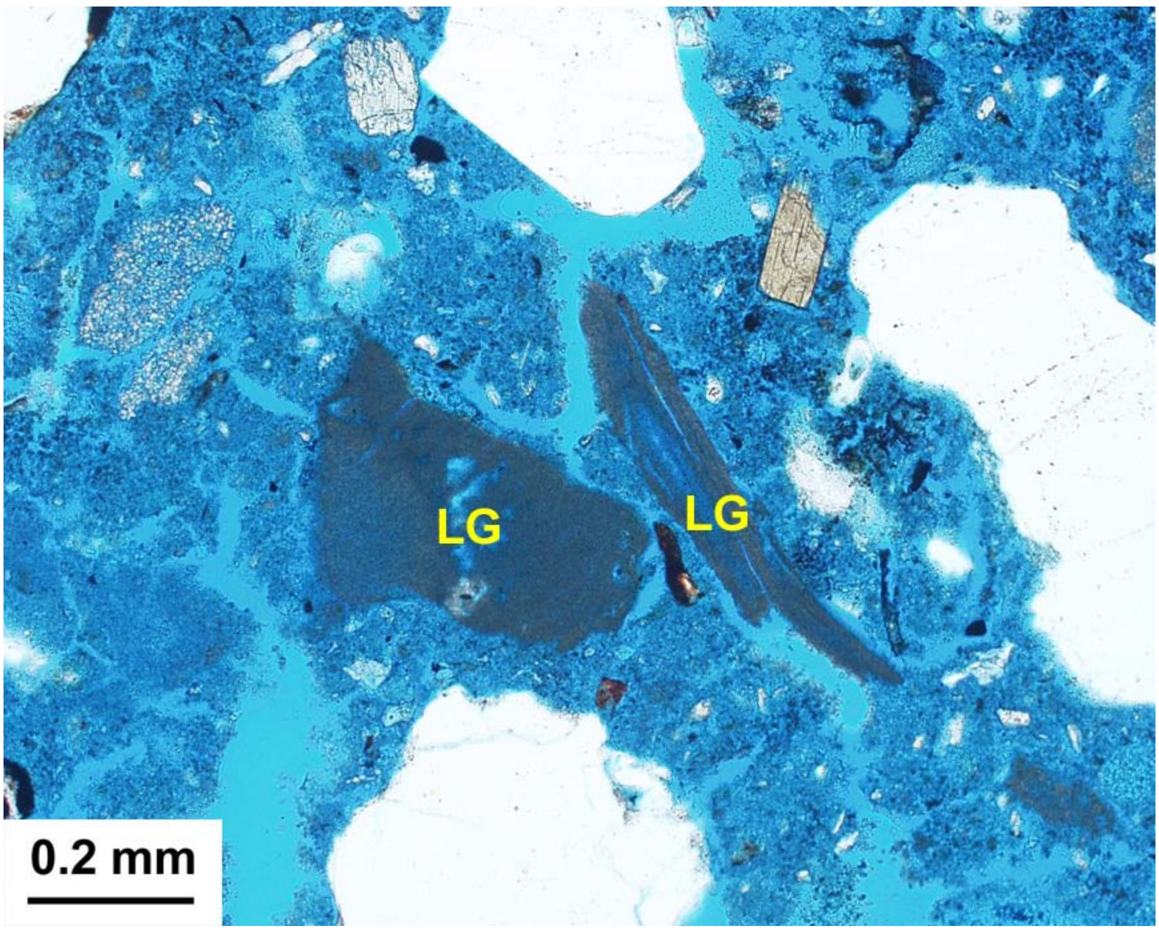
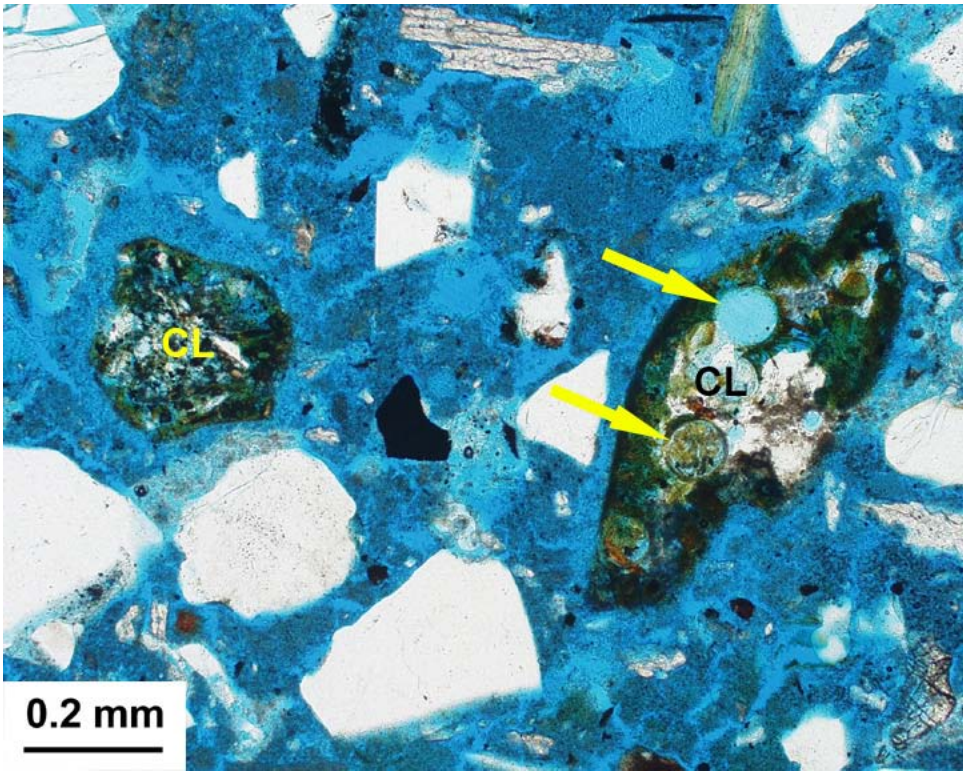


Figure 3: PPL photomicrograph exhibiting undispersed lime grains (LG). The one at right preserves a shape and internal texture consistent with the shell source used for the lime manufacture. Shell limes are generally high calcium and non-hydraulic in character.



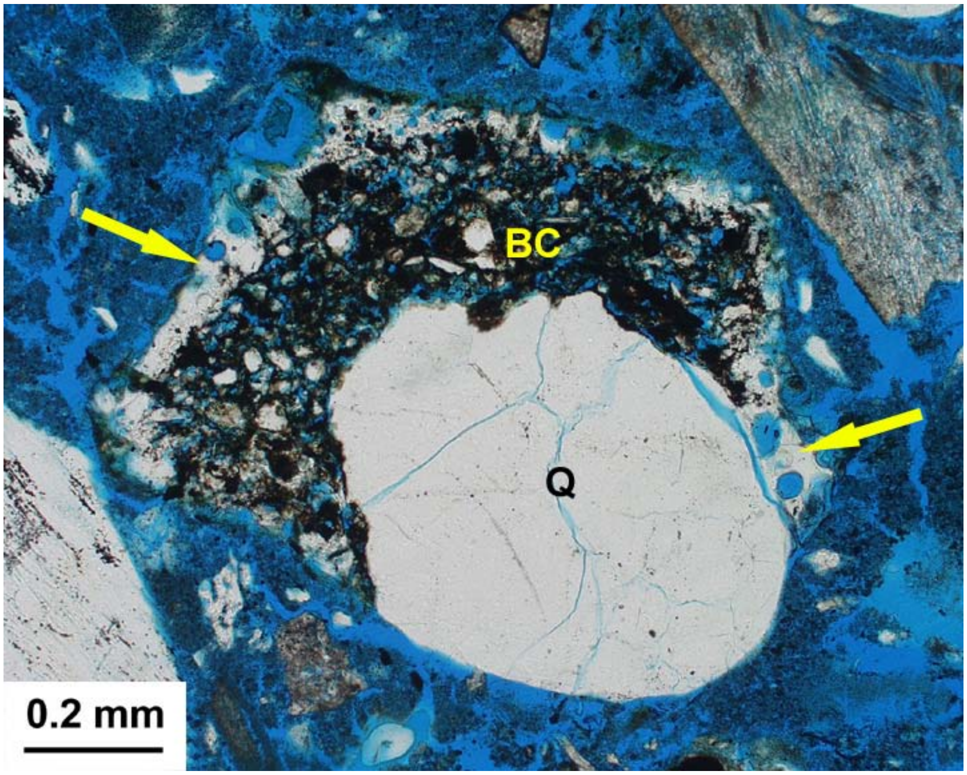


Figure 4: PPL photomicrographs. (Top) Silty clay lumps (CL) are dispersed throughout the matrix. The arrows indicate vesicles or air bubbles that mayhave been produced during firing of the clay. (Bottom) A quartz grain (Q) is surrounded a partially amorphous mass consistent with burned clay (BC). The arrows indicate a layer of vesicular glass surrounding the clay. These features suggest that the clay is not added as a fine portion of the sand or as a separate inert filler.

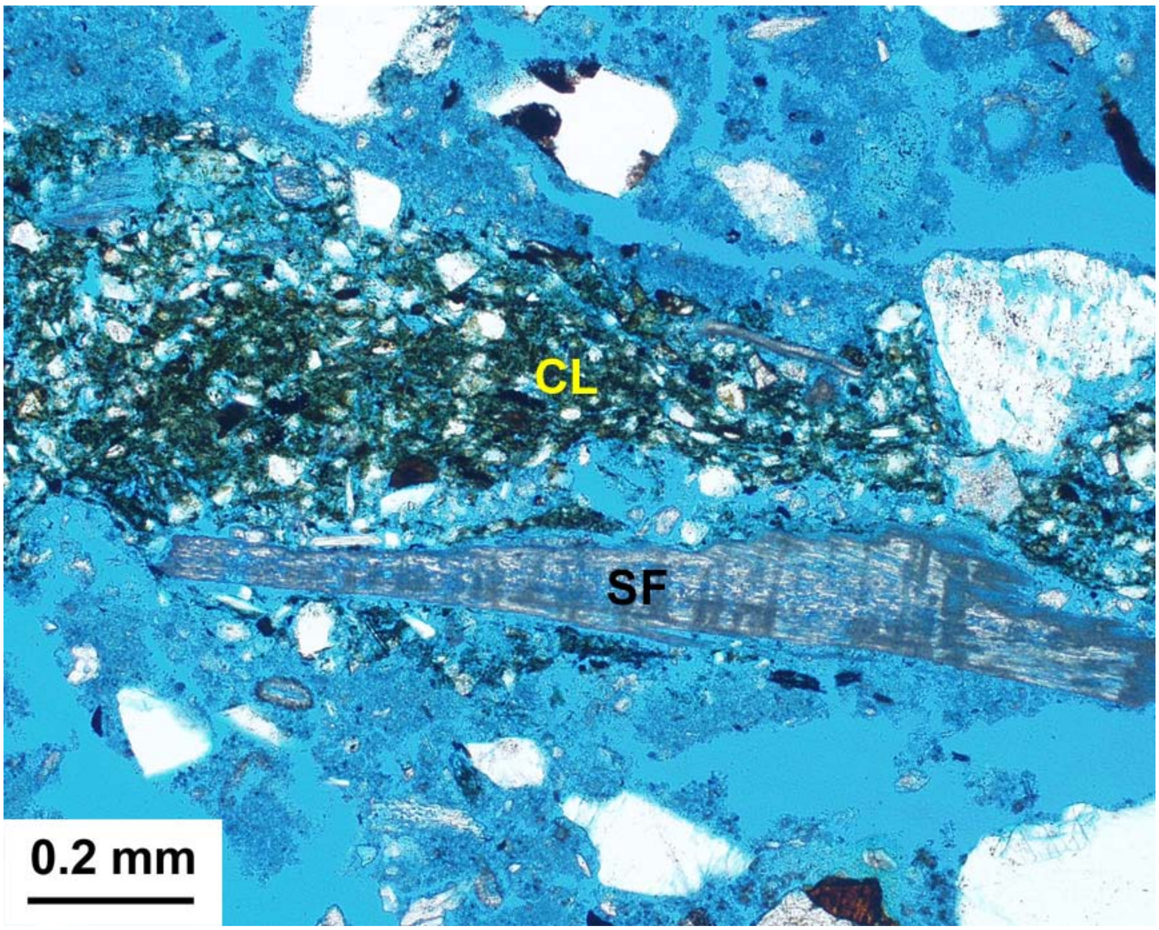


Figure 5: PPL photomicrograph. There is an association between the clay lumps (CL) and the shell fragments (SF). In some cases as shown here, the clay is adherent to the unburned lime (here partially burned) and this suggests the two were mixed prior to incorporation in the mortar. However, if the clay were calcined, it is likely the two were mixed after rather than before calcination.

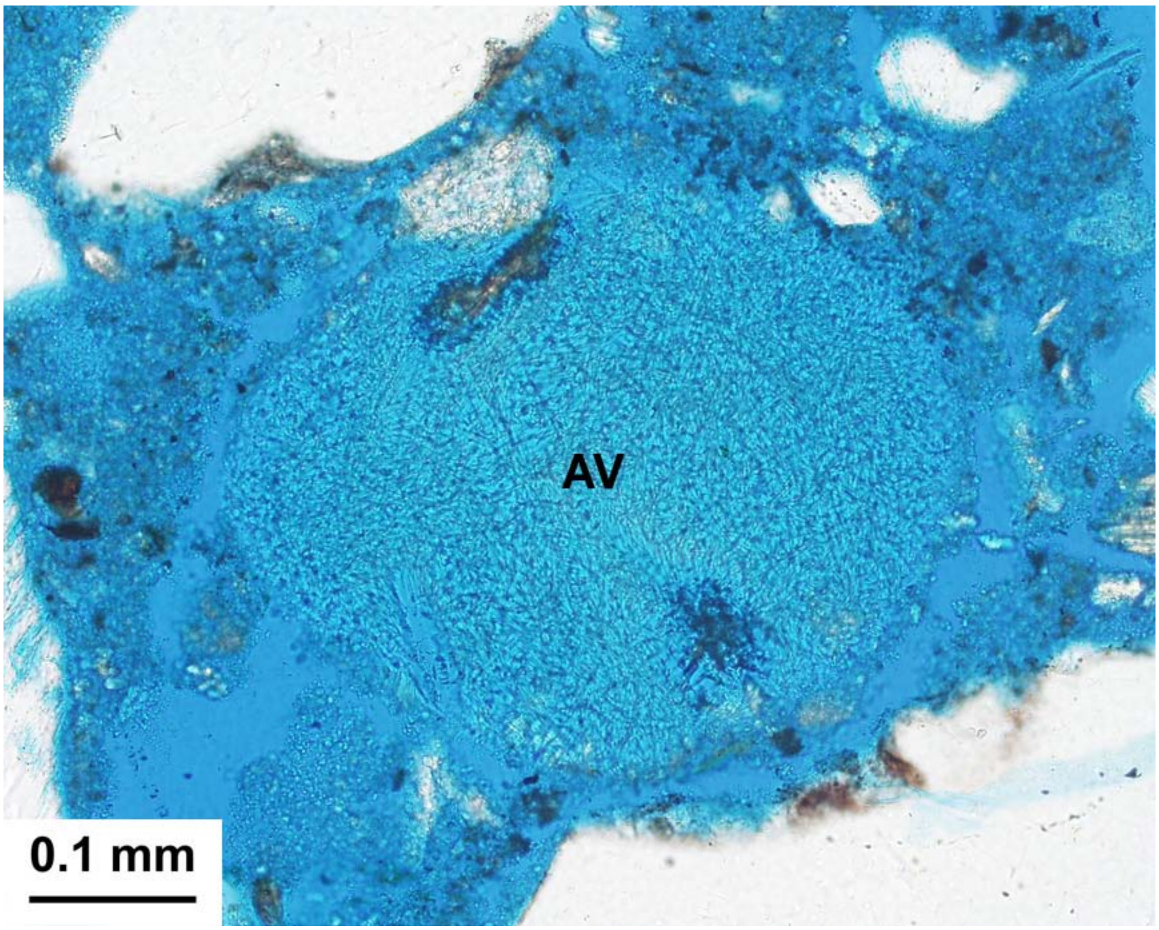


Figure 6: PPL photomicrograph. Some air-voids (AV) are filled with ettringite, a secondary sulfate mineral. The sulfate is not a common product in lime mortars and may indicate that some sulfate was present in the calcined clay.

APPENDIX B

TAX ASSESSMENTS, 1808-1842

Tax Assessments 1808-1842

Year	Address	Structure	Owner	Property Tax ($)	Personal estate ($)	Comments
1808	7 John St.	House & Lot (H&L)	John Bloodgood	1650	200	
1808	?	Shops & Lots	John Bloodgood	2850		
1808	7 John St.	H&L	Samuel Frazier		40	
1808	1 John St.	Stable & Lot	John Strineham?	500		
1808	3 John St.	Stable & Lot	George Stanton	500		
1808	3 John St.	Stable & Lot	Jonathan Little	300		
1808	13 John St.	H&L	George Lovett	3400	400	
1808	13 John St.	H&L	James Lovett		400	
1808	15 John St.	H&L	Jonathan Little	3400	1000	
1808	15 John St.	H&L	Elizabeth Little		1000	
1808	5 John St.	H&L	George Ulshoeffer		100	
1810	3 John St.	H&L	George Ulhoeffer	600	100	
1810	3 John St.	Shops & Lots	John Bloodgood	2500		
1810	3 John St.	H&L	John Bloodgood	3000		Building
1810	3 John St.	Stable	George Stanton (Horton?)	300		
1810	13 John St.	H&L	James Lovett	3400	500	
1810	15 John St.	H&L	Jonathan Little	3400	1000	
1810	192 Broadway	H&L	Edward Bacon		300	Artillery & illeg.
1815	192 Broadway	H&L	Edward Rockwell	12,000	2,000	
1815	3 John St.	H&L	Samuel Miner?	1200		
1815	3 John St.	Shops	John Bloodgood	10,000		

1815	11 John St.	H&L	John Bloodgood	11,000	5,000	
1815	11 John St.		Garrit Gilbert?		5,000	
1815	11 John St.	Stable	Charles Rocles?	800		
1815	11 John St.	Stable	Estate of George Stanton	700		
1815	11 John St.	Stable	Jonathan Little	700		
1815	13 John St.	H&L	Mrs. Ludlowes?	9,000		
1815	15 John St.	H&L	Jonathan Little	10,000	3,000	
1820	1 John St.	H&L	William Bryce		2000	
1820	3 John St.	H&L	E. Fielding	1,000		
1820	3 John St.	3 Shops	Rich. F. Lawrence	9,000		
1820	11 John St.	3 Shops	Mrs. Bloodgood	8,100		
1820	11 John St.	says (rearground)	Chas. Miller	1,300		
1820	11 John St.	Stable, rear	J. Little & B. Hyde	500		
1820	13 John St.	H&L	Robt. Center	7,200		
1820	15 John St.	H&L	Jonathan Little	8,100	25,000	
1820	192 Broadway	?	E. & S.L. Rockwell	11,700		
	192 Broadway	?	James Oram		250	
1825	3 John St.		John Roberts	900	200	
1825	7&9 John St.	3 shops	Cornl. P. Berrian	8,500		
1825	11 John St.		G. Taylor	7,500	500	
1825	11 John St.		Alex. Hewett		2,000	
1825	11 John St.		Andrew Mills		1,000	
1825	11 John St.		George A. Butt		2,000	

1825	13 John St.		G. Monell	6,600		
1825	13 John St.		Jacob Townsend		200	Attorney
1825	13 John St.		Samuel Townsend		200	
1825	13 John St.		James Anderson		200	Attorney
1825	13 John St.		John Nichol		1,000	Merchant
1825	13 John St.		Mr. Woolsey		100	
1825	13 John St.		Mr. Thompson		500	
1825	15 John St.		Jonathan Little	7,500	20,000	
1825	192 Broadway		Mrs. Robertson	11,000		
1825	192 Broadway		E. Rockwell		5,000	
1825	192 Broadway		S.S.? Rockwell		2,000	
1825	192 Broadway		Robert Tannehill		1,000	
1825	192 Broadway		Andrew Hamilton		2,000	
1825	192 Broadway		Richard Creed		1,500	
1825	192 Broadway		Mr. Edwards		100	
1825	192 Broadway		Mr. White		100	
1825	192 Broadway		Alexander McKinsey		100	
1830	15 John St.	H&L	Mrs. Hunter	8,250		
1830	13 John St.	H&L	Mrs. Brown	7,750		
1830	13 John St.		Evan Morrison		250	Agent for Lehigh Cook
1830	13 John St.		George Woolsey		250	
1830	13 John St.		Charles Thompson		500	
1830	13 John St.		Reuben Smith		250	

1830	13 John St.		Jacob Wyckoff		500	
1830	13 John St.		Joshua Moss		1,000	
1830	13 John St.		Jacob Townsend			Deceased
1830	13 John St.		Thomas Ketchum		250	
1830	13 John St.		Capt. Murphy		500	
1830	Rear of 13, 15, 17 & 19 John St.		Matthew Conolly		2,000	
1830	Rear of No. 13 John St.	Stable	John McGuire		500	
1830	11 John St.	H&L	Wm. A. & Robt. Prince	13,500		
1830	11 John St.		Wm. A. Prince		5,000	
1830	11 John St.		Robert Prince		2,000	
1830	9 John St.	H&L	Mrs. Lothrop	5,000		
1830	9 John St.		Dr. E. Condit		500	
1830	9 John St.		Wm. Cromwell		500	
1830	7 John St.	H&L	John Mortimer Sons	5,000	1,000	
1830	5 John St.	H&L	Mrs. Jones	5,000		Dap?maker
1830	3 John St.	H&L	John Roberts	1,500	250	Tailor
1830	(corner & rear)		Mrs. McMillan			assessed on Broadway
1835	192 Broadway	H&L	Esq. S.L. Rockwell	16,000		
1835	192 Broadway		James Thompson		1,000	Confectioner
1835	15 John St.	H&L	Mrs. Lorber	10,000		
1835	15 John St.		Samuel Hanna			
1835	15 John St.		John Gibson		500	
1835	15 John St.		John D. Noyers		500	

1835	15 John St.		John Lesley Howard		500	
1835	15 John St.		James Valentine			Water St.; Attorney?
1835	13 John St.	H&L	Mrs. Traphaggen	10,500		
1835	13 John St.		Smith			
1835	13 John St.		Edward Fitzgerald			
1835	13 John St.		George Wm. Fitzgerald			
1835	Alley, Factory of Lots in rear of 13, 15, 17 & 19		Sumner & Naylor	15,000		
1835	Corner of 11 John St.	H&L	no name given	17,500		
1835	9 John St.	H&L	Hamiel Fauchin?	7,000		
1835	9 John St.		Henry C. Shumway			
1835	9 John St.		John W. Southack		250	250 Broadway
1835	9 John St.		Cyprian Southack		250	
1835	9 John St.		James Rich			William
1835	7 John St.	H&L	Thomas Ingham	7,000		
1835	5? John St.		Henry Sowle	7,000		Broadway
1835	5? John St.		Cellus Etine'			16 Broadway
1835	3 John St.	H&L	John Roberts	2,000	250	Tailor
1840	15 John St.	House & Lot	Mrs. Lowber	12,000		
1840	13 John St.	House & Lot	John Anderson	12,000		
1840	13 John St.		Joseph Broadbent			
1840	13 John St.		Luther Carrington			
1840	13 John St.		Main?			

1840	Rear of 17, 15 & 13	Alley? & Factory	Sumner & Naylor for Alley? and Factory	16,000		Note: In 1840 Sumner & Naylor were located at 89 Broad St. and selling galvanized iron tinned plates for roofing, gutters, leaders, etc.(Wright 1840:186).
1840	11? John St.	House & Lot	George C. Thorburn	18,000		
1840	9 John St.	House & Lot	Corner of cutting office	6,000		
1840	7 John St.	House & Lot	Corner of cutting office	6,000		
1840	5 John St.	House & Lot	Corner of cutting office	6,000		
1840	3 John St.					Corner of Broadway
1840	Near corner of Broadway	Lot	Reformed Dutch Church	30,000		near corner of John
1842	15 John St.	House & Lot	George C. Thorburn	18,000		
1842	13 John St.	House & Lot	Charles Stewart	9,000		Corner of Broadway
1842	11 John St.	House & Lot	Mrs. Church	7,000		Corner of Broadway
1842	9 John St.	House & Lot	Edmund Beaumont	9,000	500	Corner of Broadway