The Waterford Mill
Waterford, Virginia

Historic Structure Report

prepared for

The Waterford Foundation
Waterford, Virginia

and

The County of Loudoun
Leesburg, Virginia

24 May 2013

studioAMMONS

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Acknowledgments

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We are grateful for the support of The National Trust for Historic Preservation, easement holder on the mill property, the members and friends of the Waterford Foundation, and the Waterford Citizen's Association throughout the years detailed in this report. And finally, the Waterford Mill Project lead group would like to recall the memory of Richard L. Storch, benefactor and inspiration for the most recent efforts to stabilize and interpret the mill. We dedicate the report and restoration to his memory.

Executive Summary

StudioAmmons was asked to provide the owner, the Waterford Foundation, with the following items as part a comprehensive study of the mill and its history. These take the form of an historic structure report, which contains the following elements:

1. Review of the history of the mill and all interventions since its original construction. This involved the review and collation of existing studies, reports, correspondence, and other material in the files of the Waterford Foundation.

2. Survey existing conditions, identifying all conditions that need attention, prioritized according to relative urgency, into short- and long-term recommendations. This includes a full structural assessment, produced in connection with Robert Silman Associates, structural engineers.

3. Provide documents for any repairs that are required for immediate, ongoing use of the building in the Waterford Homes Tour and Crafts Exhibit (Waterford Fair) and any other Foundation uses.

4. Provide a preliminary interpretive design for making the mill and its history more intelligible to visitors.

The Waterford Mill stands at the heart of the village of Waterford. The third mill to stand on the site, it was built in 1818 to process the fine wheat produced in the fertile land of Loudoun County. Its builders provided a technologically advanced answer to the demand for high-quality flour shipped around the nation and even to Europe and South America. They adopted the design for an "automated mill" developed by Oliver Evans in the late eighteenth century. The sturdy masonry mill was provided with a large wooden hurst frame, set below the first floor and designed to carry three sets of millstones and their gearing. The frame was intended to separate the mill from the vibrations of the machinery. The mill was equipped with elevators and chutes that carried the grain to be cleaned, stored, and milled and the flour to be processed, cooled, stored, and packed with the aid of the water-powered machinery and with a minimum staff.

The mill was altered to keep up with milling technology and to respond to the stresses produced on the building by its watery environment and vibrating mechanisms. In the period just before the Civil War, the east front and part of the south wall were completely rebuilt. In 1885, the milling machinery was entirely replaced to convert it to the newly popular and very efficient gradual reduction process which passed and repassed the grain through steel rollers to squeeze a greater proportion of white flour from the grain than was possible with traditional millstones.

Ongoing structural movement, particularly at the west end of the south wall, was successfully addressed in the late 19th century by the installation of transverse tie rods at each floor just inside the west wall. Post Civil War milling relied on a greater storage capacity, so a three-story addition was built to the west that nearly doubled the mill's footprint. At the same time more power was needed, particularly when the water levels were low, so a powerful steam engine, for "emergencies," was added in 1903 and a turbine wheel was also added. Eventually the steam engine was replaced by a diesel engine. After the mill closed in 1938, it was acquired by the Waterford Foundation in 1944, which has managed it ever since. Major repairs were undertaken over the next sixty years, including demolition of the west wing, removal of most of the milling equipment, and infilling of the tail race (which increased moisture-related rot in the basement area) in the 1940s, installation of tie rods to further limit movement in the south wall, addition of a set of fire stairs, and comprehensive restoration of the exterior building envelope in 1983–4. This was followed by partial excavation of the tail race and installation of roller milling equipment in 1998–1999 and a recreation of the west basement entry in 2009.

The current set of recommendations, divided into short- and long-term objectives, are based on a complete review of the history of the entire property from its construction until the present day. Based on our architectural and structural analyses, the mill appears to be in relatively good condition. The earlier interventions have had, for the most part, a positive effect. Any new work should extend and complete the effort to preserve the building from further deterioration and improve the opportunities to interpret its history and value.

Short-term structural recommendations include limited repair and temporary propping under the hurst frame, and the establishment of a better connection between the floor structure and the south wall to improve its lateral stability. Additionally, some internal cracks on the lower sections of the building require filling and patching. The interior gear pit and external wheel pit, as well as the tailrace, should be further excavated to their original depth in order to permit the interior to drain properly and keep dry. Finally, the ongoing deterioration of the hurst frame has caused and will continue to cause so many problems, that in order to conserve and stabilize the frame and floor above, our recommendation is to reconstruct the hurst frame incorporating existing material.

Long-term recommendations include repair of unsafe sections of the upper floors, limited repair of compromised structural members identified in the structural report, and a safer and less obtrusive electrical system with better concealed wiring, more effective lighting, and more outlets.

Historic Structure Report

History Overview

The brick building standing at the corner of Main and First Streets in Waterford was built as a merchant mill in 1818 to serve the prosperous wheat-growing region in northern Loudoun County. It is the the third in a string of mills on the site, around which the village that we see today was founded and prospered. Throughout its history, the mill has been subjected to regular rebuilding and alteration to keep up with rapidly changing milling technology. It was built by local businessman Robert Braden and millwright Jozabed White as an Oliver Evans-style automated mill, designed to be operated around the clock by a small staff. The mill's produce was sent directly by road or boat to major eastern markets until 1830, when the Baltimore and Ohio railroad opened to Point of Rocks, Maryland, followed by the Chesapeake and Ohio Canal in 1832. After that date, the mill operator maintained teams of horses to haul the flour to Point of Rocks. When the Alexandria, Loudoun and Hampshire Railroad (today's W&OD Railroad) was extended past Waterford in 1868, it further extended the reach of local producers. In the 1880s the mill underwent substantial changes to correct structural problems and to convert it to the gradual reduction process, employing iron rollers instead of pairs of millstones. The mill was powered by an overshot wheel, later supplemented by a turbine, steam plant, and a diesel engine.

In this period, prosperous mills were still continually altered and updated to keep up with expanding mill technology in order to remain profitable. The conversion to roller milling was commonplace among merchant mills from the 1880s through the early twentieth century, as owners struggled to keep ahead of their competition. James F. Dodd was said at that time to have "put a new shaft on his overshot wheel," and to have upgraded the entire mill to an output of 75 barrels of flour per day. He was also considering adding an advanced power drive: a turbine wheel. The new milling capacity required expanded grain storage, so Dodd added a three-story addition on the west end of the building, connected by a five-story receiving room and adjacent grain elevator.

The mill ceased operation in 1939 and was acquired in 1944 by the Waterford Foundation. It was stripped of most of its milling equipment and has been used for an annual craft show since that time. The Foundation has engaged in a series of interventions to ensure the long-term preservation and safe usage of the building. There has long been interest in improving the mill's interpretive value, both to visitors and the local community. Most recently, roller mill equipment salvaged from another mill was partially installed in the late 1990s, with the intention of opening the mill on a more regular basis and providing a static interpretation of milling to visitors.

I. Waterford History

The Treaty of Albany in 1722 cleared the way for settlement in the tribal lands east of the Blue Ridge and south of the Potomac. The land that is now Loudoun County was part of the vast Fairfax land grant. Quakers from around Pennsylvania settled along the South Fork of Catoctin Creek in the fertile Loudoun Valley beginning in the 1730s. Quaker Amos Janney (d. 1747), a surveyor for Lord Fairfax, arrived from Bucks County, Pennsylvania in 1732 and purchased 400 acres in the following year.

By the early 1740s, Amos Janney had built a mill to process the increasing amounts of grain raised by the settlers and to process timber from local forests [Janney 1978]. The mill is thought to have been located across the creek and upstream of the current mill site [Divine 1997]. A small hamlet began to grow up around the mill, which included the Fairfax Meeting House, built by the Quakers in 1741, and a school and cemetery that were added in 1755. The meeting house was replaced by a new stone building in 1761, which is still standing today [http://www.waterfordfoundation.org/history/quakers.html].

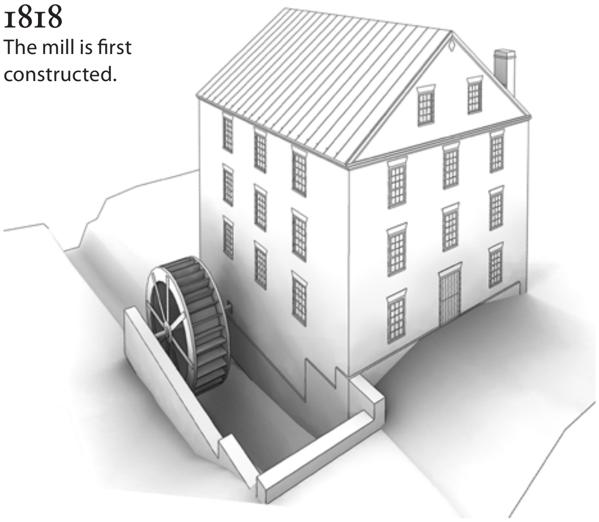
The town prospered from its location on "the Great Road to the Valley of Virginia." One nearby community petitioned the county to add a road to connect them with "Mahlon Janney's Mill" in 1774. By 1782, the village, known as Waterford, was on its way to becoming the county's second largest town [Scheel 2002]. Lots were laid out on the land of Joseph Janney soon after 1780 and the community was chartered as a town in 1801 [http://www.waterfordfoundation.org/history/.html].

Waterford originally extended only from the mill to the intersection of Main and Second streets. It was enlarged to the east in 1800 and to the south in 1817-18 [Bentley 1966]. By 1834, the population totaled four hundred persons, who occupied about seventy houses. In addition to the mill, businesses included a tannery, a chair-maker, and a boot and shoe manufacturer [Martin's Gazetteer].

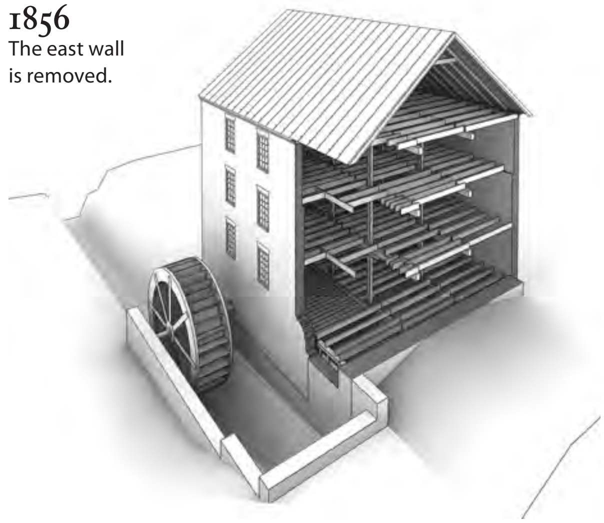
Waterford was officially incorporated in 1836. It was governed by a nine-man town council, a mayor, and a recorder [Bentley 1966]. In addition to its Quaker population, Waterford was home to Scots-Irish Presbyterians and Lutherans of German extraction. There were numerous free black families in addition to those who were enslaved. By 1830, it is said that one-quarter of Waterford's free households were headed by African-Americans [http://www.waterfordfoundation.org/history/.html], who found the town's service-based economy and large Quaker population to be congenial to their employment.

The town reached its peak in the 1820s. Local resident William Williams later recalled that "every unnatural stimulus is followed by as great prostration, Waterford about this time suddenly ceased to improve" [Scheel 2002]. Many of the Quakers left over the issue of slavery. The completion of the railroad and canal to Point of Rocks, seven miles away, in the early 1830s, meant that commercial traffic moved from Waterford to Point of Rocks. At the same time the new Snicker's Gap Turnpike (corresponding to Route 7) was finished from Leesburg to the Shenandoah Valley in 1832, shifting traffic three miles to the south of the town and choking off its commercial life. By the 1850s, Loudoun County had thirty mills and was the fourth largest wheat producing county in the state [Janney, 1978]. Waterford millers managed to compete with better located mills along the Potomac by maintaining teams of horses and wagons to transport flour to the nearest port at Point of Rocks.

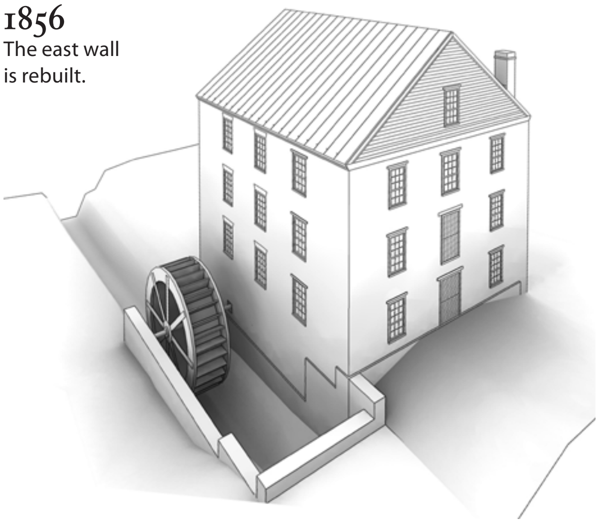
1818
The mill is first constructed.



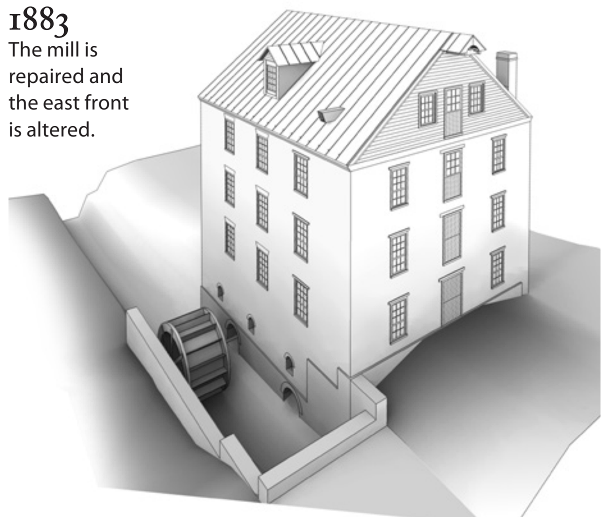
1856
The east wall is removed.



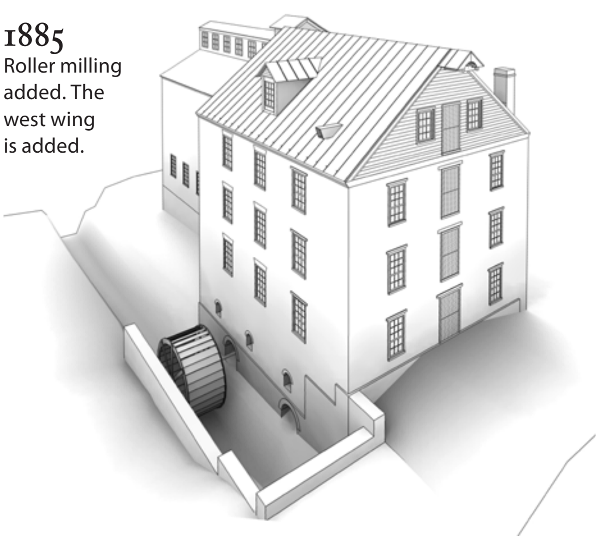
1856
The east wall is rebuilt.



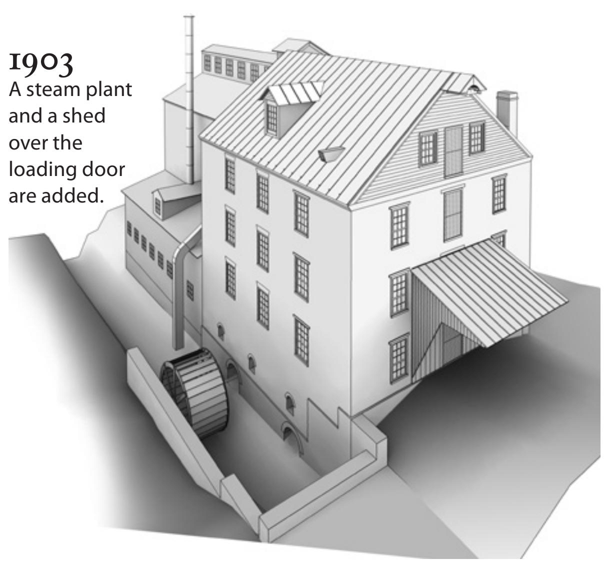
1883
The mill is repaired and the east front is altered.



1885
Roller milling added. The west wing is added.



1903
A steam plant and a shed over the loading door are added.



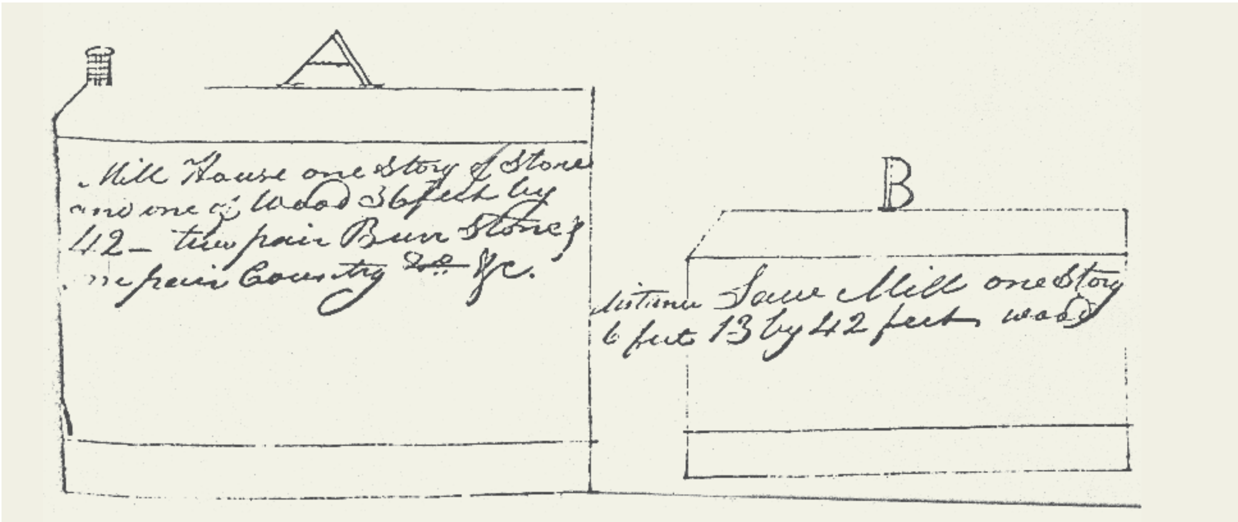
II. Building History

Introduction

Around 1750, efficient merchant mills designed to produce flour for export began to appear beside the older grist mills that met local needs by trading a proportion of grain for flour. They sent their finely milled products, which would stay fresh for months, around the world. According to one estimate, annual export of flour from Virginia ports rose from approximately 8,000 to more than 60,000 barrels between c 1740 and c 1770. Improved transportation, excellent wheat-growing country, and an abundance of water power ensured that the mid-Atlantic region became one of the world's most productive sources of flour until the expansion of the wheat-growing areas in the Midwest after the Civil War.

The invaluable contributions of Oliver Evans to the development of American milling enabled the establishment of many merchant mills across the countryside of Virginia, Maryland, Pennsylvania, and New York. Large mills grew up in the port cities of the region, but most of the export flour was produced by isolated merchant mills like the one in Waterford. These used the water power produced by small streams and rivers to mill as much or more than 50 barrels per day. Merchant mills involved a large capital investment and often represented a partnership between an owner and a miller.

The mill race looking south from near the mill in the early twentieth century [WF].



The insurance policy for the Janney Mill, 1803. Mutual Assurance Society of Virginia, Library of Virginia.

In 1810, the US was producing 4,000,000 barrels per year. Virginia, with 441 mills producing 1,000,000 barrels, was second after Pennsylvania as a source of flour. By 1850, US production had increased tenfold to 40,000,000 barrels, of which about 16,000,000 were exported. By 1860, Midwestern production overtook that of the mid-Atlantic states. St. Louis and later Minneapolis became the new centers of flour production and new technology was developed that enabled far greater efficiency and new sources of power. Steam, steel, and railroads were rapidly replacing water power, wood, and canals. Eastern mills had to adapt to meet these challenges, but for the established merchant mills, the post-Civil War era was one of diminishing returns [Lundegard 2007].

Mahlon Janney, c 1762–c 1811

The merchant flour mill now standing in Waterford, built in 1818–19, occupies the site of the earlier grist mills operated by Amos Janney and his son, Mahlon (c 1731–1812). At some point before 1762, Mahlon Janney built a dam across Catoctin Creek, which shunted water into a mile-long channel or millrace. The distance of the dam from the mill meant that as the creek fell on its route to the sea, the race full of water stayed nearly level on its approach to the mill. This resulted in an increase in power, since the total amount of fall available at the mill (fourteen feet in this case) allowed a greater diameter for the mill wheel, which was powered by the weight of water exerting leverage on the shaft.

The mill that Mahlon Janney built was of frame construction, with a single story above a stone basement. As drawn and described for an insurance policy with the Mutual Assurance Society of Virginia in 1803, it measured 36 feet in width and 42 feet in length, similar to several surviving eighteenth century mills in western Virginia, such as the Springdale Mill in Frederick County. It held two runs of expensive French buhr stones for flour and a single "country" pair of local manufacture for corn. The footprint of the single-story Janney mill was actually larger than the first floor of the current building. The mill would have utilized traditional labor-intensive technology. The combination of corn and flour production indicate that it was, like George Washington's mill at Mount Vernon, part custom (local) and part merchant mill. A long narrow sawmill (13 by 42 feet) stood six feet away [Mutual Assurance Society policy, 1803, Library of Virginia]. It was not unusual for a mill owner to take advantage of a mill seat by adding a profitable sawmill next to his grain mill. Mahlon Janney opened two other mills in Waterford. To avoid using the water already reserved for his flour mill, he harnessed the water in Ball's Run south of town to power his fulling mill for the preparation of woolen fabric in the late 1790s. This mill was known as the Moore and Farquhar Fulling Mill and served as a grist mill by the 1850s. He added another mill in 1803, later known as the Schooley Mill, used to process corn, limestone, wood, and other materials [http://www.waterfordhistory.org/history/waterford-mills.htm]. The addition of the Schooley Mill may have been intended to permit the Janney Mill to drop corn milling and focus entirely on the growth of the lucrative export flour business.

Jonas Potts, c 1811–c 1814

Jonas Potts was the first of a succession of owners who followed Mahlon Janney. The precise year in which he acquired the mill is not clear, but he did advertise it for sale as a merchant mill "in good order" on seventy acres of land in April of 1811 [April 2, 1811 advertisement, WF].

A Merchant Mill for Sale.

The subscriber wishes to sell a small tract of excellent Land containing about SEVENTY ACRES, with a Merchant Mill situated thereon. The Mill adjoins the town of Waterford in Loudoun County, (Va.) and is now in good order. This property is situated in the best wheat neighbourhood in the county. It is thought unnecessary to give a farther description of the property, as persons wishing to purchase will view it before they do so. For terms of sale apply to JONAS POTTS.

Waterford, April 2, 1811.

Sale notice for merchant mill, 1811 [WF].

Land for Sale.

Will be sold on Wednesday the 16th day of September next, under a deed of trust to satisfy a debt due by Josabed White to John Hollingsworth, a tract of land, lying in waterford containing

63 Acres

The land is under good improvement; has a large two story brick house, together with an elegant Merchant and saw mill, almost finished, on the same. A large portion of said land is in meadow. It will be sold for cash.

Enos Potts, Trustee.

Aug. 18th—4t.

Sale notice for land, houses, and mill, 1818 from Leesburg's Genius of Liberty [WF].

Emanuel Newcomer, 1814–1817

Emanuel Newcomer purchased the mill in 1814. He and his wife Catherine built the house nearby (known today as Mill End) between 1814 and 1817. They sold the combined property in 1817 [Waterford Foundation Walking Tour]. The house remained attached to the mill and served as the mill owner's house. In 1816, county tax records show that Newcomer owned two tracts, comprising one lot in Waterford and 53 acres near the town.

Mill End today.

This historic image shows the stone house on Bond Street that was mentioned in early records as the miller's house. It was conveyed with the mill property until it was demolished by W.E. Mays in 1918. It abutted the house known as Hillside on the east. [John Souders].

Braden and White, Robert Braden, or Braden, Morgan, and Co., 1817–1830

The Janney mill was purchased by local businessman Robert Braden and miller or millwright Jozabed White in 1817. The present brick mill was apparently built in 1818 by White. He advertised at Waterford in 1817 for "several journeymen Carpenters and Millwrights" [September 9 1817 advertisement, WF and Loudoun County Land Book, 1818]. In the following year, "an elegant Merchant and Saw Mill, almost finished" on 63 acres, was offered for sale to satisfy a deed of trust between Jozabed White and Jehu Hollingsworth [June 2, 1818 advertisement, Leesburg Genius of Liberty, WF]. It included a large brick house and a "convenient" stone house. It ended entirely in the hands of Robert Braden [Cary Gravatt]. The nearby stone house, no longer standing, probably housed the miller or miller's assistant.

In 1820, the first year in which the value of buildings is broken out from the value of land, Braden and White's mill was assessed at $6,000. The adjoining 53 acres contained buildings valued at $1,000. Robert Braden personally acquired the mill tract from Braden and White in 1822, but the value stayed the same. The trouble that Jozabed White previously experienced with debt now extended to Robert Braden. One possible explanation for the problems experienced by the mill owners is that Braden and White built the structure during the economic expansion that followed the War of 1812. The Panic of 1819, which coincided with the completion of the mill, brought about a wave of unemployment and bankruptcies. White and Braden were unable to repay their deed of trust.

The mill was apparently implicated in the failure of Braden and Morgan, another of Braden's businesses. In 1825, the property was transferred to the trustees for the creditors of Braden, Morgan and Co. [Loudoun County Land Book, 1826]. It was transferred to trustees Colin, Auld, and Miller in 1826 [1827], still with the same values and held by them until 1830 [Loudoun County Land Book, 1831]. The sale may also have been connected to Robert Braden's death in 1827 [Valuable Property including mill, houses, and meadow, 1830, Leesburg's Genius of Liberty].

The new mill, measuring about 37 x 40 feet in plan, is somewhat smaller than many merchant mills., which, according to millwright Derek Ogden, are often closer in size to 40 by 50 feet. It had matching north and south walls, each with three windows on three floors. The east and west ends probably

Mill, Meadow, &c.

FOR SALE OR RENT.

FOR SALE OR RENT, the well known Merchant Mill, in the town of Waterford.—Also the Meadow, (containing 60 acres,) adjoining, and a spacious and excellent Dwelling House.

The subscribers being very desirous to close their trust, will sell this property a great bargain, on a very liberal credit.

For further particulars apply to

COLIN AULD,
W. H. MILLER,
Alexandria, D. C.

April 19, 1828.—15 eotf.

Valuable Property,

FOR SALE AT AUCTION.

WILL BE OFFERED, at public sale, at the Court-house in Leesburg, on the first day of April court, being the 12th day of the month, the following valuable property, situate in the town of Waterford, Loudoun county, Virginia, viz.

A MERCHANT MILL,

Built of brick, four stories high, with two run of Burr Stones, and can, it is believed, at a small expense, be put in complete order.

A large and commodious BRICK DWELLING HOUSE, formerly occupied by the late Rob't. Braden, Esq.

A small STONE DWELLING HOUSE.—And the MEADOW, (adjoining the mill,) containing about 60 acres.

A more particular description of the property is deemed unnecessary, as persons wishing to purchase, will, no doubt, view the premises, which will be shown by Thomas Phillips, of Waterford.

The terms will be one-fourth of the purchase money in cash, and the remainder at one, two, and three years, with interest and approved security.

COLIN AULD,
R. H. MILLER,
Trustees of Braden, Morgan, & Co.

Alexandria, Feb. 13, 1830.—6 ts

Sale notice, Mill with land and house, 1828 and Valuable Property including mill, houses, and meadow, 1830, Leesburg's Genius of Liberty [WF].

also were nearly identical. The front facade, facing east, may well have been given distinction, as was typical at the time, by the use of brick laid in the expensive and decorative Flemish bond pattern, in which bricks alternate between bricks placed lengthwise and endwise (stretchers and headers) to give strength to the wall. This wall was rebuilt in the 1850s and now closely matches the remaining three walls. This brick pattern uses the more utilitarian American bond, in which every seventh course consists of a row of headers (bricks placed sideways) to bind the layers of brick together. All the brick was likely made from locally obtained clay and burned in the vicinity of the village.

The gable roof, which was oriented east-west, was undoubtedly covered with wood shingles and appears to have incorporated no dormers. Most of the roof structure survives. Each pair of common rafters, linked by irregularly placed collar beams, were lapped and pegged at the apex and sat on a false plate which acted as a thrust block to restrain the outward thrust of the rafters. The current chimney, like the rest of the east wall, dates from a mid-nineteenth century rebuilding.

A deep (about 14'-0") wheel pit, lined with stone walls on three sides, extended along the south wall. The size and layout of the hurst frame and the available fall of 14' of water indicates that the mill was powered by a high breast wheel about 18'-0" in diameter rotating in the opposite direction from the existing wheel. As Derek Odgden has observed: "With the wooden water wheel shaft being at a higher level it will dictate that the wheel will be much larger in diameter and as the water supply level is unaltered suggests it would have been about 18ft diameter. The water from the flume would allow the wooden water wheel to be of the High Breast type and rotate in opposite direction to the existing Fitz overshot wheel" [Appendix A: Comments On Drawings WF02 and WF03 by Derek Ogden, November 2012]. The wheel was served by a wooden flume extending from the head race that ended at the southeast corner of the mill.

The mill contained a 28-foot-long hurst frame. Enough of this frame survives to be able to reconstruct its original form. This was placed at the basement level to carry three sets of millstones and to house the gears that drove them. The hurst fame, made of 12″ by 10″ or 12″ hewn timbers, channeled the vibrations caused by the wooden gearing directly to the foundation, preventing damage to the building structure over time. Pairs of timbers known as stone bearers, which were mounted across the frame, carried each set of stones. The upper stone rotated on a vertical wooden spindle which was mounted on a lower cross member, known as a spur block, that could be raised up or down to adjust the distance between the stones. It seems likely that the runs of millstones would have been intended entirely for flour production, equipped with large (4′ diameter or bigger) French buhr stones. It was typical that only two of the sets of stones would have run simultaneously, leaving one set free for cleaning and dressing [Email message to Gibson Worsham, Derek Ogden]. By 1830, the only year for which capacity information is available, two buhr sets were recorded in use [“Valuable property including mill, houses, and meadow,” 1830, Leesburg Genius of Liberty, WF]. As a merchant mill producing expensive flour, it is very unlikely that it was involved in milling corn at all—that would have been left to the local grist mills [Email message to Gibson Worsham, Derek Ogden, 28 November 2012]. It does appear that a sawmill was continuously in operation at the site from the time it was built by Braden and White in 1817, if not earlier.

It is not clear when the north dormer was added, but it is likely that it was needed to provide extra light to the hopper boy located just inside. Its physical form suggests a date within a decade of the mill’s original construction in 1818.

Thomas Phillips, 1830–1832

The mill, dwelling house, and sixty acres were put up for sale or rent in 1828 by Colin Auld and W. H. Miller [April 19, 1828 advertisement, Leesburg, Genius of Liberty, WF, see page 16]. The structure was auctioned by the same men, trustees of Braden, Morgan and Co., in 1830, as “a merchant mill built of brick, four stories high, with two runs of Burr stones.” The advertisement indicated that the building was somewhat out of repair, since the text indicated that the mill could “it is believed, at a small expense, be put in complete order” [April 19, 1830 advertisement, Leesburg: Genius of Liberty, WF, see page 16]. It was acquired by Thomas Phillips, a enterprising local Quaker who was active in several transportation improvement schemes, only some of which came to fruition. He kept the house and land and sold the mill in 1832 [Cary Gravatt, "Talk at Lyceum on Mill History”].

McPherson and Bond, Russell and Bond, or Edward Bond, 1832–1848

Samuel McPherson and Edward Bond purchased the mill in 1832 and operated it together until 1834, when McPherson withdrew from the partnership. Edward Bond indicated that year that he was ready to exchange flour for “merchantable” wheat and “to stand the District and Baltimore inspection” [July 14, 1834, advertisement, Leesburg, Genius of Liberty, WF]. This would seem to indicate that the mill was accepting wheat in return for a toll, like a custom mill, in addition to sending

NOTICE.

THE partnership existing between Samuel M'Pherson and Edward Bond, at the Waterford Mills, is this day dissolved, by mutual consent.--- The business will be continued by Edward Bond, who will, at all times, change Flour for Merchantable Wheat, and stand the District and Baltimore inspection.

SAMUEL M'PHERSON;
EDWARD BOND.

Waterford, July 14, [26,] 1834.—30 tf

Advertisement, 1834, Leesburg’s Genius of Liberty [WF].

flour to export through Washington and Baltimore. The Chesapeake and Ohio Canal and the Baltimore and Ohio Railroad both opened to Point of Rocks at about this time and the mill was in a better position than previously to get its flour to Washington and Baltimore.

By 1836, the mill, without any other tracts, was owned by Russell and Bond and was valued at $6,000, the same value it had enjoyed since it was built in 1818. It once again became the sole property of Edward Bond in the following year [Loudoun County Land Books, 1837]. In 1841, the mill was reduced in value by one-third, probably as part of a county-wide reappraisal. It may, by this time, have begun to show some signs of the structural problems that would plague it for decades to come. During the decade of the 1840s, the structure remained at a value of $4,000.

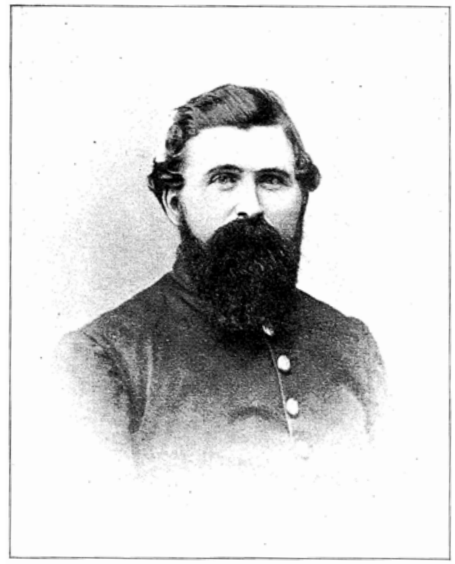
By 1847, Edward Bond owned substantial sums to a number of creditors, including Jacob and Lambert Myers. He executed a deed of trust on the mill, the sawmill, a steam engine, and a dwelling house that agreed that the mill would be sold to the highest bidder if he failed to repay his debts [Deed of Trust, Edward Bond, March 3, 1847, Loundoun County Deed Book 4 x 290]. The deed indicates that there was a sawmill by this date and that the mill owner had made use of steam power at this early date, perhaps for use when the water level was low or perhaps only to power the sawmill. Steam power is not mentioned again until after 1900.

Nathan Walker, 1848–1856

Nathan Walker, first president of the Mutual Fire Insurance Company of Loudoun County, acquired the mill in 1848. His business ledgers survive. By that time, the mill race also supplied a plaster mill located somewhere on the site. In 1849, the mill building was valued at $4,000, continued from previous years. It lost one quarter of its value in 1850, probably as part of a general reappraisal. From 1851 through 1855, the Loudoun County Land Books show Walker as the owner of three tracts in the town of Waterford: one, including the mill, with buildings valued at $3,000, a second lot, with buildings valued at $950.00, and a third with buildings valued at $650.00 [Loudoun County Land Books, 1853–55]. In 1856, the value of the house known today as Mill End and the mill were separated, with the mill building valued at $2,400 and the house at $1,300. Walker sold the mill in 1856 to Samuel Means. In 1857 he had only three tracts, with buildings valued at $1,000, $400, and $350. The 1853 Yardley Taylor map, below, shows that the sawmill was located on the south side of the tail race from the flour mill.

1853 Yardley Taylor Map of Waterford

Walker's several alterations to the mill property are recorded in the files of the Mutual Fire Insurance Company of Loudoun County, Virginia. Nathan Walker indicated in 1853 that he had "put up a stable west of my mill and about 21 yds distant therefrom" [Mutual Fire Insurance Co. of Loudoun County, Minute Book A, Library of Virginia]. The stable was needed to accommodate the teams of horses needed to pull wagons of flour ten miles to Point of Rocks, Maryland, where they could be loaded onto boats on the Chesapeake & Ohio Canal or cars on the Baltimore and Ohio Railroad.


Capt. S. C. Means, Co. A.

Samuel Means, 1856–1868

By 1855, Samuel Means was operating the mill for Nathan Walker. On December 25 1855, the mill "accidentally caught fire" causing moderate damage assessed at $25.00 [Mutual Fire Insurance Company of Loudoun County, Minute Book A, Library of Virginia]. The damage, still visible today, appears to have been limited to charring of several central first-floor joists around the southwest column and the western end of the north side of the hurst frame. The 1857 land books for Loudoun County show Means' acquisition in 1856 of the mill, newly valued at $4,000, from Nathan Walker. The value remained the same for the next several years [Loudoun County Land Books, 1857–60].

The decreasing value of the mill since 1840 and the 1855 fire indicate that the mill had declined in its physical condition. Several changes in the building appear to date from this period. The southwest post on the first-floor interior was moved a little less than two feet to the east. It may have been moved soon after 1855 because of recent fire damage to the beam below. Indications in the brickwork (variations in coursing and window head types) indicate that much of the east wall and the eastern bay of the south wall were completely rebuilt at the same time. The substantial change in value in the year of Means' purchase (1856), documented above, appears to indicate that the east wall was rebuilt at that time. The type of window heads in the added section confirms a mid-nineteenth century date [the newer windows have wood lintels instead of jack arches].

The original west end and the rebuilt east end of the building were held in place by iron ties with S-shaped wrought iron plates on the exterior that appear to have been added at the time the east end was rebuilt. These were bolted to the ends of the two longitudinal beams supporting each floor, so that there are six S plates on each gable end. The west wall is headed by a brick gable, while the east gable is built of timber. The form of the east wall as built is seen in the sketch made in 1882, shown on page 21, and confirmed by evidence in the brickwork. The central opening in the first and second floors were doors, but the three openings in the third floor and the single opening in the attic were windows.

The era of very profitable merchant flour milling in the American South ended even before the start of the Civil War. Mills like the Waterford Mill found it worthwhile to include corn milling along with flour in their business. In the Industrial Census of 1860, Samuel C. Means operated a successful merchant and grist mill that produced 6,667 barrels of flour from 30,000 barrels of wheat, but he also milled 12,500 bushels of cornmeal from 10,000 barrels of corn. That works out to 20 barrels of flour per day, six days per week. The mill had a workforce of three. It also produced 100 tons of plaster. The sawmill cut as much as 800 board feet per day [U. S. Industrial Census, 1860].

Sam Means is one of Waterford's most famous citizens. Means, although married to Rachel Bond, a Quaker, was not, as he is often reputed to be, a member of his wife's pacifist denomination (when they were married in Baltimore in 1855, she was said to be marrying "out of unity") [Hinshaw]. He is most famous as the founder of the Loudoun Rangers, a Unionist calvary unit that opposed the secessionists (and one of the only indigenous Federal units in the state). He was provoked to take up arms by the repeated seizing of his mill and horses by the Confederates. His relationships with local secessionist farmers ruined and unable to pay his creditors, he was forced into bankruptcy and left the area after the end of the war.

Oliver Lantz/ James F. Dodd, 1868–1883

Samuel Means transferred the mill to Oliver Lantz in 1868 to help settle a debt [Cary Gravatt, 2003]. Lantz was a Baltimore-based grain and flour merchant, and the mill clearly deteriorated during the years of his ownership. James F. Dodd, who previously was employed at Georgetown's Arlington Mills, was eventually hired to put the mill to rights. The Loudoun Telephone reported in 1881 that Mr. Dodd "transformed the Waterford Mill from a rat harbor to a first-class country establishment, having expended much money and time in so doing, and he certainly deserves creditable mention" [Loudoun Telephone, Hamilton, VA, 16 September 1881, WF].

Waterford Mills advertisement, Loudoun Telephone, September 1883 [WF].

Charles R. Paxton/ James F. Dodd, 1883–1889

Charles R. Paxton purchased the mill from Lantz in 1883. James F. Dodd continued as a miller. In the same year, Dodd advertised that "the old Waterford Mill" had "undergone thorough repairs" and was "in perfect order" [September, 1883, Loudoun Telephone, WF].

In 1885, the mill was converted to the newly popular and very efficient gradual reduction process, passing the grain numerous times through steel rollers rather than once between a pair of millstones. Dodd advertised that the "full roller process" would produce "beautiful and perfect flour" with which his customers would make "the very best bread" [June 18, 1886, Loudoun Telephone, WF]. The business was generally known as "Waterford Mills" after this date.

In this period, prosperous mills were still continually altered and updated to keep up with expanding mill technology in order to remain profitable. The conversion to roller milling was commonplace among merchant mills from the 1880s through the early twentieth century, as owners struggled to keep ahead of their competition. Dodd was said at that time to have "put a new shaft on his overshot wheel," and to have upgraded the entire mill to an output of 75 barrels of flour per day, almost four times what Samuel Means was able to produce thirty years before. He was also considering adding an advanced power drive: a turbine wheel [June 18, 1886, Loudoun Telephone, WF]. There is no direct evidence, however, that he added it at that time. The new milling capacity required expanded grain storage, so Dodd added a three-story addition on the west end of the building, connected by a five-story receiving room and adjacent grain elevator.

The 1882 sketch of the mill and the surrounding area show that the mill had a door in the center of the east wall at the first and second floor levels, but that the third-floor and attic-level doors and the hoist were not yet in place. Inspection of the brickwork around the second and third-floor doors confirms that the former was built as a door, but the latter was probably a window, as the bricks below sill level are fragmentary and show clear evidence of having been cut. It seems very possible that the openings in the upper

1882 Sketch and detail showing "Mr. Dodd" at the door of the mill. The sketch shows the mill as it appeared before the changes associated with the conversion to the gradual reduction process. There is no reason to think the generally accurate drawing has incorrectly showed the door and window locations, although the artist has misrepresented the number of lights in the windows. Even the S-plates are visible, showing that the sketch was probably executed on site [WF].


Waterford Mill, c. 1900. Shows the new west wing of c 1886 [WF].

stories were cut in the mid-1880s to facilitate the introduction of material or equipment to the upper floors. While exterior pulley houses or hoistways like this can be seen on many mills, manual transport of flour and grain between floors was not required by either Oliver Evans or gradual reduction milling. This does not account for the wider boards of the (reconstructed) door in the third-floor opening, visible in mst mid-twentieth-century photographs, which make it seem the oldest of the doors on the east front. Perhaps it was recycled from elsewhere.

The new wing was traditionally built and closely resembled the older mill. An historic photo (seen to the left) shows it and the hyphen with a similar stone foundation and similar nine-over-six windows, arranged in the main west wing in three bays (only on the first floor) and a plain gable roof. It was separated by the narrow hyphen that contained the receiving room and grain elevators. It extended up though all the floors and blocked only the north set of west windows in the old mill. The framed structure was sheathed with brick-patterned sheet metal, which appears to have been painted to match the main building. A central monitor with windows on the north and south sides lined to top of the roof ridge and provided ventilation as well as light to the interior. The wood shingle roof on the old building may have been replaced with corrugated metal at this time to match the new building. The photograph to the left was taken before the new steam engine was added in 1903 and a new sheet metal forebay and cylindrical flume replaced the older wooden flume in about 1910 [Sale Notice 1914, WF]. The mill race ended in the surviving concrete dam. This picture shows the older wooden flume and control gate that extended from the end of the head race.

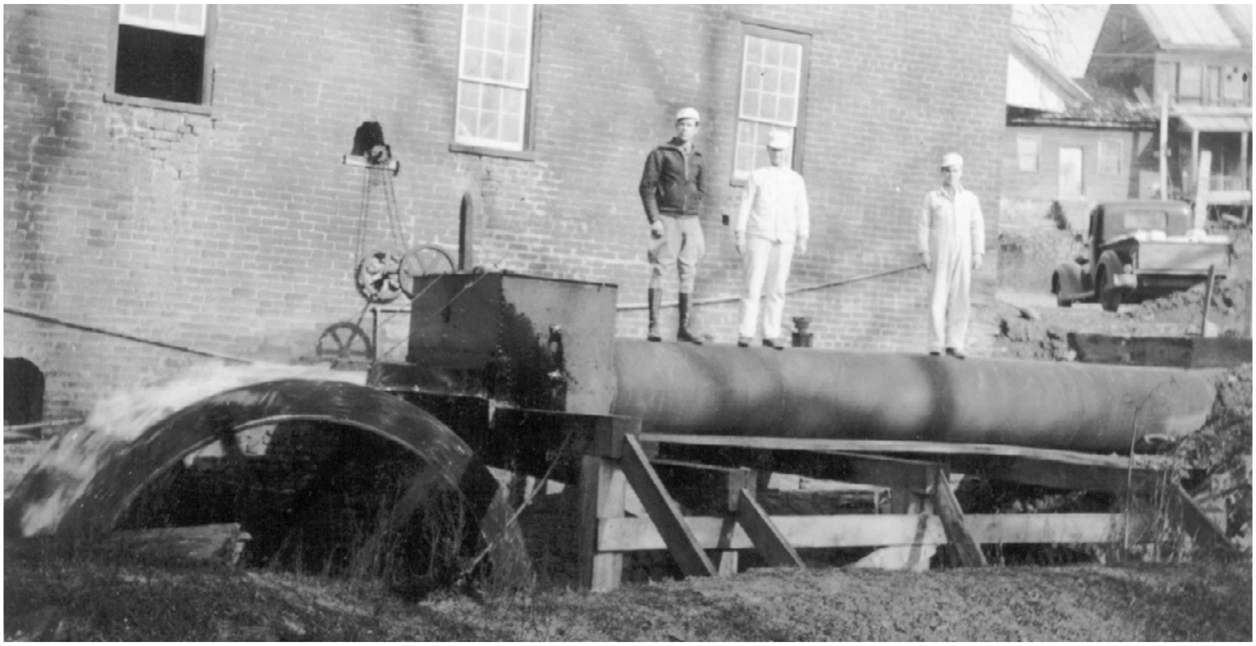
Today, the southern side of the building is seven inches out of plumb at the top, which resulted from moisture-related subsidence. The internal structure has a decided sag as well, apparently caused by subsidence or decay in the wooden posts that supported the internal structure at the basement level. Sloping braces were added to the south row of posts on the first floor. These ran into the basement and were designed to transfer horizontal forces to the front sill of the hurst frame along its north side and to prevent further leaning on the part of the structure above. Chamfered corners and other details indicate that the braces were made by a traditional millwright. They are likely a part of the "thorough repairs" mentioned above that were made in 1883, but it is also possible they were made as part of the repairs in 1856. A series of wrought iron tie rods were also added at each floor level just behind the west wall. Instead of the wrought iron S-plates on the exterior, they have beveled wood blocking to spread the pressure to a larger area of wall. They are equipped with iron keys that permit tightening. These appear in the exterior photo above dating from about 1900.

The 1886 article quoted above indicates that "a new shaft was purchased for his overshot wheel." This wheel had likely replaced the older breast wheel (as construed by Derek Ogden from the shape of the hurst frame), which would have involved replacing the entire power train. This wheel, probably the

Above: Waterford Mill. East end. Postcard, early 20th century. Shows the stable beyond the mill and the cantilevered canopy over the receiving room in the hyphen between the mill and the west wing. Note the stone bollard still present at the northeast corner of the mill [WF].

Right: Bates' Mill, Waterford, c 1903. Shows added steam plant along the south side of the west wing. The clerestory is not visible in the earlier view, but is likely an original feature of the west wing. The similarity in tone of the walls suggests that the west wing, clad with metal sheets stamped to resemble brick, was also painted to match the brick of the main building, giving the entire complex a cohesive appearance. The millrace is shown depleted of water, with the water level probably below the top of the water wheel. The wall can be seen at the end of the mill race and the metal flume beyond [WF].

current metal wheel manufactured by the Fitz Water Wheel Company, may have been installed in 1883 as part of the initial renovation. It appears to have been installed more than four feet lower than the high wooden breast wheel that Derek Ogden postulates was original to the mill. It appears from evidence in the mill and from the text of the sale notice in 1914 (see below) that the mill interior was adapted in 1885 for the gradual reduction process by the addition of five roller stands near the center of the mill. The wooden gearing that powered the mill equipment was probably replaced by a new metal power drive at the same time. A large new arch with a brick surround appears to have been added below the bottom of the hurst frame to permit entry of the new metal water wheel shaft. It is not clear when the south dormer was added. Its physical form suggests a date well after the Civil War. It is likely that it was needed to provide extra light to some new equipment located just inside.



Waterford Mill, with Albert White and millers in 1937, showing the metal pipe and control gate in detail [WF]. It does not appear that at this time there was a turbine attached at any point to the pipe.

Waterford Mill, spillway from head race, 1920 [WF].

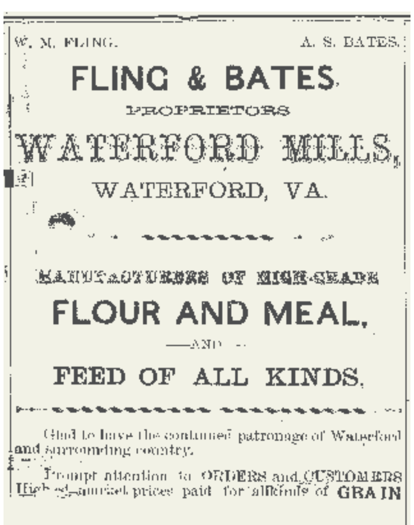
Mill in 1937 showing control gate, mill wheel, and wheel pit in operation. The controls against the south wall of the mill are for a governor (just out of sight) that regulated the speed of the wheel, necessary with the gradual reduction process, unlike more traditional systems. The foreground at the bottom of the image seems to confirm the existence of a stone wall along the south side of the wheel pit on or beside which the photographer would have been standing. [WF].

The hurst frame remained in use supporting, according to documents, two small (36″) sets of millstones [Sale notice, 1914, WF]. The single set of late-nineteenth-century stones that survive at the east end of the hurst frame probably were one of the two pairs listed in the 1914 notice. A painted inscription on the bottom of the bedstone shows that they were imported by B. F. Starr & Company of Baltimore, Maryland, active in the late nineteenth century. The company advertised their "Baltimore French Burr Mill Stone Manufactory and Mill Furnishing Establishment" in 1873. According to researcher Charles Hockensmith, B. F. Starr sold French buhr millstones, as well as Esopus, Cocalico, and Cologone millstones [Hockensmith 2009, 91]. The millstone assembly was shifted south to this location from the center of the frame, possibly to make room for the power train serving an added turbine (see below) and retained afterwards to satisfy local demands for stone-ground corn meal. According to Derek Ogden, stones this small were not used in merchant flour production and were usually maintained to prepare grain for milling. They have since lost their curb and casing (enclosure). The runner stone was turned by a surviving iron millstone spindle abandoned and lying in the gear pit below.

Fling and Bates, 1889–1916

In 1889, A.S. Bates acquired the mill. He took W. S. Fling as a partner at a later date. He briefly left the mill proprietorship. In 1901, The Leesburg Record announced that "Our enterprising miller, Mr. A.S. Bates, is erecting a new pair of wagon scales and also building a new ware house in which to store flour, &c" [Waterford Waifs column, The Record, Leesburg, VA, 15 November 1901, WF]. In 1903, W. M. Fling joined Bates as a proprietor of the "Waterford Mills," where they manufactured "high-grade flour and meal and feed of all kinds" [July 3, 1903, advertisement, The Record, Leesburg, WF]. Records of the mill in the collection of the Waterford Foundation show that, in the month of January, 1901, Bates sold $840 worth of products derived from wheat, including 167 barrels of flour, valued at $587, and $472 worth of corn-based meal and its by-products, including meal sold for $445 [Accounts of A.S. Bates & Co., Proprietors of Waterford Mills, January, 1901, WF].

On June 28, a "fearful cloud-burst" created a flood on Catoctin Creek that washed away several outbuildings. A second storm in August caused the water to rise above the mill's basement floor [June 28, 1903 and August 14, 1903, The Record, Leesburg, WF]. The unreliability of water power, particularly after



Above: Detail from c 1945 photo of the mill shortly after acquisition by the Waterford Foundation. The metal flume, the top of the wheel, and the concrete dam at the end of the mill race as it was built by A.S. Bates can all be seen [WF].

Left: 1903 advertisement for the Waterford Mill from Leesburg's *The Record* [WF].

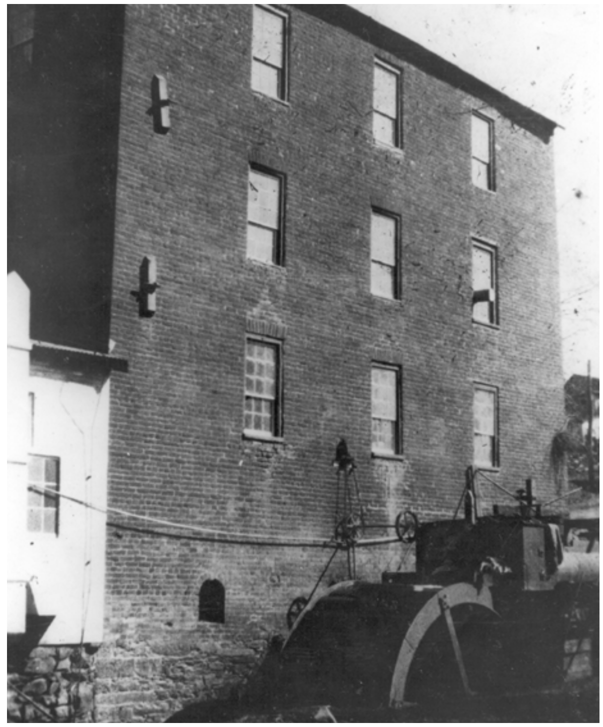
extensive damage to the mill race during the storms of 1903, caused Fling and Bates to buy a steam engine to power the mill in emergencies. They took delivery in December and had the steam engine at work by the middle of January, 1904 [Dec. 11, 1903 and January 15, 1904, The Record, Leesburg, WF].

The milling industry and its profitability changed much as the nineteenth century drew to a close. The development of vast wheat lands in the Midwest, improved long-distance rail transportation, and industrial milling operations at growing cities like Minneapolis resulted in a stagnation of merchant milling in small localities in the East. Most mills declined and returned to use as grist and feed mills. William Fling was forced to borrow against the mill in 1910 and in 1914. Eventually the mill was put up for sale due to a default on the payments. At this time the mill had a fourteen-foot fall of water, a 23-inch Leffel turbine wheel, an overshot wheel, a new flume, and a steam plant for emergencies. The Leffel turbine was a very different kind of enclosed water wheel that produced greater power than a conventional wheel. The description of the mill is very complete. It indicated that a new water wheel might be needed to put it all "in first-class running order in every respect."

> *Its daily capacity is given as 40 barrels of flour and 400 bushels of meal. It has five double stand rolls, 2 36-in Buhrs on meal, Allis bolter, Allis purifier, two mill reels, provided with all necessary elevators and wheat receiving separator, with 40-bushel Hopper scales, corn sheller, 200 bushels capacity, which can be driven either by the engine or overshot or turbine water-wheel, and all other necessary machinery for a complete operating mill. Attached to this mill is a fine metal-clad elevator of 12,000 bushels capacity, wherein is afforded room for storage of 500 barrels of flour.*
>
> *On said lot is a good-sized barn, with stable room for eight head of horses and three cows, wagon house, large hay mow, and the like, and within a few feet of the mill door, is a pair of Fairbanks cattle scales, in good condition, in a well metal covered building, with*

Waterford Mill, c. 1900. Shows the new west wing of c 1886 and a wooden flume and control gate as well as the wood plate at the end of the lowest of the iron tie rods at the west end [WF].

South side of the mill, probably 1930s. The chute appears to be for impurities removed from the grain and the shed addition probably housed the diesel engine [WF].



Waterford Mill, 1930s, Showing South wall and Fitz wheel with sheet metal headstock and conduit along with controls of the governor that maintained the regular speed required for the roller milling process [WF].

> *a ware house on one side, and a 75-bbl. corn crib on the other side of the building, with a well-built cattle pen, all well arranged and most convenient of general access.*

The nine-room brick house now known as Mill End and stone tenant house were included in the sale [Sale notice, 1914, WF]. The scale house (now known as the Weigh Station) survives today across the road from the mill. A cantilevered shed roof over the mill's east door was probably added in the early years of the twentieth century.

It appears from evidence in the mill and from the text of the sale notice that when the mill had been adapted in 1885 for the gradual reduction process, it included five roller mills near the center of the building. The wooden gears were probably replaced by a new metal power drive. At some point in the early twentieth century, three massive tapered concrete piers aligned with the mill wheel were added below the roller stands to carry the drive from the gear pit.

The Scale House that originally contained the scales mentioned in the 1914 announcement still stands today across the street from the mill.

This painting by Garnet Jex shows the west wing and the landscape in 1941 [WF].

East front of the Waterford Mill, probably 1930s. Shows an added cantilevered canopy covering the mill's main door for loading of flour, dating from the early twentieth century [WF].

The photograph on page 26 showing the mill about 1900 was taken before the new steam engine was added in 1903. The wooden flume was still in place. A new sheet metal control gate and metal cylindrical pipe replaced the older wooden flume in about 1910 [Sale Notice 1914, WF]. The headrace ended in the concrete dam that survives today. The metal pipe (part of which survives) extended from the side of the concrete dam to the headstock.

Although a turbine was mentioned as a possibility in an 1886 article, there is no direct evidence that it was acquired at that time. The Leffel turbine mentioned in the 1914 sale notice was likely acquired around 1910, since it would likely have required the use of the enclosed pipe added at that time. Although more efficient, the turbine would have used a great deal of water and was probably placed in tandem with the wheel to be used as needed. Its location has caused a good deal of speculation. It appears most likely that it was placed at the bottom of the millrace to the east of the Fitz wheel and its vertical drive shaft would have transmitted power to a horizontal shaft that entered through the south wall. It would have been placed below the headstock and behind the conventional wheel and thus would not have been visible in any of the historic photographs. However, the 1937 photo on page 24 of the mill wheel turning does not show any pipe descending to a turbine. It may have already been disconnected.

W. E. Mays, 1916–1922

William E. Mays acquired the mill in 1916. He operated it until 1922. Not much was uncovered related to his occupancy.

William S. Smoot and William S. Smoot, Jr., 1922–1938

The mill was purchased in 1922 by William S. Smoot. He operated it from 1922 until he died in 1936. A diesel engine was added for back-up power, probably by Smoot. The steam plant and the one-story lean-to that contained it along the south side of the west wing were removed. A photograph from the period shows a small one-story shed extending south from the hyphen that probably housed the diesel plant. While the deflection of the original building to the south dated from much earlier in the building's history, it was probably during this period of decreased prosperity that increased sagging of the frame began, resulting from the decay of the feet of the six wood posts in the basement.

When Smoot died, local preservationist and investor Edward Chamberlin took over operation of the mill, dismayed that the tradition of milling in Waterford might die out, but found it impossible to continue past 1937. Then William S. Smoot, Jr. tried his hand at it for another year, after which the mill was closed permanently.

III. Building Alterations

Overview

As detailed above, the mill appears to have been extensively repaired over many decades in the nineteenth century. Subsidence along the south side and the constant shaking caused by mill gearing and equipment had threatened the building's structural stability on more than one occasion. The entire east end and a short section of the south wall were completely rebuilt in the third quarter of the nineteenth century. The formerly brick east gable was rebuilt in weatherboard-covered framed lumber. Changes on the interior resulted from replacement of equipment relating to changes in milling and power-generating technologies. Iron S-shaped government anchors were likely installed at

Waterford Mill soon after acquisition by Waterford Foundation in 1944 and after the west wing had been demolished. The corrugated metal roof appears loosely attached [WF].

Waterford Mill, c. 1952. This shows the east wall after the canopy had been removed around the front door and the brick around door had been replaced. These bricks were replaced again and the sign above the door removed in 1983–4. The white-painted wooden screens were added to enhance ventilation of the building during regular use as a craft center [WF].

the same time on the east and west facades. Additional reinforcing rods and wooden [cushions] were probably installed in the later nineteenth century near the west end. Angled timbers were added on the interior to prevent deflection of the structural frame to the south by bracing the second-floor framing against the inner sill of the hurst frame, probably in the post-Civil War era. The many penetrations of the floors on each level had caused the flooring to be unsafe for use by the general public. Late nineteenth-century additions at the west end of the building, designed to serve a high volume industry, were removed, leaving only the stone foundation to serve as a terrace on the west end.

Since it was purchased by the Waterford Foundation in 1944, the mill has been the subject of at least four, mostly piecemeal, architectural and structural interventions. At no time has the building's condition been holistically examined or its defects fully addressed. It is likely that much of the damage now visible, including the pronounced sag in the interior structure and the near loss of the hurst frame, occurred after the mill closed.

Waterford Foundation Ownership

First Interventions, 1944 and later

The historic structure was acquired by the Waterford Foundation, which had been founded in 1943, in part, to take charge of the building. The western additions were demolished. The milling equipment was removed soon after and donated to the war efforts. Perhaps because it was not the original equipment, the foundation clearly felt that making space available for general use in the mill building was of greater importance than preserving the artifacts of late nineteenth-century milling technology. In spite of difficulty of acquiring building materials, the mill opened as a center for exhibiting and reviving the production of traditional handicrafts. An annual exhibition and a summer tea-room were housed there beginning in 1946, as were classes in crafts for several years. While reviving the building as a grain mill was considered by some members of the Foundation, there was never sufficient funding to make it possible, and as time passed, loss of essential elements, including the water supply, made full restoration less and less feasible.

By the mid-1940s the west additions had been removed. The stone foundation of the addition was preserved and capped with a temporary roof, and upgraded into a deck with a railing by early 1948. The west wall was repointed and former doors in the first and third floors of the north bay of each floor were returned to form as windows. Although the window sashes were replaced, there is no evidence that any intact window or door frames were altered, except the sills, which were replaced with concrete. Contemporary photographs show that the doors in the east end were preserved on each floor.

First on the agenda for the building were repairs to the exterior to make the building presentable and usable. The canopy over the east entry was removed, although the white paint surrounding the door remained. The brick around the first floor door must have been in very poor condition, because sections on either side were removed and new brick patched in.

In 1948, the board was informed of the potential collapse of the mill due to subsidence of the foundation along the south wall into the tail race. Reports submitted by structural professionals allayed the fears of immediate collapse, although the south wall was said to be six inches out of plumb at the

Above: Waterford Mill, c 1948. Shows wood platform installed over stone foundation of the west wing, which has been removed, leaving clear difference in brick color on the west wall [WF]

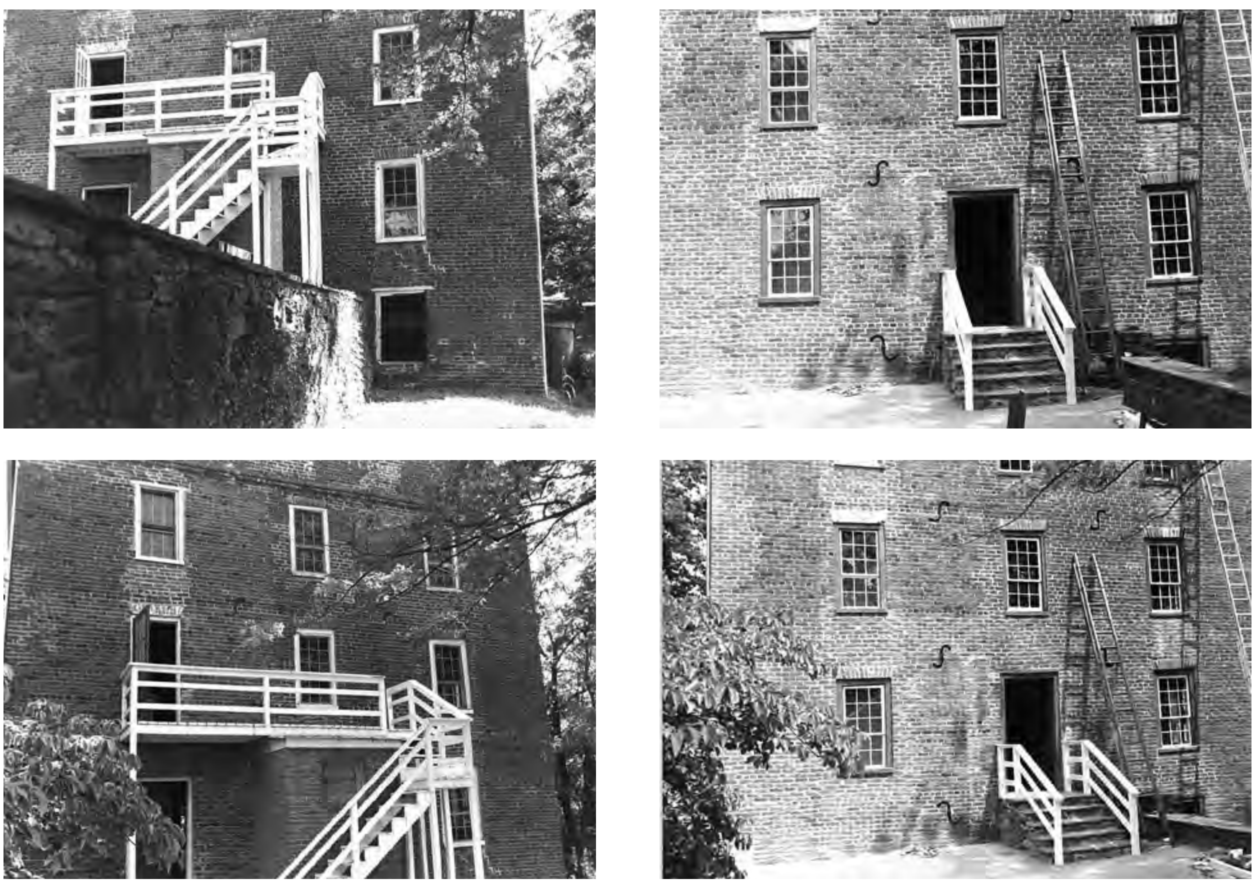
Right: Waterford Mill, west end, 1968. Shows the completed west terrace, fire stair, and small brick toilet room under the stair [WF].

Below: Tail race in 1968 [WF slide collection]

top. Three tie rods were installed at the top of the side walls to check any further tilting of the south wall. They originated in a three-foot-long steel angle above the central window. The central tie rod ran to a point directly opposite on the north side. Two more rods ran diagonally from the central angle to points over each of the other two windows on the north side. In addition, the third floor ceiling joists were tied to the brick wall below by the use of iron straps in four locations along the north side.

Although no additional movement had been detected over a period of months, the board decided to fill in the mill race to remove the source of stagnant water thought to be causing subsidence. The head and tail races were infilled, eliminating stagnant water but burying the mill wheel nearly to its top. Immediately the mill basement filled with water, thought to be from a spring. Drains were installed in the former tail race and the water subsided, although the basement remained damp.

The floorboards in the first story were replaced, but the board, "conscious of the need to preserve all they could," was careful to leave the only remaining set of millstones in place, "even if it interfered with laying the new floor or access to the staircase." A new brick hearth was laid, probably at the same time, in front of the fireplace and a plain shelf mantel on brackets was added. Complaints about "weak" first-floor flooring in 1945 suggest that the top of the hurst frame, bridged over with circular-sawn joists at an earlier date, was a source of potential trouble. The hurst frame appears to have been clumsily incorporated into the first floor structure well before this time.



Documentary Photos from 1984 show the appearance of the west wall before and after the restoration [WF].

During the 1950s, a wood fire stair was constructed to serve as an emergency exit from the second floor. It rose against and ran above a small brick toilet room that was accessed by means of the historic west door of the mill. The west foundation was converted into a terrace with a stone-paved concrete slab floor, probably at the same time, since it can be seen in a 1968 photo coexisting with the fire stair. A new stone stair was added at the northwest corner of the mill to get from grade level to the terrace. In 1975, the Waterford Foundation gave an easement on the structure to the National Trust for Historic Preservation to ensure its long-term preservation.

New basement vent in center of north wall.

Second Intervention, 1984

The second major intervention was in the early 1980s, when the mill received several extensive repairs overseen by the Ehrenkrantz Group, a major architectural firm with an office in Washington, DC. Mary Oerlein served as project architect, W. Brown Morton was employed to prepare complete existing plans, elevations and sections of the mill, and Neal FitzSimons, a civil engineer in Kensington, Maryland was contracted for structural advice. Triangular crack gauges, three leveling stations, and three tension wire gauges were placed to monitor any structural movement. Structural remediation was carried out to improve the building's long-term stability and usefulness, but did not resolve problems of dampness, standing water, and structural decay.

Exterior and Interior work performed in 1984 [WF].

The project was funded by a grant from the Endangered Properties Fund of the National Trust for Historic Preservation through the Jessie Ball

Removing portland cement repairs, south wall, April 1984 [WF slide collection]

Third-floor jack arch under repair, March 1984 [WF slide collection]

East entry door brick during repair, April 1984 [WF slide collection]

Northeast corner during and after repair, March 1984 [WF slide collection]

Above: Roof framing with rafters, collars and purlins on stud posts.

Left: West end with scaffolding, March 1984 [WF slide collection]

DuPont Religious, Charitable, and Educational Fund, a grant from the Virginia Historic Landmarks Commission, and contributions raised in the community by the Waterford Foundation. The contractor was Leeds Construction Company of Warrenton, Virginia. The project cost a little more than $100,000.

Exterior work performed in 1983–4 included extensive and much-needed tuckpointing. Interior repairs included wholesale replacement of the wooden support posts in the basement with eighteen new brick piers and repair to damaged joists, bolster, blocking, and flooring throughout the building. The floors were leveled and blocking inserted in the joists throughout. Two brick piers were also added along the southern top beam of the hurst frame to support it and the floor joists it carries. Repair also extended to replacement of some posts on the upper floors, including several on the second floor and the addition of a center post on the north side of the third floor. Additionally, public safety issues were addressed by the provision of a second, enclosed set of stairs in the northwest corner connecting the first, second, and third floors. A small toilet room was provided that projected out from the west wall under the stairs. Longitudinal purlin plates supported by posts were added in the attic to support the roof structure.

The exterior fire stair was removed. The frames and sashes of the windows in the north bay of the west wall, added in the 1940s, were replaced to more closely match those in the rest of the building. The central door and frame on the first floor of the west end was replaced and a new wood stair, with a "hand-planed" finish, was added at the west door. Brick repair is detailed in the architectural drawings for the restoration prepared in 1983 [Ehrenkrantz Group. Architectural drawings, Waterford Mill, 1983]. It included repointing large areas: two thirds of the west end, half of the east end, the lower third of the south wall, the chimney, and the entire north wall. A new wood window frame was added in the central basement vent at the bottom of the north wall. The only access to the basement was through an original window opening at the south end of the west wall, closed with a modern batten door.

Left: Flood in March of 1984 [WF slide collection]

Third Intervention, 1997–1998

The third campaign of repairs was undertaken in 1997, in order to provide support for a set of roller milling equipment. Not only structural engineers, but experienced millwrights as well, were called in to solve the problem of the slowly deteriorating hurst frame. A desire to better interpret the building to visitors had led to an interest in acquiring milling equipment for placement in the building. With the cooperation of the National Trust, Neal FitzSimons was recalled to the mill and asked to evaluate the previously installed but later ignored structural gauges. Correspondence seems to indicate that he found no dangerous level of movement after examining the basement level settlement marks. He proposed and it appears was hired to reestablish and augment the earlier monitoring points and analyze the data [Neal FitzSimons, 1997-98, WF].

Structural Concepts, of Winchester, Virginia, was asked to provide recommendations for repair of the building in conjunction with Derek Ogden, a millwright and expert in historic mill construction who had been recommended by the managers of the Colvin Run Mill in Fairfax County. In the basement level the engineers noted brick and metal piers from 1983–4, more than a foot of stagnant water in the former gear pit, and the compromised hurst frame as well as the temporary wood posts and pipe columns scattered around for added support. They issued a preliminary report on 6 January 1997 and supplementary observations on 18 March 1997 [Structural Concepts, 1997, WF].

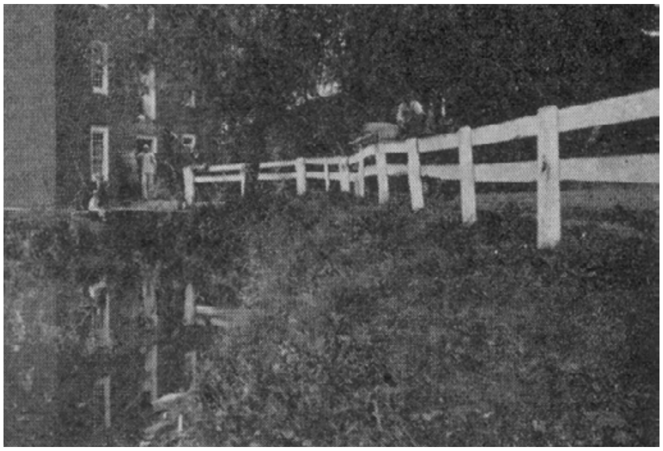
The firm analyzed the loading capacity of the mill's floor for use during the Fall Fair. They indicated that the capacity of the floors was almost but not quite sufficient for a live load of 75–100 psf. On the upper floors they found that the north and south walls were out of plumb, and that although the building had formerly shifted to the south, examination of a crack at the northeast corner indicated that the building had not moved since the crack was repointed. The shifting was possibly caused by settlement into the water infiltration along the south wall. The firm recommended removal of all loose debris and timber from the basement and that the building be monitored until it can be determined that it was not shifting.

Structural Concepts also recommended a more thorough structural analysis and indicated that geotechnical investigations should be undertaken to determine the makeup of soils and nature of the groundwater, and to explore the possibility of underpinning and dewatering if the previous studies show that subsidence is an ongoing problem. The firm also advocated closing the archways on the south wall and regrading the land there to direct water away from the building, and possibly installing sump pumps on the interior. Later, they modified these comments based on recommendations of mill expert Derek Ogden, who suggested that the gear pit should properly be drained by outlets at the bottom of the pit, which would require a lowering of the level of the water in the tail race closer to that of the nearby creek, in which case the other changes would be unnecessary. Ogden additionally recommended removing several feet of soil and debris from the floor of the gear pit (the southern third of the basement) to permit it to drain. He felt strongly that without excavation of both the tail race and the gear pit, the mill would continue to have moisture problems.

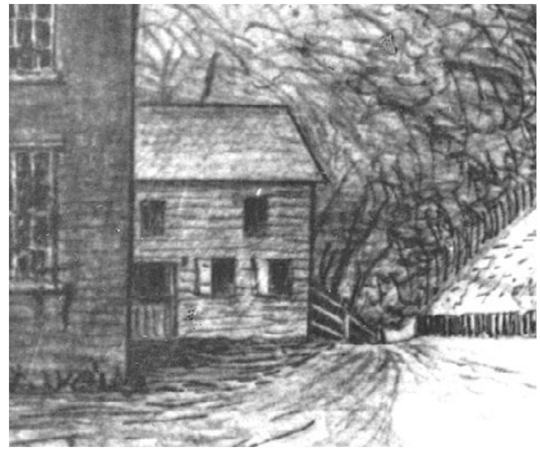
Repairs were made in 1998 to the site and basement area based on the recommendations made in early 1997 [Structural Concepts, 6 January 1997, WF]. These repairs included cleaning out material from the basement and excavation of the tail race, which was intended to improve drainage of standing water in the basement. It also resulted in damage to a part of the stone wall defining the south side of the wheel pit, according to Neal FitzSimons, who visited on 25 March 1998 [FitzSimons, 25 March 1998]. The gear pit was not, however, excavated according to Derek Ogden's recommendations, although drains were observed about five to six feet below the water wheel shaft [Gravatt, Waterford Mill Summary, 1998, WF].


Waterford Mill, excavation of mill race, 1998 [WF].

FitzSimons made some recommendations about an interceptor trench along the road side of the mill to reduce water infiltration there, instead of a full waterproofing of the entire wall. Drain tile was installed along the north wall, which, together with the road-side downspouts, discharged into the tail race [Gravatt, Waterford Mill Summary, 1998, WF]. The brick arches on the south wall that were formerly below grade were rebuilt. FitzSimons indicated that the floor structure along the south wall of



Detail of c 1905 postcard of Waterford Mill. Probably the photograph of historic two-board fencing sent to the National Trust in 1998 [WF].



Detail of an 1882 sketch also shows a three-board fence running along the edge of the mill property [WF].

the first floor (replaced c 1945) was carried by the hurst frame and not by the foundation. The jerry-built nature of previous repairs was seen as a continuing problem for the structural stability of the first floor.

On the interpretive level, the Waterford Foundation indicated interest in adding some milling equipment for a static mill display. Derek Ogden knew of some available roller mill equipment, if, he said, it could be documented that the mill was adapted for use with roller milling technology. At the same time that Structural Concepts was making its recommendations, the Foundation asked Neal FitzSimons to check their calculations to see if the building would support the milling equipment that Derek Ogden had recommended they acquire. He replied that the building could accommodate the equipment, including the 800 lb. Wolf roller mills if the remedial work that had been proposed in 1983 had been fully carried out. In 1997 the mill equipment was transferred from the Olive Mill in Banco, Virginia to a barn in Waterford.

The turn-of-the-century roller mill equipment and some chutes and elevators were installed in the Waterford Mill in 1998 to give a static impression of the interior of a working mill, based on a series of sketches showing a conjectural, but not specifically accurate, layout of the equipment [Odgen, Derek. Layout of Wolf Roller Mill Equipment, 1997, WF]. This installation began with minimal cleaning and repairing of the attic floor in March, followed by cleaning and bracing the hurst frame and opening the small arches in the south wall of the basement. The "pulley house" at the top of the east gable was repaired and the screening renewed in May. Between May and July all the roller milling equipment was placed in the mill and partly assembled, including cutting a hole in the second floor to permit the packer/bagger to stand upright. Elevators, chutes, elevator heads and boots, and other mill parts were distributed to the various floors where they would be installed. It was expected that the mill would be open to tours and visitors on a regular basis. The installation was never completed, although some holes were cut in the floor and some chutes and elevators were added [Gravatt, Waterford Mill Summary, 1998, WF].

Detail of early 20th century mill and buggy postcard. This shows a three-board fence that is more similar to the fence installed in 1998.

It appears that the reinforcing done in 1984 was not deemed sufficient. The first floor was further reinforced by the addition of beams made of pairs of 2 x 14 boards at the center of each structural bay, supported on lally columns. The beams in the northern and central sections were continuous, while those in the area of the hurst frame were discontinuous, interrupted by members of the hurst frame. The floor structure was given improved rigidity by the installation of cross-bracing between the joists immediately above the new support beams. This was likely done to ensure the necessary structural support for the new milling equipment.

Extensive site work executed in September or October of 1998 included, in addition to the tail race excavation, clearing of shrubs and other vegetation around the mill, replacement of the fencing along the south side of the site, and construction of a pedestrian bridge over the tail race. The Foundation indicated that it wanted cleared lawns around the mill to facilitate its use for functions. The National Trust, in its review of the proposed site work, approved a new board fence that followed the actual property line (the former wire fence took a diagonal path across the property line). Additional board fencing was approved along the edge of the newly deepened tail race for safety purposes. The design of the new fencing and bridge railing was based on two-board fencing visible in an historic photograph, with a third board added to provide more security [letter from George E. Siekkinen, Jr., Senior Architect, National Trust, 1 September 1998, WF and fax showing location of proposed boundary fence, 18 September 1998, WF].

Fourth Intervention, 2007-2009

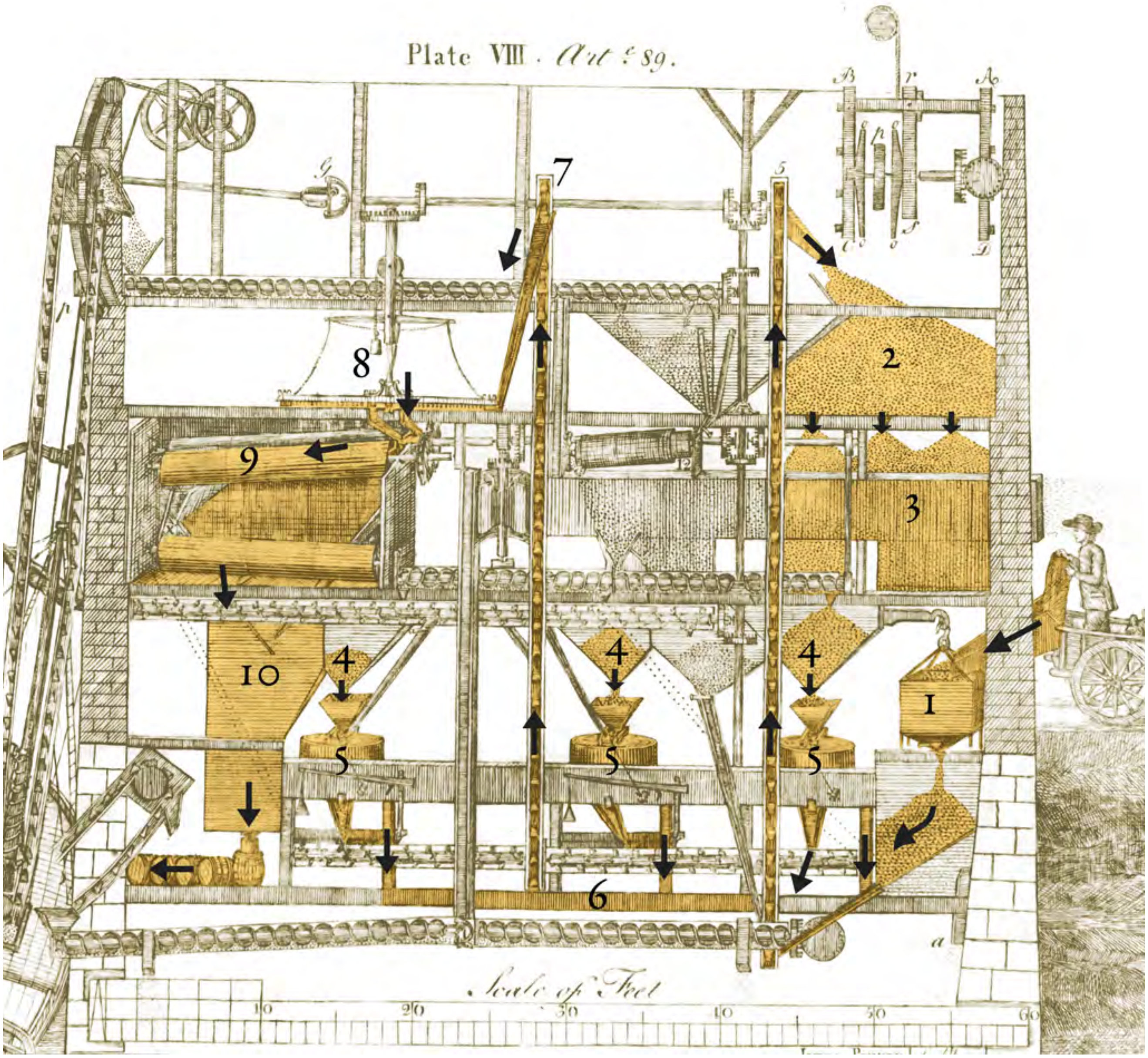
The fourth campaign began in 2004, when William J. Davis, a structural engineer from Richmond, was asked to make further recommendations for improving the appearance and integrity of the mill, probably with a view to opening it as a static mill display. He was asked to correct the structural problem with the connection of the hurst frame and the first floor. He questioned the reason for the addition of the central beams below the first floor. He felt that the tie rods had done their job in stabilizing the structural movement and should not be removed. He felt that the water in the tail race had to be moved along and not allowed to sit, possibly by the use of a pump, and that the retaining wall should be repaired. He recommended an entry to the basement, apparently for the purpose of historic interpretation to members of the public. Foundation members were checking once again on the weight of planned milling equipment and of visitors.

Davis proposed continued use of the hurst frame for support of the first floor, because it would not be needed for mill machinery since the water source was no longer available. He recommended addition of a "dummy joint" in the floor to represent the separation of the hurst frame from the rest of the floor. Davis noted that the two main beams supporting the first floor had failed and were temporarily supported. They should be reinforced and supported on new piers. He also advocated "righting" the leaning columns in the first floor and raising the lowered column and beam on the south side of the second floor. Finally he advocated supporting the wheel axle on the south side of the race so that it would appear ready to operate, but leaving the rust in place. The new basement entry was created under the west terrace slab in 2009 and the former opening at the south end of the west wall was provided with a sash window. Two brick supporting piers were installed under the south side of the hurst frame as he recommended, but the first-floor flooring and other structural elements remain as they were. The electrical system was entirely replaced in 2007 in order to meet the concerns of building officials before the opening of that year's Waterford Fair.

IV. Mill Operation

A. Oliver Evans Merchant Mill

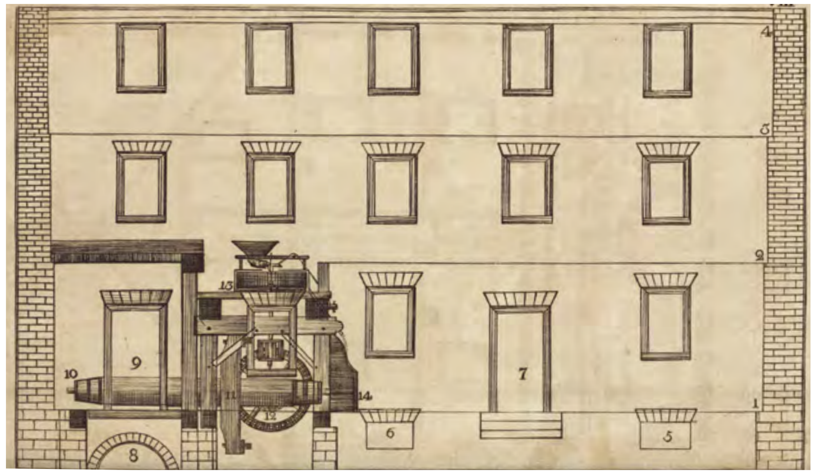
How did Waterford Mill work in the beginning?



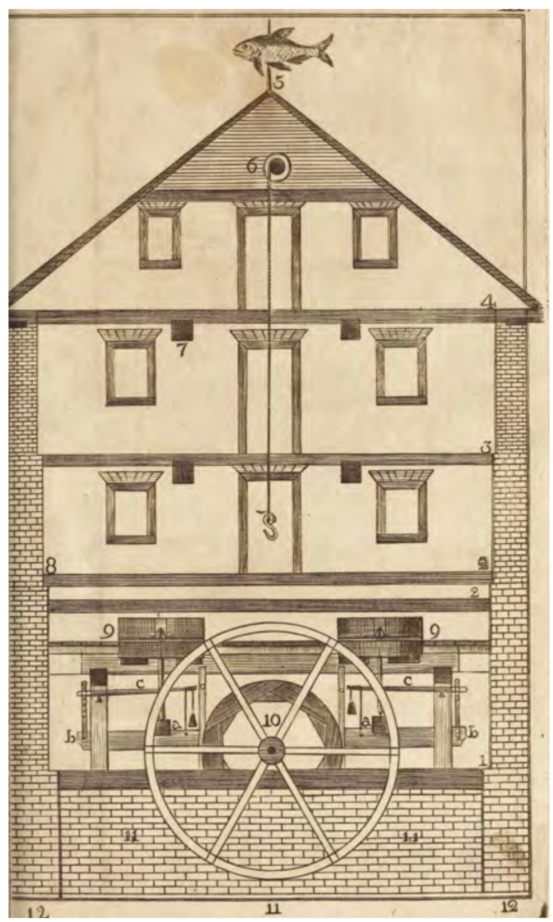
Section through typical merchant mill from Oliver Evans, The Young Mill-wright and Millers' Guide (1795). The illustration has been altered to show the steps involved in the milling process. These numbers relate to the text on the following pages.

The Automated Mill

The Waterford Mill was an automated mill based on the innovative material handling technology promoted by Oliver Evans in the late eighteenth century. Although the many alterations undergone by the mill have made it hard to track its internal workings, much can be gleaned and more remains to be understood from inspection of parts of the building now covered by furniture and modern flooring. While the pattern at Waterford may have been somewhat different in particulars, the basic movement of grain through the mill can be described simply and those parts of this building that fit the Oliver Evans pattern can be related.



Above: Hurst frame end elevation. Below: Hurst frame side elevation [Oliver Evans, The Young Mill-wright and Millers' Guide (1795)]



1. Wheat was placed in a receiving hopper, probably near the front door on the east. It was likely taken down in a chute to the basement where it entered an elevator made of buckets attached to a continuous belt and enclosed in a wooden case. No trace of a receiving hopper could be found. It was probably replaced in the late nineteenth century by a new one in the hyphen between the present building and the new west wing. The elevator was probably directly inside the east door, below a wheel still in place on the power shaft in the attic ceiling.

2. After passing through a double mesh rolling screen that filters out foreign matter, the wheat may have been stored in bins on the second floor. These bins are no longer present as they would have been superseded by larger bins in the west wing.

3. Wheat is placed in a fanning mill or smutter that removes attached dirt and mold. No trace was seen of any early machines like a fanning mill.

4. From storage bins directly above the stones, the grain fell into hoppers that were located near the eye of the upper, runner stone. A device called a shoe, which is oscillated by an element known as a damsel, regulated the flow of grain into the eye of the runner millstone. It seems unlikely that any of the three historic sets of stones survived in place at the time the mill was cleared of its contents in the early 1940s. In 1948, the board carefully preserved the only remaining set of millstones in place and it seems unlikely that they would have removed any other stones when they disposed of the more modern equipment. Physical evidence shows that the remaining small set of stones were placed in their current location in the late nineteenth or early twentieth century and were attached to the contemporary iron power drive by a surviving millstone spindle lying in the gear pit. They may have been provided for making the much-desired stone-ground cornmeal for locals and outside visitors.

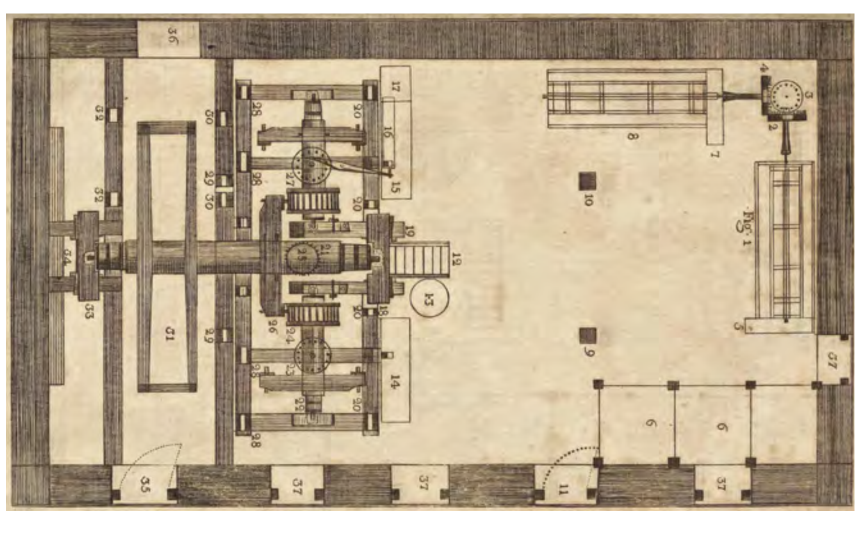
5. The grain was reduced and ground by the stones that rotated at about 125 revolutions per minute.

6. The warm, moist wheatmeal fell through a chute into the basement where it was transferred to elevators that would carry it to the attic. The location of this elevator has not been determined, but it may correspond to one of the wheels on the attic power shaft.

7. The meal, having reached the attic, is transferred to the "hopper boy."

8. The wheatmeal was sifted onto the attic floor where the "hopper boy" cooled and dried it with a circulating rake that slowly moved it to the center, where it dropped through a hole. It is possible to locate the position of the hopper boy at Waterford Mill. Circular grooves in the attic floorboards indicate its position, as the revolving blades often dug deep gouges in the floor over decades of use. The approximately 7-foot diameter device was located on the north side of the attic and was centered about 16 feet from the west end and 6′-6″feet north of the roof ridge. The seven-foot diameter hopper boy flight arm was very small. It is likely that the hopper boy here was an illegal appropriation of Oliver Evans' invention. By 1819, Evans was dead and his patent had expired.

9. The flour was moved horizontally into the top end of a sloping, revolving cylinder covered with cloth screen of decreasing fineness, removing the flour at first, the middlings at the center and bran or tailings at the end.

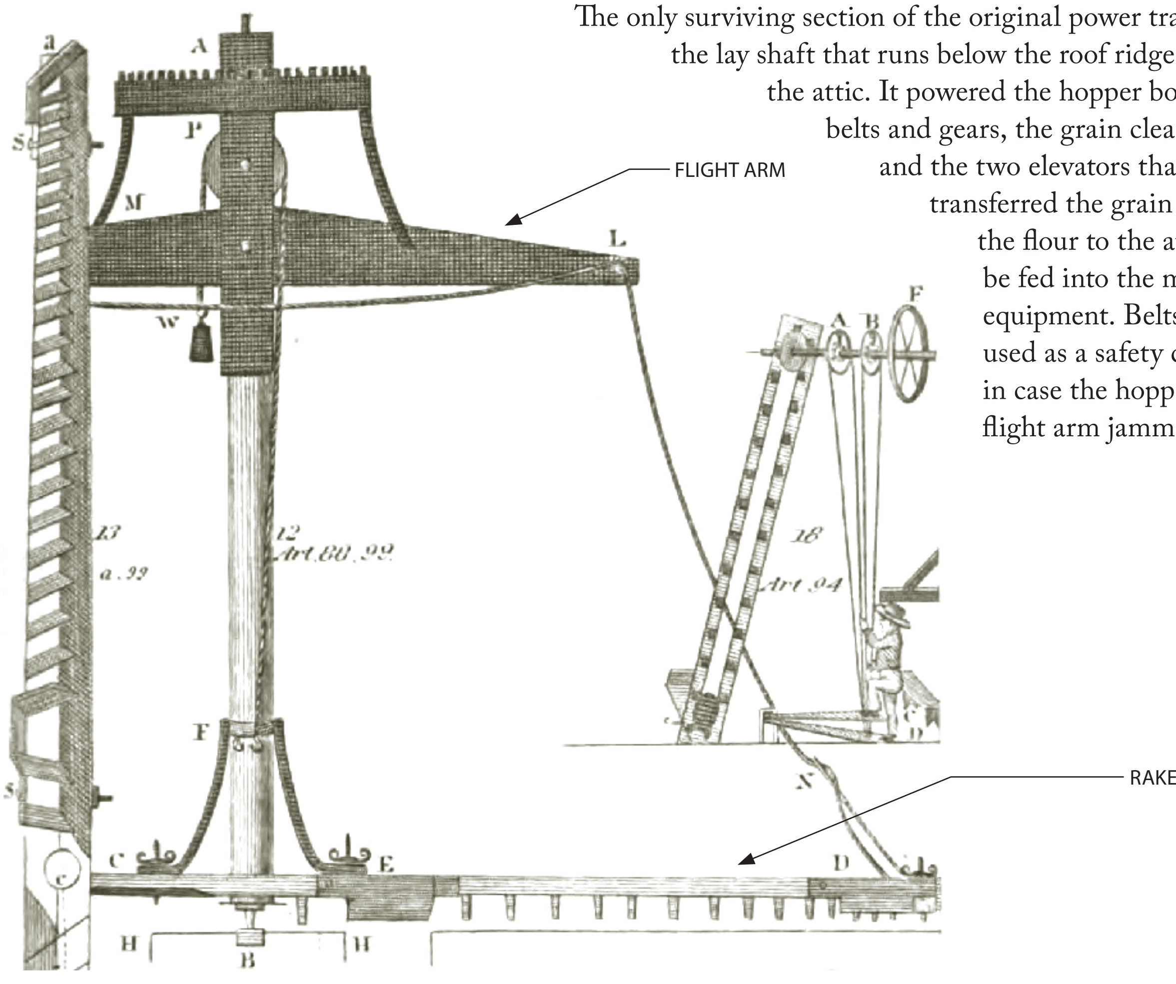


Hurst frame plan view with water wheel on the interior [Oliver Evans, The Young Mill-wright and Millers' Guide (1795)]

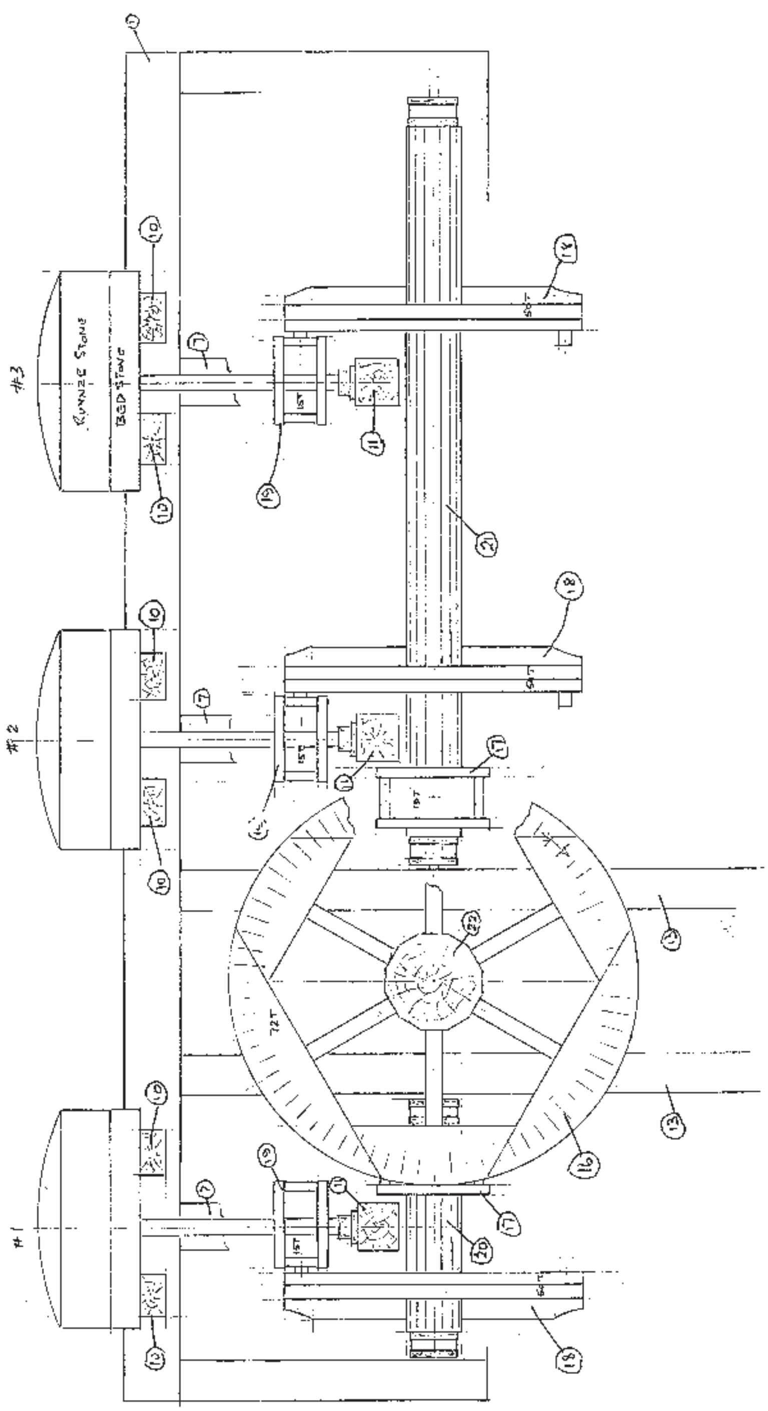
10. The different grades were separated, placed in holding bins, and eventually loaded into barrels using a barrel packer. None of the augers, chutes, or bins survives from the early period of the mill and it has proved difficult to trace their precise location due to added floors, furniture and many alterations.

11. The Waterford Mill was probably powered by a wooden breast wheel. The shaft connected to the water wheel entered the mill through a small opening in the south wall above the western archway. It rested in a gudgeon or bearing and turned a large master cog wheel or pit gear just inside, equipped with wooden teeth. Smaller horizontal countershafts extended to the east (long countershaft) and west (short countershaft) to transfer power to the three millstones. Smaller gears called wallowers on the end of each countershaft engaged with the teeth on the master cog wheel. Little cog wheels below each set of stones transferred power to the stones by means of a lantern gear called a stone nut placed at the bottom of each vertical spindle. At the same time an auxiliary drive gear at the bottom of a long vertical auxiliary drive shaft also engaged with the teeth on the pit gear. The auxiliary shaft extended from the basement to the attic and transferred power to equipment throughout the mill. Because it was smaller it increased the rotation of the vertical main shaft from the speed of the millwheel axle. Throughout the mill gearing was used to control the speed of the power train.

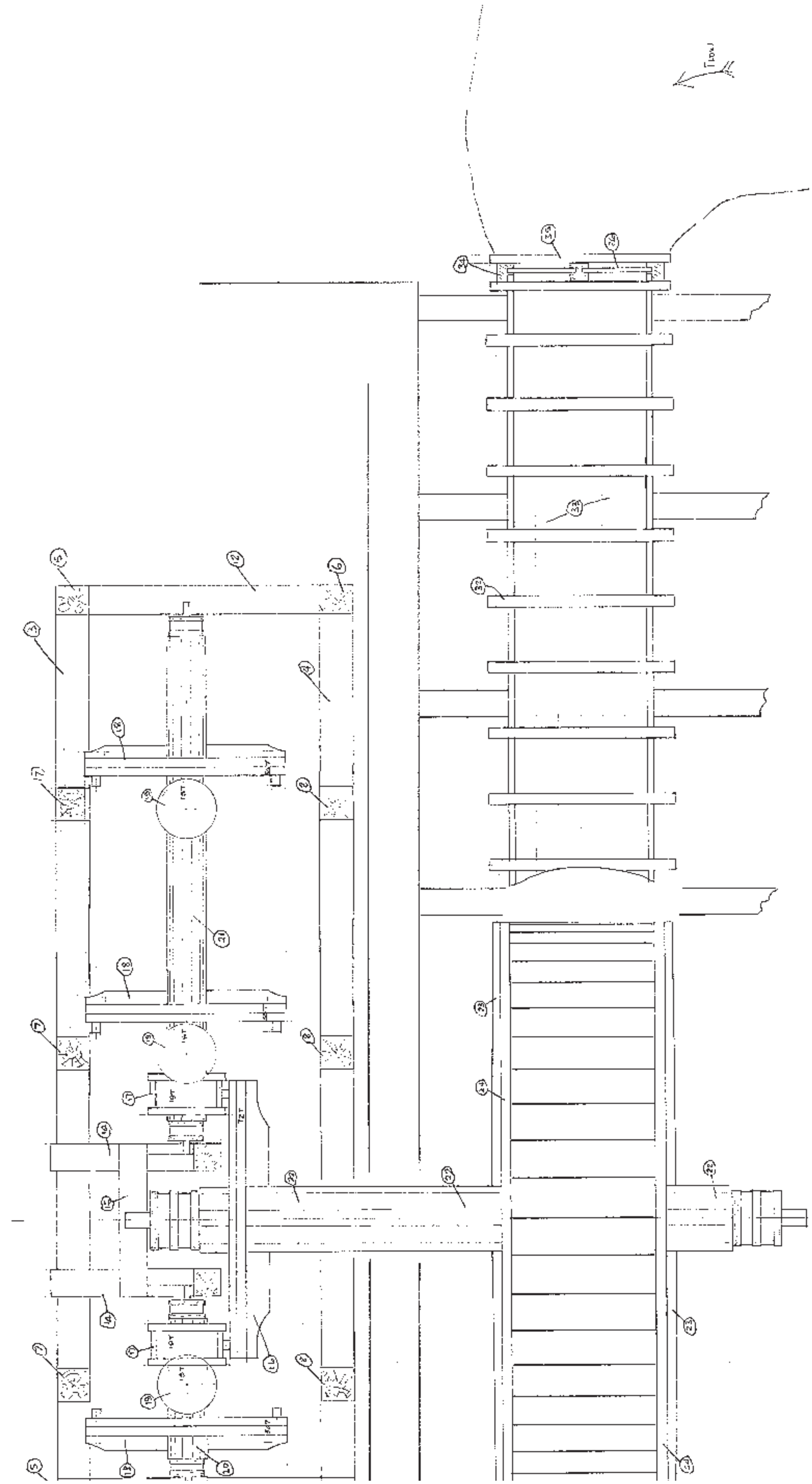
The only surviving section of the original power train is the lay shaft that runs below the roof ridge in the attic. It powered the hopper boy via belts and gears, the grain cleaner, and the two elevators that transferred the grain and the flour to the attic to be fed into the milling equipment. Belts were used as a safety device in case the hopper boy flight arm jammed.



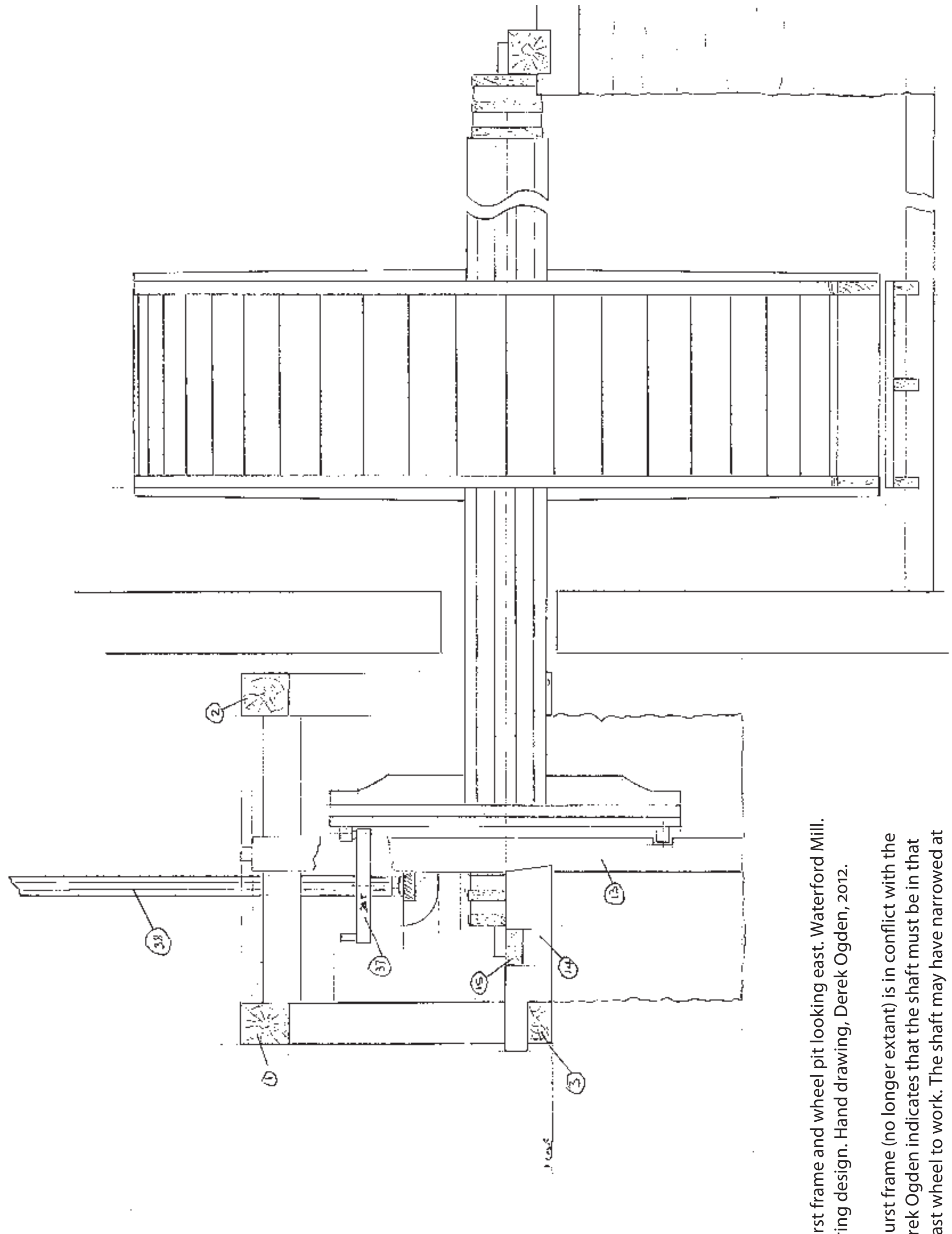
Hopper Boy illustrated in Oliver Evans, The Young Mill-wright and Millers' Guide (1795)



Section through hurst frame looking north. Waterford Mill.
Reconstructed gearing design. Hand drawing, Derek Ogden, 2012.



Plan of hurst frame and flume. Waterford Mill. Reconstructed gearing design. Hand drawing, Derek Ogden, 2012.



Section through hurst frame and wheel pit looking east. Waterford Mill. Reconstructed gearing design. Hand drawing, Derek Ogden, 2012.

The rear sill of the hurst frame (no longer extant) is in conflict with the millwheel shaft. Derek Ogden indicates that the shaft must be in that location for the breast wheel to work. The shaft may have narrowed at that point to pass through a notch in the rear sill ["With regard to the water wheel shaft cutting through the rear sill, I have seen this problem many times and often the shaft is rounded in this area or even slightly undercut. This does give a little more strength to the sill but I do not like reducing the diameter of this very long shaft because it already has a heavy dead load to take with an 18ft diameter wooden wheel" (Derek Ogden, Email message to Gibson Worsham, 28 Nov. 2012)]

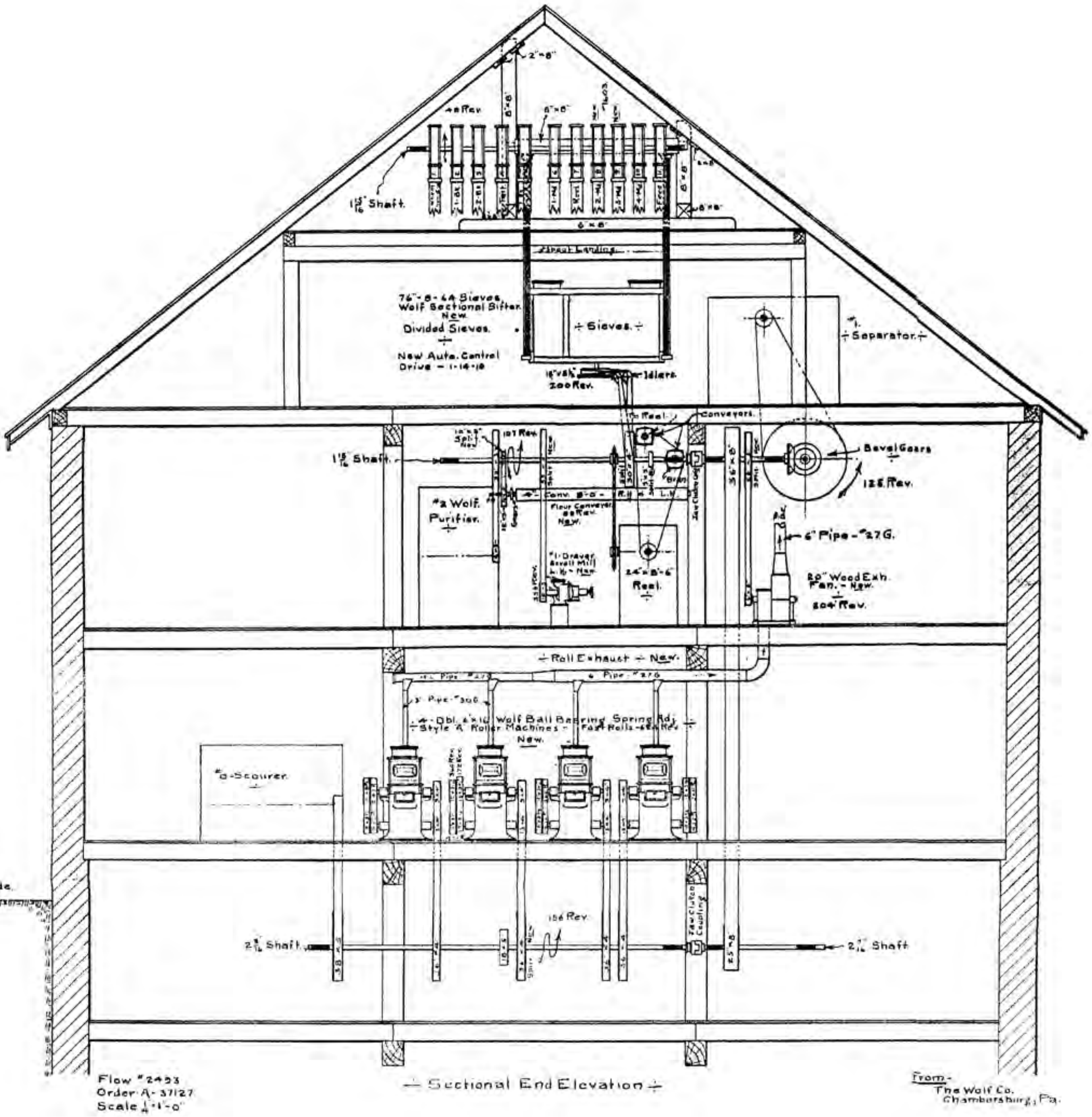
Below: Drawing Legend. Waterford Mill. Reconstructed gearing design. Derek Ogden, 2012.

ITEM	DESCRIPTION	NOTES
1	MILL BEAM	
2	TOP REAR RAIL	
3	FRONT SILL	
4	REAR SILL	
5	FRONT CORNER POST	
6	REAR CORNER POST	
7	FRONT BRIDGE POST	
8	REAR BRIDGE POST	
9	BRACE	NONE SHOWN
10	STONE BEARER	
11	BRIDGE TREE	
12	BOTTOM TIE	
13	TOMKIN POST	
14	SPUR BLOCKS	
15	BEARING BEAM	
16	MASTER COG WHEEL	PIT GEAR
17	WALLOWER	
18	LITTLE COG WHEEL	
19	STONE NUT	
20	SHORT COUNTERSHAFT	
21	LONG COUNTERSHAFT	

ITEM	DESCRIPTION	NOTES
22	WATER WHEEL SHAFT	
23	ARMS	
24	SHROUDS	
25	SOLE BOARD	
26	BUCKET BOARD	
27	APRON BOARD	
28	APRON RIB	
29	APRON SUPPORT BEAM	
30	FLUME SUPPORT BEAM	
31	FLUME RAIL	
32	FLUME FRAME	
33	FLUME BOARDS	KEYED TOGETHER
34	HEADGATE POSTS	
35	RAIL	
36	GATE	
37	AUXILIARY DRIVE GEAR	TO MACHINES ABOVE
38	AUXILIARY DRIVE SHAFT	INCLUDING HOPPER BOY

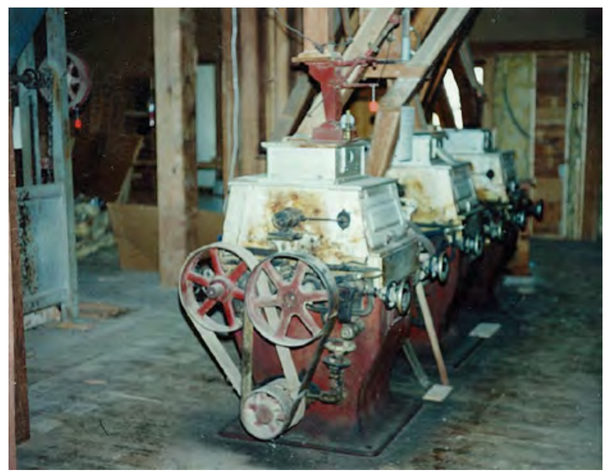
B. Gradual Reduction Process Mill

How did Waterford Mill work after it was refitted for gradual reduction milling?



Flow Diagram, Roller milling equipment, Aldie Mill, Aldie, Virginia.
The Wolf Co. Chambersburg, PA, 1911. [Courtesy of Derek Ogden.]

The gradual reduction milling process required a complete change in milling equipment and power transmission. The process involved grain receiving, preparation, grinding, sifting, and packaging. The equipment was removed from the Waterford Mill in the 1940s. Most of the current milling equipment was acquired and placed in the mill in the 1990s to improve the interpretation of the building as an industrial structure. Obscured flooring, repairs and the many alterations have made it difficult to reconstruct the exact form of the mill in the late nineteenth and early twentieth centuries, but the basic form is described below.

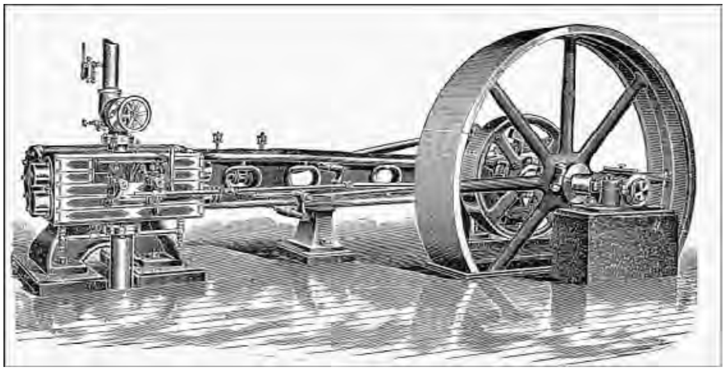


Gradual reduction milling. Olive Mill equipment before relocation to Waterford Mill in 1998 [WF].

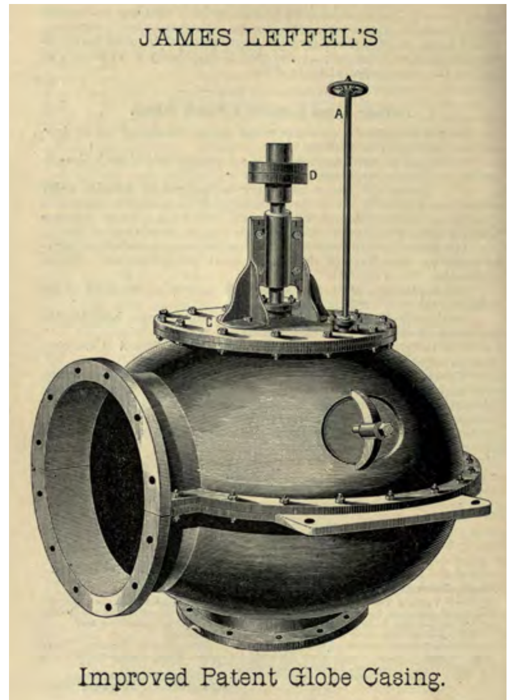
1. Wheat (and corn) was delivered in wagons to the receiving room in the hyphen between the mill and the west wing. The grain was weighed and dumped into a bin below the floor. The farmer was either paid for the grain at market price, or the miller "exchanged" flour or meal for the grain at a specified rate per bushel.

2. Just as in the Oliver Evans process, the grain was first passed though a 'fanning mill' to blow off the chaff and through screens to remove foreign material. The grain then was stored in large bins in the west wing until needed.

3. Wheat was then moved from the bin by gravity and auger to a scouring machine to remove the outer layer and to a tempering bin where it was held until it had reached the right moisture content for milling. One more scouring and it was sent via gravity to a hopper above the roller mills, which had replaced the original buhr stones. The new technology fed the grain between two iron rollers, each with a different grooved pattern and rolling at different speed toward each other. These were made of "chilled" iron, resulting from a molding process that produces an extremely durable surface. The grain is passed between the rollers or "breaks" numerous times, gradually breaking the kernels and extracting the white flour with the greatest efficiency then possible. Between each trip through one of the five roller stands, each of which contained two sets of rollers, the flour was carried up and down in a complex pattern through the mill in numerous elevators and chutes. The more breaks the more fine flour could be extracted from the grain. The roller stands were in the center of the first floor and the scourers, bolters, sifters, and bleachers were in the second and third floor of the mill. At Waterford, two traditional millstones were retained for corn meal. One of these appears to survive near the southeast corner of the hurst frame. The stone was probably



Above: Fitchburg Steam Engine. A typical mill engine in the 1903 catalog of the Fitchburg Steam Engine Company, one of several manufacturers. The boiler was separate. http://home.iprimus.com.au/metzke/Engines.sketch.html



Right: Leffel turbine similar to the one at Waterford Mill.

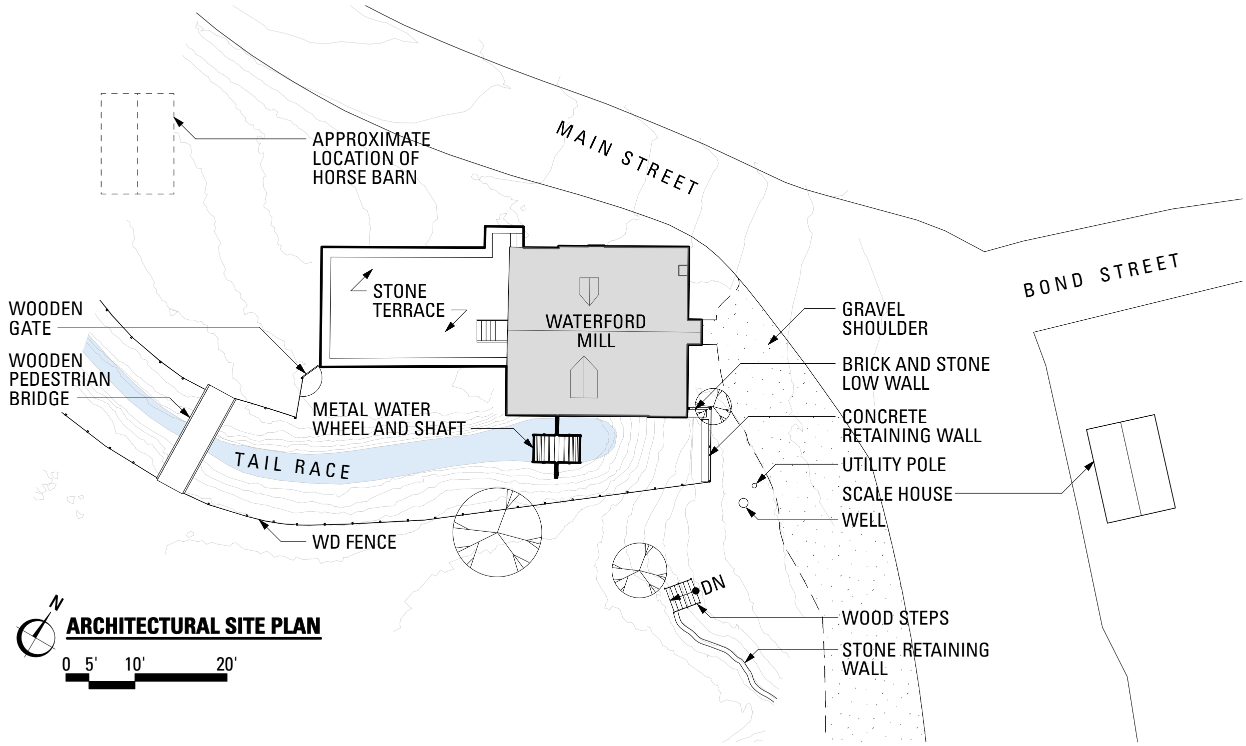
shifted to the south from the original millstone location at some point in the late nineteenth or early twentieth centuries, possibly to make room for the power train serving the Leffel turbine.

4. The flour moved during the process through separators, machines that sorted the flour into different levels of fineness. The sifter, a large machine housing many rocking trays with bottoms made of silk of various degrees of coarseness extracted fine flour and sent meal back through the process until it reached the appropriate level required. Bolt sifters passed the meal down revolving silk-covered cylinders separating the flour from the middlings and bran.

5. Bran and middlings were bagged and sold as feed. Sometimes middlings were ground and bleached and added back into the flour. The flour was placed in barrels or bags and shipped by wagon from the central door in the east end. Farmers would get one barrel of the roller process flour and 40 pounds of bran for six bushels of wheat or one barrel of the "family" grade (not quite as white) and 40 pounds of bran for five bushels of wheat [Sale notice, 1914, WF].

6. Power was transmitted from the Fitz overshot wheel by an iron main shaft to an iron pulley system using mostly belt drives to all machinery.

7. The power for the mill was also supplied by a Leffel turbine. This efficient source of water power could be placed in the bottom of a wooden penstock or inside of an iron enclosure fed by a cylindrical conduit like the one still in place at the Waterford Mill. It would have had a vertical shaft. The turbine seems to have entirely vanished. A steam engine (later a diesel engine) supplied power when there was insufficient head of water to drive the wheel, which would probably be frequent because a roller stand and all auxiliaries would require more power than the millrace could supply.



Site plan, Waterford Mill, StudioAmmons, 2012.

V. Architectural Assessment

Description Narrative

Site

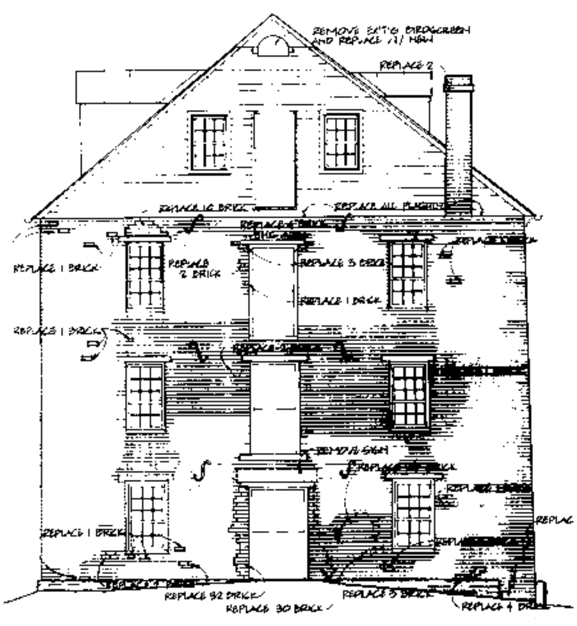
The mill at Waterford is a three-story, nearly square brick structure with a full basement and attic, originally providing room on five floors for a complex assembly of Oliver Evans-type milling equipment and its associated power transmission system. The building is situated on the east bank of the South Fork of Catoctin Creek. Motive power was provided by a mile-long mill race that paralleled the creek and formed a small pool at the southeast corner of the mill. Water was released to turn a wheel midway

Waterford Mill site looking east (left) and west (right), 2012 along the south side and, after dropping fourteen feet, exited the stone-walled wheel pit by means of a tail race that fed directly into the creek. The mill was built into the sloping bank of a terrace of land east of the creek, so that it was entered on the first floor on the east end. The land sloped gently along the north side from the east to the west end, while the full height of the basement was exposed along the south side and west end. Although the building was built of brick, wherever the walls extended below grade the foundation was built of coursed limestone rubble. Since the building was built into the bank, this meant that the stone foundation was stepped up and down around the perimeter according to the level of the grade. The main road through the village passes directly along the north side of the building and sweeps around the northeast corner. The corner is protected by a rough stone bollard that has been in place at least since the early twentiath century, when it is visible in photographs, but proabably longer. A low, flat area to the west was the site of subsidiary buildings in the nineteenth century.

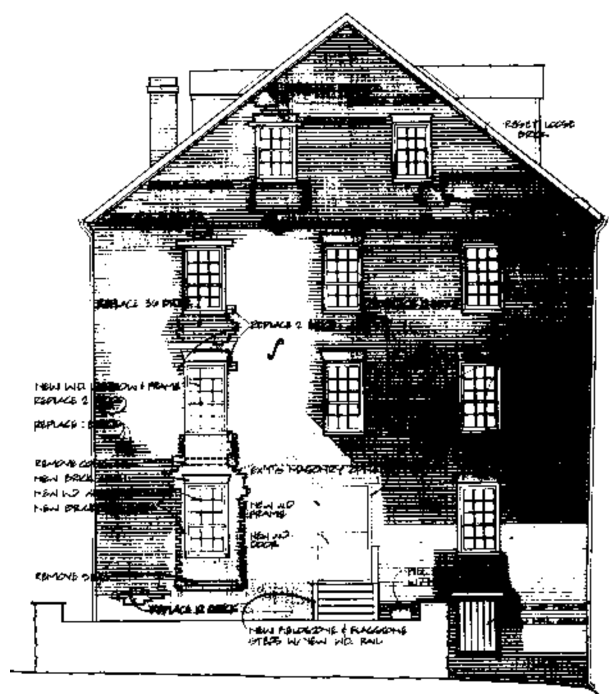
Today the site is carefully manicured. A small pulloff parking area is located along Main Street to the immediate southeast of the mill. A set of steps assist visitors in moving down the bank of the head race to the flat area next to the tail race. Three-board plank fences keep visitors away from the tail race area. A bridge over the tail race to the west of the mill makes it possible to move safely around the building without walking in the road. The foundation of the former west wing has been adapted as a stone-floored terrace where the interpretive panels are located. The Phillips Farm Interpretive Trail begins from the southwest corner of the mill property and extends to the mill dam on Catoctin Creek.

Exterior

The mill measures 37′-0″ by 39′-3″ and is 26′-6″ tall from the first floor level to the bottom of the roof. The walls are built of locally-made, six-course, American-bond brick. The brickwork shows some



East end, Waterford Mill, Drawings, The Ehrenkrantz Group, 1985.



West end, Waterford Mill, Drawings, The Ehrenkrantz Group, 1985.

West End, Waterford Mill, 2012. A double row of projecting bricks can be seen above the third-foor windows.

evidence of staining (a red glaze) and penciling (white lines added over the joints), common practices in the nineteenth century undertaken to increase an appearance of regularity. The walls incorporate random glazed headers and stretchers. The shallow eaves are supported by two courses of corbeled brick along the north and south sides and are finished with plain wooden rake boards in the gable ends. A square chimney rises near the north end of the east front. A nail attaching a small remaining area of roof sheathing on the south slope is an early machine headed nail, of the type made between the 1810s and the 1830s. Similarly, a surviving roof shingle nail in the same area is a handmade T-head nail (usually before 1830) [Nelson 1963].

The building is covered by a modern standing-seam metal gable roof. Dormers pierce the north and south slopes of the roof near their centers. Windows and doors throughout are equipped with gauged brick jack arches, except in locations that have been altered. Doors and windows in the rebuilt east end have wood lintels that extend several inches to each side of the frame. Except on the south side, the window openings on the first floor are slightly wider than those on the two upper floors. This results in thirteen bricks in the first-floor jack arches and only twelve on the upper floors. However, the amount of glass is the same in all the windows and the two inches is counteracted by extra thickness of the window frames. The very plain mortise and tenon window frames have pegs in the upper corners and appear to be original. Most window sills were replaced with concrete in the mid-twentieth century. The nine-over-six-light window sashes are modern and were replaced at the same time.

West End

The original west end incorporates three nine-over-six sash windows on each floor and a door in the center of the first floor. Doors were added in the north bay on each floor when the west wing was added but these were returned to use as windows in the 1940s. The brick gable is set off from the wall below by a double row of projecting bricks corresponding to the corbeled cornice on the long sides.

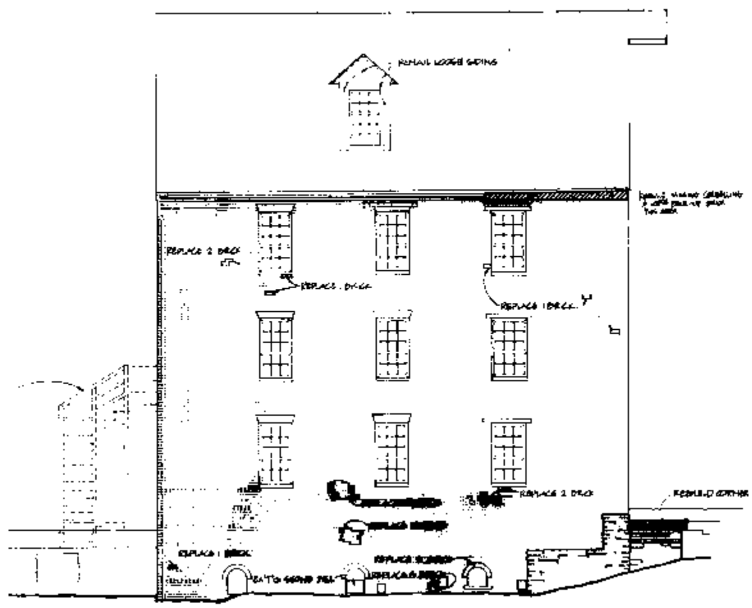
East end of Waterford Mill, 2012

The attic is lit by two evenly spaced six-over-six sash windows. A small decorative diamond pattern made with glazed bricks is set near the apex. Most of the windows show signs of alteration either in the 1940s and 1980s. Several jack arches have awkward shaped bricks that don't match the majority of bricks elsewhere in the building. The top window on the north has a wood lintel. Traces of a jack arch over the door in the first floor can be seen in the angled cuts remaining in the brick coursing to each side of the current wood lintel. The wall has a noticeable bow outwards in the center. It was stabilized in the mid-nineteenth century when six S-plates were added on the exterior, bolted into the ends of the two longitudinal beams at each floor level. Evidence in the basement interior suggests that there was a central door at grade giving access to the basement and flanked by sash windows like those on the floors above. The southern basement window, formerly used as an access door, was restored in 2009 at the same time that the central entry was reopened under the west terrace.

East End

The east end is the most altered of the walls. The entire wall was taken down and rebuilt for structural reasons in the mid-1850s. The gable end, originally of brick like the west end, was rebuilt in wood sheathed with weatherboards at the same time. The bond courses of headers in the rebuilt east end do not, for the most part, line up with the bond courses on the rest of the building to the west. Additional stability was provided by six S-plates on the exterior that were bolted into the ends of the two longitudinal beams at each floor level.

As on the other walls, three regularly spaced window bays provide light and air to the interior. The central bay contains doors on all floors, including the attic. The doors were probably added with the new wall and their position was originally occupied by conventional windows. A hoist is sheltered under a projecting hood or pulley house at the top of the gable. The framing supporting the hoist is not hewn like the rest of the roof structure. The hoist and doors were not required for bringing grain or flour in or out of the building, but did allow equipment to be easily added or removed from each floor. The doors were often left open to help ventilate the mill.



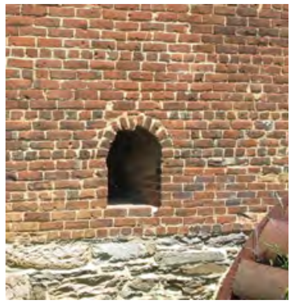
South side, Waterford Mill, Drawings, The Ehrenkrantz Group, 1985.

The doors and windows have plain wood lintels that extend several inches to each side of the openings. The windows themselves match the other windows in the building and were probably reused when the wall was rebuilt. As elsewhere in the building, the first-floor windows are slightly wider than the upper ones. The door openings are infilled with "Dutch"-style batten doors, all replaced in the 1980s restoration to match what was there at the time. The doors vary from top to bottom. As can be documented from photographs, the first-, second-, and attic-level doors were made with narrow tongue-and-groove boards, but the third-floor door incorporated wide, beaded boards. The second-floor door, the only door opening in the upper stories that was present at the time of the wall's reconstruction in the 1850s, has a sill made of stone.

South Side

The south side of the mill, like the other walls, has three evenly spaced window bays. The eastern end of the building was rebuilt in the mid-to-late nineteenth century. The bond courses of headers in the rebuilt section do not, for the most part, line up with the bond courses to the west, but do line up with the bond courses in the east end. The windows in the eastern bay have been rebuilt as well, with wood lintels that protrude to either side of the window. The window frames themselves match the other windows in the building and were probably reused when the wall was rebuilt. Late-nineteenth-century iron tie rods project at the second, third, and attic floor levels near the west end and the forces are distributed by beveled wooden plates. The replaced section of wall appears to correspond to the marked change in level of the stone foundation below. A diagonal crack extending from the foundation to the western

South side, Waterford Mill, 2012



Westernmost of the upper arches in the south wall in the 1930s (above left) and today (above right). It and the brickwork around have not been greatly changed. The crude rowlock arch does appear to have been inserted in the later 19th century- note the neat section of running bond to the right of the opening that does not match the rest of the brickwork.

Left: View of western archway from northeast, 2012. The wall is patched just above and to the west of the large arch where the wheel shaft would have entered the building (circled).

corner of the east first-floor window sill corresponds to the replaced section of brickwork. This could represent an area of differential movement that required the rebuilding of the entire east end to prevent collapse of the mill.

The south wall has a long history of deflection. It bulges in the middle and the wall projects as much as six inches at the top center. A six-foot long steel angle spanning the middle window at the top of the wall was added in the 1940s to prevent further movement of the wall. A large dormer near the center of the roof above appears, from the form of its structural members and heavier profiles, to date from the late nineteenth century and differs from the earlier dormer on the north side. The six-over-six sash window has a plain frame, modern sashes, a box cornice, and a projecting gable roof infilled with weatherboards. The sides are covered with corrugated metal.

The lower section of the wall is the most complex area of the exterior. The stone foundation is pierced by two approximately 3′-6″ diameter arched openings that were buried below grade in the 1940s when the wheel pit was filled. The two arches are similar in size but vary in location and height. These were uncovered in 1998 and the soldier brick arches restored on the exterior, although they remain in their original form on the interior. Both arches appear neatly inserted in the stone exterior. On the interior they are surrounded by irregular areas of brick (areas where brick coursing is altered and inconsistent).

Both large arches were likely added to the lower wall, probably to accommodate the entry of the metal water wheel shaft added in the 1880s at the west and the turbine drive at the eastern opening and to ventilate or drain the basement. Few mills have an impounded head race so close to the mill itself. The close proximity of the head race to the east wall of the mill may have provided a source of an unusual amount of continuous water infiltration. This may have caused a need for increased drainage as well as the subsidence over time of the east and south walls.

A patched area of brick above the arch is more carefully laid than the surrounding brick work. It appears to correspond closely to the entry point for the wooden water wheel shaft required by our analysis of the hurst frame. In order to work, the shaft had to enter the mill above the rear sill of the hurst frame (beginning about 10″ above the stone foundation level). The three small arches appear to have been added at the same time that the wooden gearing was removed, possibly to improve ventilation, although the odd juxtaposition of the large and small eastern arches suggests that one was added before the other. In any case, the use of brick arches in a stone wall suggests that the large arches were not original, but that they were added in the mid-nineteenth century or later.

The eastern archway projects a foot above the stone foundation. It has brick voussoirs that were restored in 1998. The opening extends below current grade and is infilled with stone from the bottom of the arch down. The brickwork and stonework around it have been disturbed. Its location does not align well with the hurst frame or with the locations of the stones. It is possible that it may have been added to aid in ventilation. It probably served as an entry for the shaft or belt drive of the turbine wheel that was added in the late nineteenth century.

Above the stone foundation level there are three smaller arched openings, 2′-0″ feet in diameter. The arches are surrounded with a single rowlock course. These are offset to the east of the three windows above. The two western openings flank the large western arch that contained the wheel shaft, but the eastern one stands slightly offset above the large eastern arch. They appear to correspond precisely to the three runs of stones supported by the hurst frame. These appear to have been added to aid in ventilating the basement level, rather than to provide light below each set of millstones. Three square insets in the brick on the east side of the small central arch and on both sides of the eastern arch supported the framing carrying the headstock.

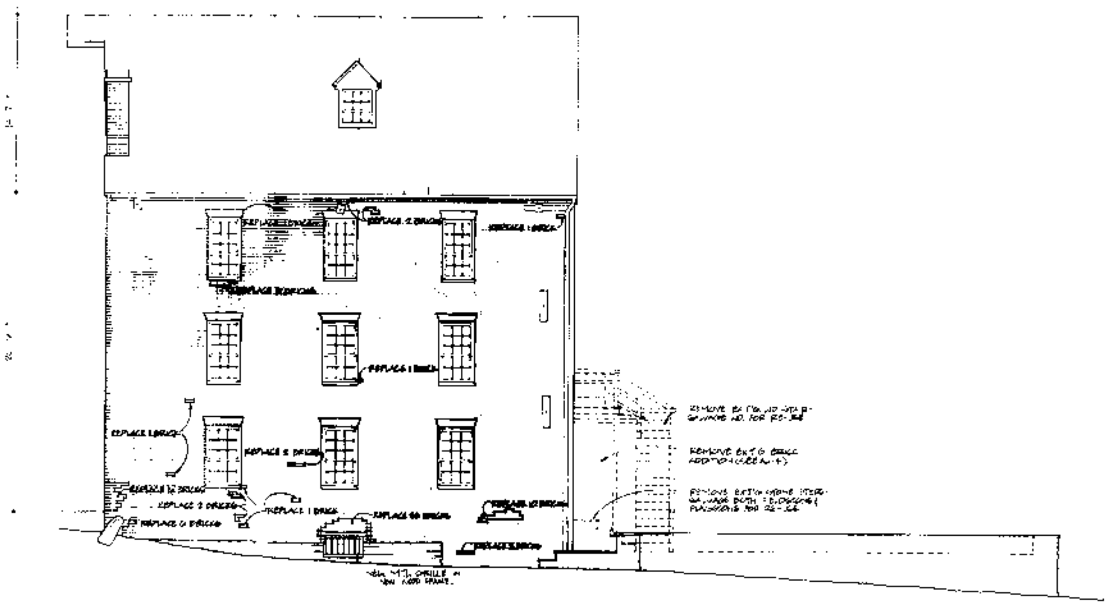
North Side

The north side has three evenly spaced window openings, all headed by original gauged jack arches. A wide basement vent with a wood lintel appears to have been added in the mid-to-late nineteenth century. The frame was replaced in 1983–84. The stone foundation steps down at the last bay to the west. Late-nineteenth-century iron tie rods project at the second, third, and attic floor levels near the west end and the forces are distributed by beveled wooden plates. Square metal plates provide the same service where two steel ties rods added in the 1940s project just below the cornice at the east end and above the central window.

Unlike the larger dormer on the south, the small dormer near the center of the roof above appears to have been added in the decades soon after the mill was constructed. It would have provided light to the area around the hopper boy located just inside, which otherwise would have been very difficult

Close-up view of dormer

North side, Waterford Mill, 2012



North side, Waterford Mill, Drawings, The Ehrenkrantz Group, 1985.

to inspect or manage. It has a beaded window frame with a fragment of molded architrave trim over the six-over-three sash window, modern sashes, a box cornice, and square rakes trimming the gabled roof infilled with flush boards. The sides are covered with corrugated metal. The interior shows diagonal siding in the side walls and small lapped and pegged rafter pairs.

Interior

Structure

The lowest level of the mill foundation extends across the south, where a stone foundation three feet thick supports both the mill and the hurst frame. The main foundations are built of stone, 1′-10″ thick. The basement level brick wall on the south is also 1′-10″ inches in thickness. The 1′-6″ thick brick walls begin well below the first-floor level, except on the east, where the first-floor is at grade. The walls are reduced by one wythe in thickness in each story (1′-6″ at the first floor and 1′-0″ at the third), with the tops of the floor joists generally set even with the resulting ledges.

The mill is divided into three structural bays from north to south by two large beams on each floor. The building is divided into four structural bays from east to west by three evenly spaced, approximately 9 1/2″ square wood posts with lamb's tongue chamfered corners. The posts and the rest of the framing are built of red oak. These support two beams on each floor measuring approximately 9 1/2″ wide by 11 1/2″ tall. Forces are transmitted from beam to post by means of a traditional bolster with sawn ogee ends. The posts are mortised into the bolsters and fixed with two pegs. The bolsters are attached to the beams by pegs at each end. Each floor is carried on 3″ x 10″ pit-sawn joists that span from north to south between the beams and pockets in the long walls of the building. The arrangement of six posts and bolsters was also used in the basement, but the posts rotted away and only one bolster survives. This may have been a principal cause of the downward bowing at the center of each floor. Many of the joists

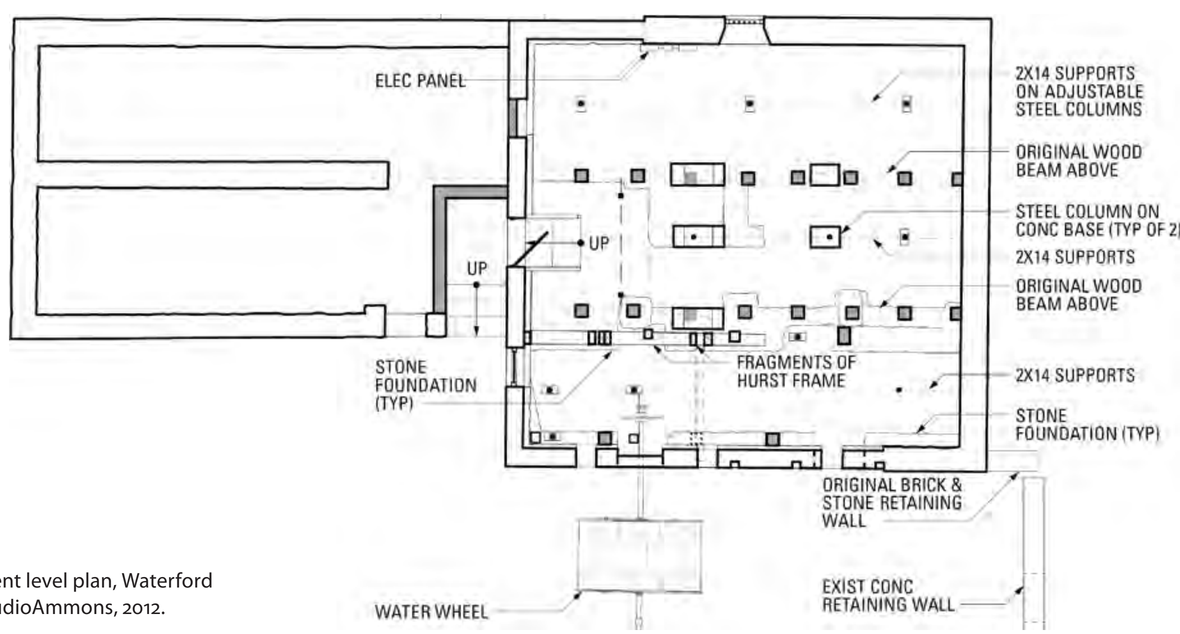
The north bay of the basement looking east

The central bay of the basement looking west.

were sistered in the 1983–84 repairs. Much of the damage repaired at that time was a direct result of the buildup of moisture in the basement that resulted from the backfilling of the tail race in the 1940s.

The Basement

The basement story retained a large amount of original material until the repairs were made in 1983–84. Fortunately, record drawings from 1983 show how it appeared before that date. It contained a single room divided into three parts by two low, lateral stone walls corresponding to the east-west beams on the floors above. Each stone wall carried three approximately 9 1/2″ square wood posts topped by bolsters that carried the 9 1/2″ by 11 1/2″ lateral beams. The lower sections of these had been replaced with brick piers as they rotted. The dirt floors of the central and northern thirds of the building probably corresponded to the grade outside at the west end. In 1983–84, the



Basement level plan, Waterford Mill, StudioAmmons, 2012.

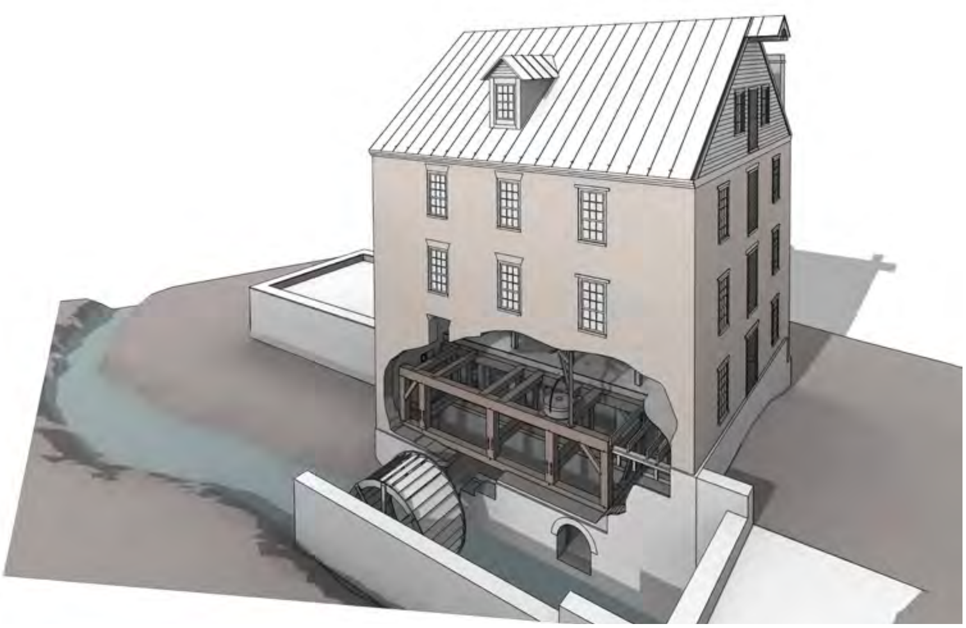
posts, all of which had been cut off and placed on partial height brick piers (probably in the 1940s), were removed and the beams supported by a new line of nine brick piers under each beam.

The southern third of the basement, however, extended well below the rest of the basement, nearly to the level of the millrace, and contained the gear pit, the location of the main drive mechanism of the mill. Separate stone foundations placed inside the gear pit extended to the top of the basement floor and carried a massive frame structure known as the hurst frame and transmitted tremors caused by the wooden gearing directly to the ground without contact with the mill building or its structure. As Derek Ogden has shown—"When the Evans mill system was using all-wooden gearing it was humanly impossible to make each of the rock maple gear teeth precisely the same by hand. There was always some very slight variation in each tooth. With a large gear having say 60 or more wooden cogs it caused the gears to shake slightly and this was and still is known as 'tremor.' With careful dressing the millwright was able to reduce the tremor considerably but an unskilled millwright could provide considerable tremor. It was of such high frequency amplitude that if neglected it could and has been known to bring portions of the building down" [Derek Ogden, Personal communication, 20 August 2012].

In the late 1990s, continuous double 2 x 12 beams carried on lally columns were added at the center of each of the three sets of joists, with certain exceptions. Each of the joists was cross-braced above the support beams. The center beam stops short of the west end to permit access to the door in the center of the wall and is carried on a steel beam spanning between two steel posts. The beam on the south side of the mill stops where intact parts of the hurst frame intervene.

Hurst Frame

The hurst frame was more intact in 1983 than it is today. It was probably more sound in 1944 when acquired by the Waterford Foundation. Ongoing decay due to moist conditions in the basement and removal of detached sections of the frame have resulted in considerable loss of fabric. However, record drawings made in 1983 and a close examination of the remaining material make it possible to reconstruct



Conjectured restoration of the 1818 hurst frame with existing stone set in the present-day Waterford Mill. S. Bay Koulabdara for Studioammons, 2012 its original appearance. It was made of strong, approximately 12″x 12″thick timbers, and designed to accommodate three runs of stones arranged in a row from east to west just inside the three windows on the south wall. It was intended to transfer the tremor caused primarily by the wooden gearing directly to the ground without affecting the mill structure. The wheel shaft entered the mill through the western archway, and connected with the milling equipment by means of a main, vertical shaft that ran to the attic and by side shafts, all provided with wooden gearing.

The hurst frame was twenty-eight feet long, nine feet wide, and about seven feet tall. The frame did not extend the entire length of the mill but was placed towards the western end, from which it was separated by just a few inches. It was made of heavy hewn members connected with mortise-and-tenon joints and strongly braced at the corners. The long top timbers that formed the sides of the frame are called the mill beam (along the inner side) and the top beam (along the outer wall). They measure 12″deep by 13 1/2″tall. Both of these survive along their full length. The corresponding members on the bottom were the front and back sills. Only a portion of the front sill survives and it measures 12″deep by 10″tall.

Hewn corner posts extended between the top and bottom members. These were 5′-6″in length and measured 10″in width and 12″in depth. Only the upper portion of the corner post at the southwest corner survives, although the northwest corner post was shown in the measured drawing made in 1983. The corner post contains the sole evidence of the original bracing. The north and south sides of the hurst frame were connected by girts near the top of the east and west end. These were mortised into the corner posts just below the side beams to avoid a conflict of tenons. A mortise-and-tenoned brace measuring 6″tall by 4″deep still extends up from the post into the bottom of the top beam. The tenon survives for a similar brace extending down from the post to a missing girt at the bottom.

Seats for the each of the three pairs of millstones were formed by a pair of beams, often referred to as stone bearers, that were partially let into the top of the hurst frame and are spaced between 14″and 24″ apart. Today, the stone bearers sit in 6 1/2″deep notches and project about three inches above the level of the mill beam. It seems likely that they would not originally have projected above the top of the hurst frame, so as to permit the installation of the independent flooring that extended over the entire top of the frame. According to regional precedent, this would normally have consisted of three-inch

The hurst frame looking east with the surviving bridge beam in foreground.

Southwest corner post seen from northeast showing surviving brace

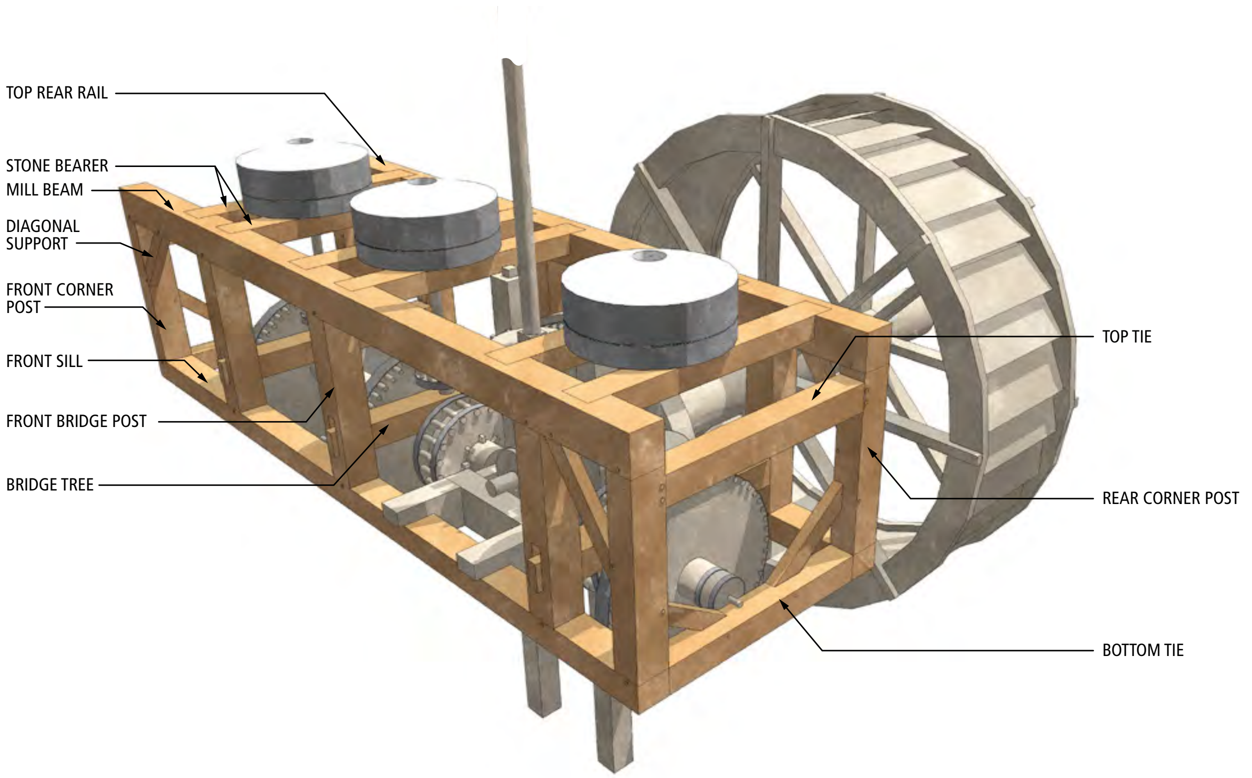
Above: Mill beam and western and central stone bearers looking northeast.

Right: Eastern millstones shifted to the south on original stone bearers.

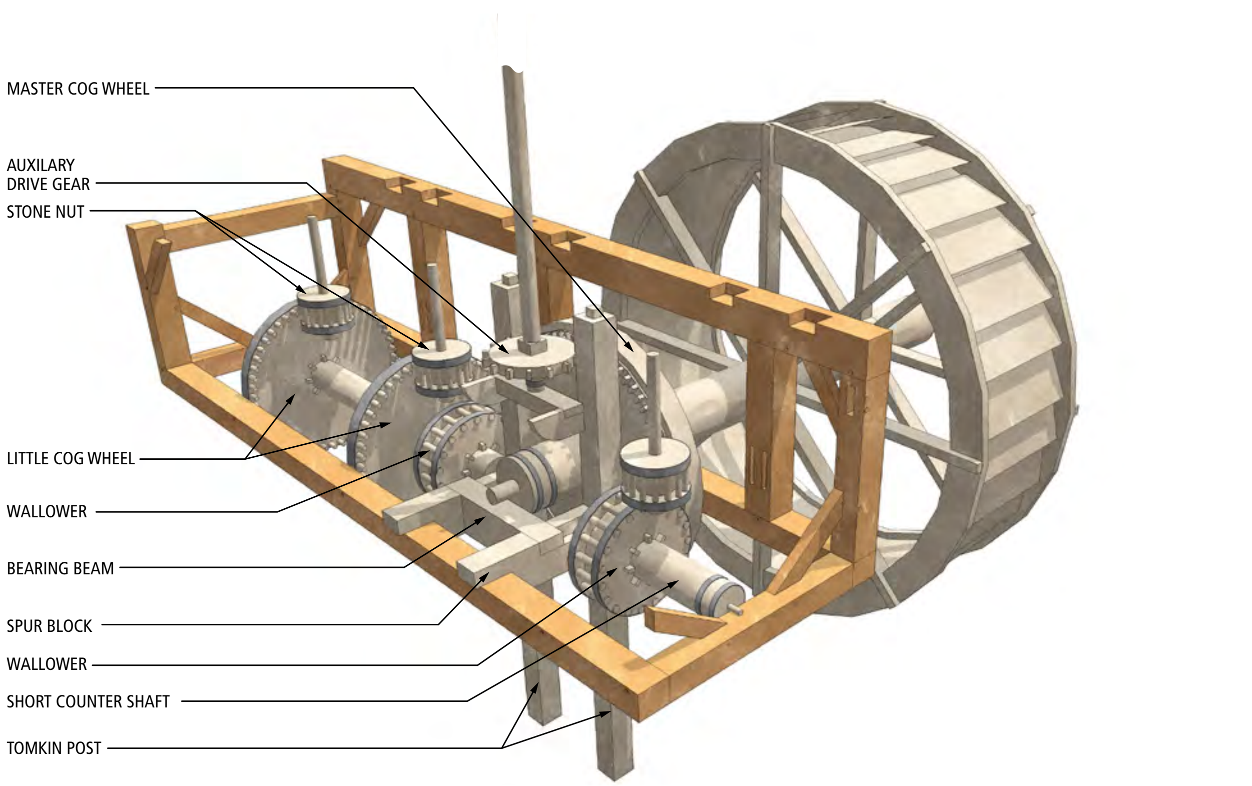
planking inset so as to be flush with the mill beam and then covered by a one-inch finish floor. Here, it appears that both the planking and the finish floor extended across the top of the mill beam. The 9 1/2 inch square planed western and center pairs of stone bearers, which have been shifted slightly in location, appear to be replacements, when they are compared to the two hewn beams at the east end, 8″ tall and 14″ wide. Closer examination, particularly from above, may make it possible to better understand the frame's change over time.

The spacing of the sets of millstones is irregular. The two western sets were spaced equidistantly from the mill wheel shaft in the gear pit below. They were placed about 10′-0″ feet apart to leave room for the large master cog wheel (or pit gear) that revolved on the shaft. This transferred power to the two wallowers, which transferred power by means of lateral countershafts to the lantern pinions (or stone nuts) attached to each set of stones. The eastern millstone location was placed closer (7′-4″) to the center set, because there was no need to accommodate the master cog wheel.

The center lines of the original millstones can be determined from the mortises of vertical posts on the north and the south sides that originally aligned with the stones. These members carried the movable bridge beams that spanned the hurst frame and held the feet of the millstone spindles. A bridge beam survives only at the central millstone location. The 10″ tall by 12″ wide timber had two tenons at the west end, which rotated in a pair of slots in the face of the southern post, which also survives nearby. Each bridge tree had a single tenon at the north end that extended 10″-12″ beyond the northern post (called a front bridge post or pivot post) and was the means by which it was raised and lowered to adjust the space between the millstones. Most of the bridge-tree support posts were later replaced by pairs of scabbed-on posts which held the bridge beams in place (the southern bridge-tree post was reused in this way). The surviving framing gives the impression that the two western millstones locations flanking the wheel shaft were used longer than the eastern one (two 36″ buhr stones were still in use in 1914 for corn meal).



Above: Hurst Frame—conjectural restoration.
Below: Hurst Frame—conjectural restoration of power drive (little cog wheel and bridge tree in foreground removed).
Renderings of design by Derek Ogden, Bay Koulabdara 2012.



The hurst frame flooring was replaced with circular-sawn 2″x 11 3/4″joists level with and lapped beside the adjacent original floor joists. This probably happened after 1914, when the mill still had two runs of millstones, because the joists extend across the former millstone locations.

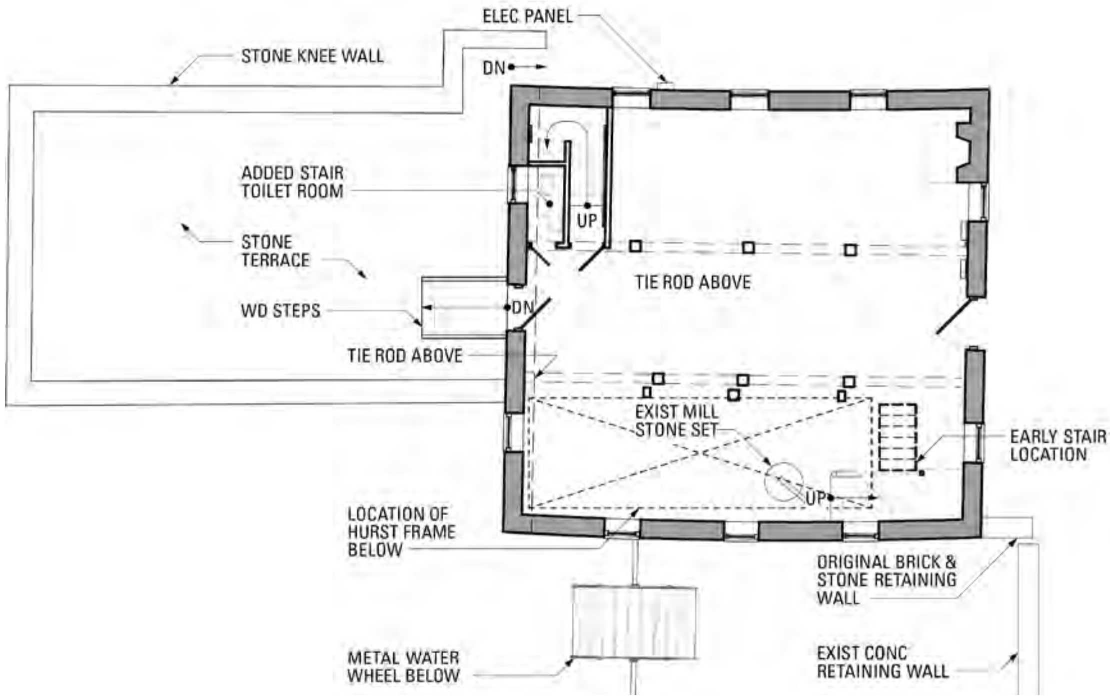
The hurst frame rested directly on stone foundations on the north and south that are both roughly 8′-3″ below the top of the first-floor joists. As observed above, the hurst frame would have been spanned by flooring separately from the rest of the first floor without joists. If the stone bearers were level with the top of the hurst frame they would have assisted in carrying the floor. The stone bearers that span the hurst frame and carried the millstones were mortised into the upper members. With a 4″thick floor, this would have resulted in a floor that was about 7″below the main floor of the first story.

A set of millstones, missing its case, was relocated by a previous owner at some point to the south end of the pair of stone bearers that originally held the eastern run of stones at their center. They were likely placed there in the very last years of the mill to "keep the trade going." The stones were manufactured by B. F. Starr, a late nineteenth-century importer and manufacturer of millstones [Hockensmith 2009, 91]. It is therefore likely that it is a "hulling stone" used to remove the hulls from the wheat before sending it to the cleaner and separating machine on the second floor. On the other hand, its post-Civil War date and size match may mean that it is one of the two 36″buhr stones used for cornmeal mentioned in the 1914 advertisement. They may have been shifted to that position to avoid the gearing powered by the Leffell turbine. By the time the Waterford Foundation acquired the mill in 1944, it appears to have been the only intact set of millstones and was carefully preserved in situ in spite of its proximity to the foot of the stair.

First Floor

The first floor is one of the most altered areas in the mill. A new continuous wood floor was added in the 1940s and all trace of piercings through the floor is gone. Although most of the flooring above the ceiling joists is still in place, it has been altered and covered from above. The principal frameing members are hewn and chamfered. The western post on the southern side of the room has been shifted a little less than two feet to the east at some point in the past (the post on the floor above was moved even further, a total of almost four feet, to the east). The main southern beam is braced with angled timbers that extend from the beam to the front sill of the hurst frame below. Today, deterioration of part of the hurst frame front sill means that the eastern brace is independently supported by brick piers. These carefully chamfered braces appear to date from the major repairs undertaken by James F. Dodd in the 1880s, but may date from the repairs of the 1850s and after the fire of 1855. The western brace does not share in the charring of the structural members around it. The northeast corner is the original location of the mill office, no longer enclosed, but heated by a small fireplace in the east end with a jack arch over the firebox. While the firebox may predate the north wall, it is clear that the chimney itself was rebuilt with the east wall. The hearth brick is modern in date.

The exposed brick walls and the exposed framing is entirely painted white. The interior window trim dates from the mid-twentieth century. The original windows are equipped with relieving arches, while the newer ones in the east have wood lintels. It is clear that the west door is its original size. The batten doors in both the east and west fronts are modern. A modern enclosed fire stair extending from the first floor to the third floor was inserted in the northwest corner in 1983–84. A small toilet room was added in the space under the upper flight of the stair. The stair and toilet room are lit by the northern windows in the west wall. The late-nineteenth-century iron tie rods inside the west wall are square in section and are visible inside the stairway at each floor.



First floor plan, Waterford Mill, StudioAmmons, 2012.

A wide stair ascends to the second floor in the southeast corner. The upper flight of the stair incorporates beaded stringers exposed below and a mortise-and-tenoned landing base that appears to date from the same period as the rebuilt east wall (c. 1856). The stair has a generous tread-to-riser ratio and it is wide and easy to climb. The railing and the treads and risers of the entire stair, as well as the lower flight, were replaced and the upper flight enclosed below the second floor in the 1940s. The brick walls of the stair are not whitewashed or painted but the space below the landing is. Mortise patches in the adjacent south wall show that the stair landing formerly extended across from the corner to the adjacent window jamb and the lower flight of steps returned beside the upper flight, forming a dogleg stair. Since the rebuilding in the 1940s, the stair nearly collides with the set of millstones that give every appearance of having been there since the early twentieth century. The center of the room is filled with equipment that was brought to the mill in 1998 to form a static milling display.

First floor looking east in north structural bay

First floor looking east from south structural bay showing added braces and roller stands.

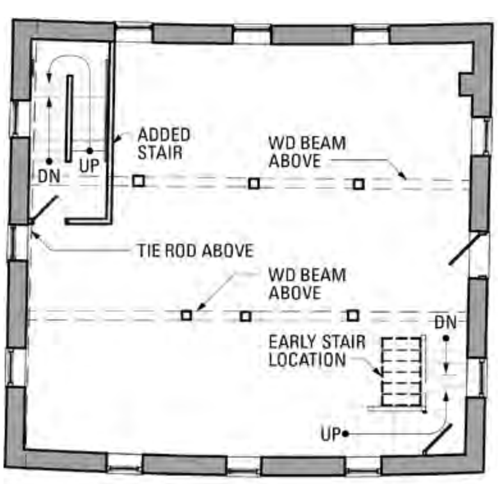
First-floor stair in southeast corner.

Infilled mortise for landing support at center, first-floor stair.

Second Floor

The second floor is lit by three windows on all sides except on the east where the center is occupied by a dutch door and at the north end of the west wall where the modern stair obscures the window. The exterior door is modern (1983-84). Comparison with historic photographs show that it is a reproduction of the former door. As on the floor below, the plain window trim dates from the 1940s and the windows are headed by segmental relieving arches, except for those located in the rebuilt sections of wall that are equipped with wood lintels. The floor of the second story is made of plywood panels fastened to largely intact sections of the butt-joined, 1-inch thick original floor, visible only from below.

The three structural bays are similar to those on the first floor, except that the western column on the south side was long ago shifted about four feet toward the center, even more than the column below it on the first floor. Its relocation was undoubtedly to facilitate the addition of a new power system or piece of equipment and it caused further sagging of the beam above. The two western posts on the north side and the center post on the south were compromised as well and were completely replaced with copies in 1983–84.



Second floor plan, Waterford Mill, StudioAmmons, 2012.

The southeast post on the first floor, showing typical blocking and sistering performed in 1983–4.

South bay of the second floor looking west.

Typical scarf joint, center of northern beam on second floor.

Above: The two sets of peg holes on the right (located near the west end of the center structural bay) are probably the location of a support for a central longitudinal second-floor power shaft. Looking north at Joist 18, Zone B, Sheet A-15 on the 1983 record drawings. The floor to the left is mostly old and to the right is replaced.

Above: The second-floor stairway showing modern risers and treads. The earlier landing may have been supported on a joist that was held in the notch in the window jamb just above the sill before the stair turned and descended to the north.

Left: Interior of the east door on the second floor dating from the mid-nineteenth-century rebuilding of the wall. The vertical boards feature very small edge beads. The door appears to be a modern reproduction of the mid-nineteenth-century door.

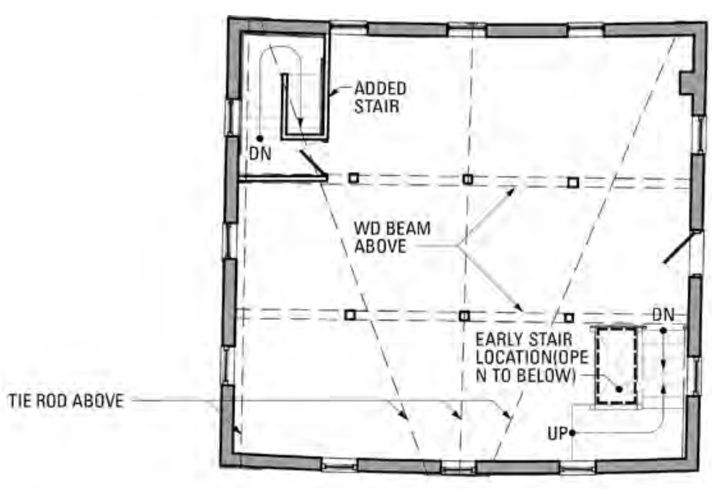
The single flue from the first-floor fireplace is much smaller on this floor and projects into the room near the north end of the east wall. The north wall and the northern half of the west and east walls are plastered from the floor to a point even with the window heads. The plaster is only a brown coat and covers an earlier coat of whitewash on this area only. The eastern half of the exposed ceiling joists and boards is also whitewashed. It may indicate that this side of the second floor was set apart for the storage of grain during the early nineteenth century. The southern half of the room has walls of bare brick.

The stairway from the second to the third floor has been reworked but incorporates beaded stringers that date from the mid-nineteenth century rebuilding of the east wall. The stair appears to have formed a dogleg with a long landing extending from the southeast corner to the eastern jamb of the adjacent window in the south wall.

Third Floor

The third floor has unfinished brick walls. The framing is similar to the lower floors. There was no middle column or bolster on the north side of the room in 1983, when the record drawings were prepared. Either it had been removed at some point in the past or it was omitted for a reason having to do with the placement of equipment. This is supported by the absence of a scarf joint at this location, which would have provided a beam capable of spanning the central two bays. Most of the beams, including the one on the opposite side of the room, have scarf joints over the central post. A post was added there with a new bolster in 1983–84. The middle column on the south side was replaced at the same time and the scarf joint braced with added timbers bolted on each side. New members matched original dimensions.

The original flooring of the third floor is covered with narrow tongue-and-groove boards, probably added in the early twentieth century. The flooring of the attic is exposed above. Approximately half has been replaced. Some of it has tongue and groove connections. The floor in the central area of the central bay was replaced with narrow tongue and groove boards in the late nineteenth or early twentieth century. The area to the west above the rolling stands was apparently so cut up by elevator legs and chutes that it is mostly unfloored today.



Third floor plan, Waterford Mill, StudioAmmons, 2012.


Stair to attic showing original baluster locations, newel post and rail.

The disturbed brickwork below the sill level of the former window shows its conversion to a door in the late nineteenth century.

The upper flight of the stair from the second to the third floor, showing nineteenth-century stringers.

Typical metal strap along the third-floor north wall.

Third floor looking southwest from the north bay, showing the 1983–84 post at the center right. Note that there is no scarf joint over this post, making this the only continuous beam in the building.

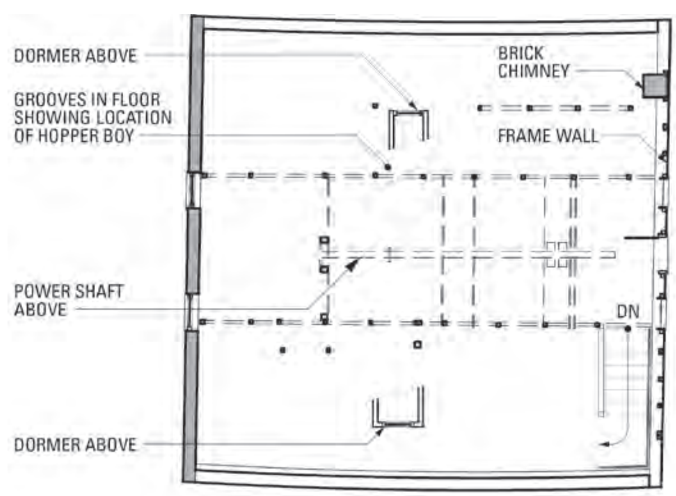
Above: The attic looking west.
Right: Traces of a hopper boy flight arm on the attic floor

The section of stair from the third floor to the attic is the best preserved of the entire stair. It is steeper than the stair on the lower floors but includes the same kind of framing of the landing and the same stringers. It appears to be original to the building. Here, however, the open stringer treads and riser and the original railing survives, with an oval-shaped rail, ogee-topped square newels, and two now-missing rectangular-section pickets per tread (as can be seen from their surviving mortices). The intermediate landing in the southeast corner extends across the stairwell below to run along the south wall.

The three mid-twentieth-century tie rods are visible in the ceiling. Metal straps were added in the 1940s to tie down four of the joists along the north wall, but none were added on the south.

Attic

The attic is one of the most interesting, if least accessible, parts of the mill. The early unpainted rafters and modern sheathing are exposed inside. Small sections of early roof sheathing remain where the dormer roofs intersect the main roof. The wide boards are attached with an early type of cut nail dating from the 1815–1830 period. A shingle nail found on the sheathing under the south dormer roof was hand headed and had a flattened end. Both types of nails date from before 1830. The room is lit by two original windows in the brick west gable, two windows (flanking a dutch door) in the rebuilt frame east gable, and two added dormers, a small one on the north of early date and a later, larger one on the south. The room retains some original tongue-and-groove floorboards over the outer structural bays, although the center section is covered and infilled with temporary boarding.



Attic floor plan, Waterford Mill, StudioAmmons, 2012.

The floor boards in the center of the north side bear the deep circular grooves that indicate the early presence of a hopper boy, one of the inventions of Oliver Evans that helped revolutionize milling in the late eighteenth century. The hopper boy at Waterford Mill, which cooled and dried flour by raking in a circle, was about 7 feet in diameter.

The auxiliary drive shaft and common rafters looking northwest.


Grooves and notches in the vertical posts at the west end of the auxiliary drive shaft (located above) show where bevel gears connected to another drive shaft.

The long common rafters extend from ridge to eave and measure about 5″ wide and 5″ tall. Some are flattened poles of approximately 6″ diameter. They are seated on a false plate and each rafter pair is located directly over the corresponding floor joist. All rafters are lapped and pegged at the apex. The rafters show no evidence of original purlins (long members providing intermediate support for the rafters) or collar beams (members connecting the rafters near the apex). At some point in the mid-twentieth century, before 1984, when they are shown as existing on the framing plan, the Waterford Foundation added new purlins and supporting struts nearly above the two longitudinal beams on the third floor. The few extant collar beams are irregular in form and have been subject to many alterations over the years.

A pair of larger principal rafters (6″ wide x 7″ deep) are located near the center of the roof, on the eastern side of the two dormers. These hewn members appear to be reused from a previous frame building. The angled lap joints on the sides indicate that the two members were probably wall plates in the mill that formerly stood on the same site. At one point the top of an intermediate wall post can still be seen pegged into a mortise in the member.

The absence of a column at the center of the north side of the third floor until 1983–84 may have been due to the presence of the hopper boy directly above and to the bolting machine that stood below it. Similarly, any posts or support walls in the attic would have interfered with the operation of the hopper boy. The reused members may have been inserted as principal rafters to give additional rigidity to the roof at the point where the dormers cut into the structure or they could be original members recycled from elsewhere.

The wooden auxiliary drive shaft that runs east to west above the collar beams is the only remaining element of the original power train. Scars and pulley marks on it may aid in better understanding the mill as more fabric is uncovered over time. It does appear that the top of the grain elevator attached to the wheel eight feet west of the center of the east wall, near where the grain was delivered and cleaned. Three early vertical posts connecting the floor joists to the rafters are located at the west end of the shaft. They appear to have supported a lateral power shaft connecting to the vertical auxiliary shaft rising from the floor below.

VI. Condition and Recommendations Narrative

This historic structure report concerns the Waterford Mill, one of the most important elements in the landscape of the Waterford National Historic Landmark District. The report has been designed (1) to document alterations and additions to the original structure and their subsequent history and (2) to evaluate the condition of all major building elements and the impact of major current policies and practices relating to the physical condition of the historic fabric, in order (3) to make recommendations for repair, conservation, and other changes needed to ensure the optimal preservation and interpretation of the mill.

Specific recommendations are at the heart of this report. The discussion of the structural system is based on the attached evaluation by Robert Silman Associates, structural engineering specialists. The recommendations have been placed in the context of the history of the building and its site and the interpretation of their significance. The interpretation questions that come up in presenting the property to visitors probably remain second only to building stability among the problems that have confronted the Foundation leadership in making decisions in the past. This report will endeavor to clarify the historical process and more recent decisions that have led to the hybrid form that the structure now exhibits. It also deals with future alterations that might further improve its safety and comprehensibility, not only as a historic site, but as an active part of a community, moderated by a realistic approach to maintenance that will best preserve the fabric.

The recommendations are based in a philosophy that emphasizes a light touch with historic fabric such as that codified in the Secretary of the Interior's Standards for the Treatment of Historic Properties and more recent conservation theory. Under this approach, old fabric is rigorously conserved and repairs tend to be reversible and as modest in scope as is possible and prudent.

Of particular interest will be the importance of the added tie rods, the condition of the walls, structural system, and foundation, as well as issues associated with moisture in the basement. The report will evaluate the potential for the addition of public toilets and improved lighting systems. A final section of this part of the report will assemble all the recommendations and prioritize them in context with timelines and cost estimates. Proposed interventions and treatments will be broken out into those of short- and long-term significance, based on their cost and importance within the maintenance and interpretive goals of the Foundation.

Overview

The Waterford Foundation will make decisions about alterations to the property based on the appropriateness of the work and the availability of funds. The condition of the main building and grounds suggests a series of actions. The buildings, grounds, contents, and any proposed exhibits should be provided with the kind of planned maintenance which will guarantee long-term stability.

1. Waterford Mill, the historic centerpiece of the village of Waterford, should be provided with the greatest public access possible commensurate with conservation of its building fabric and contents using current architectural and material conservation standards. This would include an improved standard of interpretive programming offering increased

clarity concerning the appearance and use of the property over time. The importance of Waterford Mill is not limited to the antebellum period alone, but to the ways that the building has contributed to the history and context of Waterford after its conversion to a gradual reduction mill using roller milling technology. In particular, it includes the way in which the preservation of the mill since 1940 has led in the preservation of the village as a whole and to its recognition as a nationally significant resource.

2. The Foundation should ensure that the building's structure, envelope, and systems are maintained over time so that the building and contents are not subject to damage. In addition, wherever possible, needs of the contents should be balanced against the care of the building. Solutions to questions related to interpretive issues should take the unique environmental requirements of the building into consideration.

3. The building and grounds should be made as safe and accessible as possible without compromise to its historic character. Excavation should be accompanied by archeological supervision.

4. Corrections of structural and functional problems should be addressed within the context of a prioritized schedule. Minor repairs and adjustments of the structural and building systems should be made more promptly than projects that adjust interpretive goals or correct non-threatening architectural anomalies.

Architectural Goals

The condition of the Waterford Mill suggests several actions, each requiring capital outlay. Some of the recommendations involve repairing or restoring some elements, while others may require the undoing of past repairs in favor of more secure or less intrusive interventions. All alterations should meet the Secretary of the Interior's Standards and be approved by the National Trust for Historic Preservation, the foundation's easement holder. The building fabric has no overwhelming problems at this time, and its general lack of mechanical systems is a benefit both from a cost perspective and from a conservation position, since addition of HVAC could spur both long- and short-term building damage (differentials in temperature and humidity can lead to stress to building fabric). The repairs of the 1940s, 1980s, and 1990s, while they resulted in great improvement in building integrity, also caused a few serious problems which still have negative effects.

1. **Site**

   Condition: The site is in good condition. The fencing and paths make it possible to safely walk around and observe the mill from all sides. The wheel pit and tail race are partially filled with earth and silt and prevent full drainage of the basement. The metal water wheel is in poor condition.

   Short-term recommendations: It may not be necessary to fully excavate the wheel pit to reach a point below the basement drains for the mill itself, but it is in the Foundation's best interest to establish the bottom of the wheel pit, so that the full scale of the water power system is open to view and so that archeology will no longer be needed when it is time to clean out the pit. Even when the pit is excavated and the tail race is lowered to help it drain effectively, it will be necessary to regularly clean it out to prevent it from filling in and ceasing to drain into Catoctin Creek. As Derek Ogden forcefully observed in a recent communication:

As well as digging out the gear pit the tailrace must also be cleared and graded to become part of the complete drainage after flooding. In the same manner a programme must be developed to regularly maintain the drainage of tailrace. It is absolutely no good to clean out the tailrace with a back hoe once every 10 or 20 years. It needs to be cleaned out, probably by hand or limited mechanical means twice a year. When the mill was fully operational it would have been done every week or month and probably by slaves. Unless there is a maintenance plan the building will continue to suffer from a damp basement because that is the nature of things. With each and every flood there is always large quantities of river silt deposited and it is this which must be removed [Derek Odgen, email 28 Nov 2012].

Part of the excavation of the wheel pit will involve establishing the location of the surviving parts of the surrounding walls, rebuilding those stone retaining walls, and adding protective fencing along their edges. The water wheel should be only be repaired and supported enough to ensure its long-term survival. Provide soil treatment for termites at the perimeter of the building to prevent damage to wooden elements.

Long-term recommendations: Other site improvements discussed below would require additional paths. We recommend that handicapped toilets be built in the vicinity of the mill (see handicap section below). A small parking area to the west of the mill would add to the traffic safety for visitors attempting to back into the road from the parking area near the east front. Consider the addition of a new wooden breast wheel if needed to augment the interpretative program.

2. Exterior

Overall

Condition: The exterior elements are in good condition for the most part. The walls have been repointed and the wooden surfaces kept painted. The standing-seam metal roof and rake boards are in very good condition. Likewise, the doors and windows are generally in good condition.

Short-term recommendations: One area would benefit from immediate repair. The wooden blocking distributing the lateral forces at the ends of the tie rods at the western ends of the north and south walls should be repaired and painted to ensure their long-term preservation. One restored wood sill on the west wall dating from the 1980s is in poor condition and should be replaced as part of a general repair program.

Long-term recommendations: The window sills throughout the building were replaced with concrete in the 1940s. Concrete-to-wood joints like those between the window sills and jambs can lead to moisture damage. Replacement of the sills with wood members would result in a more long-lasting and more appropriate window units, although the concrete sills appear to be adequate for the immediate future.

Walls

Condition: The most severe structural problems suffered by the south wall were effectively dealt with in 1983-84, when the wall was tied back at the center with tie rods. The buildings is now structurally stable although the walls display noticeable bowing and deflection. There are few areas of deterioration in the exterior masonry, which was thoroughly repointed in the 1980s. The face of the north wall on the interior of the added stairway shows some signs of moisture infiltration. This may have occurred over a long period of time and may not threaten the integrity of the building.

Short-term recommendations: The structural consultant strongly recommends as a priority that the walls should be braced at the first-floor level by the improvement of connections between the first-floor framing girders and joists and the masonry walls. The alterations will be designed by the structural engineers. In addition, the engineers recommend that the Waterford Foundation commission a geotechnical analysis of the underlying soils to determine the likelihood of additional subsidence in the future. In addition, the west wall of the basement adjacent to the areaway giving access to the basement shows signs of water infiltration on the interior and exterior and appears to be taking on water, possibly when the drain in the areaway outside the basement door is clogged and the area fills with water. This condition should be observed during wet weather and the cause of the infiltration identified and corrected based on those observations. Tie rods should be tightened as needed. The cause of brick damage inside the added stairway should be determined. Observe the area for ongoing changes over time. Water-proofing or other exterior treatment is not recommended in any area.

Long-term recommendations: The structural consultants, Robert Silman Associates, strongly recommends regularly scheduled biennial testing for movement as described in their attached report. If the monitoring program shows any additional movement, they suggest that the addition of additional reinforcement, possibly including the addition of horizontal ties between the interior structure and the south wall at the attic and lower floor levels to increase stability. All work should be undertaken with the approval of the National Trust for Historic Preservation, the foundation's easment holder, and should follow the Secretary of the Interior's Standards for the treatment of Historic Properties.

West Terrace

Condition: The west terrace is in good condition. The stone walls that surround it are covered with vegetation.

Short-term recommendations: The walls around the west terrace show no signs of structural distress, although the life of the stonework will be prolonged if the vegetation is removed. Interpretations in this area should be upgraded. If interpretative panels are provided in this area, the lack of handicap accessibility will require similar interpretation to be provided elsewhere. See the interpretive design section below.

Roof

Condition: The roof was sheathed with wood shingles until the late nineteenth century, when it was covered with metal roofing. The metal roofing is in good condition. Similarly, the two dormers, which retain, in their irregular finish treatment, evidence of their long and complex history, are in good condition. While painted standing-seam metal is probably the most appropriate roofing material for the mill as enlarged in 1885, wood shingles would be the ideal roof type for a period restoration. However, standing seam metal, having been in use continuously for many years and being a long-lasting and practical solution, may be the best option for the building, given the Foundation's modest interpretive goals.

3. Interior

Basement

Condition: The basement suffers from high levels of moisture and accumulation of debris. The structural engineers found areas of deterioration of interior brickwork on the south and west walls of the basement and a small crack on the north wall. Entry to the basement is currently restricted, since footing is uneven and there is no railing to restrain visitors from entering dangerous areas. According to the attached structural analysis, the basement-level framing differs from the other floors in not being tied into the masonry walls. The former wooden posts that supported the two main beams have been replaced with twice the number of brick piers. The added built-up 2 x 14 beams at the center of the joist spans are supported on metal lally columns (post shores), which show superficial rust and are supported on grouted concrete blocks. These require constant maintenance and impede the view. Many of the key wood posts and canted braces were inadequately supported, as their lower sections resting on masonry bases had deteriorated. The most important of these connections, the bases of the canted column braces and adequate support under the southern bay joists, were improved as part of this project in order to open the building for use in October 2012.

Short-term recommendation: Areas of joist deterioration should be remedied by engineered sisters or new joists placed between the existing joists within a year or when larger loads are anticipated. Areas of insect-related damage should be checked by a wood scientist and remedial treatment performed if recommended. We recommend that all debris be removed. Historic elements should be preserved on-site. The basement floor should be fully excavated in the area of the gear pit under the supervision of an archeologist. The original drains should be uncovered and made functional. The gear pit should be re-cleared after any future periods of high water to minimize moisture damage in the future. Masonry repairs should be addressed as part of an ongoing program of repairs. The hurst frame foundation and the other historic stone foundation elements should be rebuilt, repaired, or repointed. Deep repointing or masonry unit replacement is recommended at the existing cracks on the interior of the basement walls.

Long-term recommendation: When the hurst frame is restored, it will be desirable to provide a place from which to view the basement. The area inside the west doorway could be provided with a platform from which the basement could be safely viewed. In addition, once the hurst frame is restored, it may be desirable (see addendum #4 to project RFP) to replace the brick posts with a smaller number of wood columns and restore the interior more completely. Based on the period of interpretation chosen, if mill equipment is removed from first floor, correspondingly reducing the load on the floor structure, remove the intermediate beams and lally columns that clutter the basement and require constant maintenance.

Hurst Frame

Condition: The hurst frame has suffered from the high levels of moisture in the basement and is currently in a fragmentary condition.

Short-term recommendations: The Waterford Foundation should make it a priority to restore the hurst frame as an essential part of the mill building. To allow it to deteriorate further without repair will result in its complete loss. It is strongly recommended that the Foundation repair the hurst frame masonry support structure and, retaining those members of the frame that are sound, replace missing and rotted elements with new members of similar shape, grade, and species, using the reconstructed design that is part of this report. The existing millstone set should be retained for the short term, since it seems to have been in use in the mill from the early twentieth century. As part of the restoration of the hurst frame, its structure should be made visible from above by means of a glazed panel or other device. The hurst frame's front sill will still be required to support the truss transmitted by the three added first-floor braces.

Long-term recommendations: While we do not recommend a full reconstruction of the power train or original millstone arrangements at this time, nothing should prevent the board from making that decision if conditions should seem propitious at some point in the future. It would be good to reconstruct one of the original millstone sets as part of the overall interpretive program.

First Floor

Condition: The first floor is in relatively good condition. None of the secondary problems mentioned here prevent it being used for craft sales as part of the Waterford Fair. As observed in the attached structural report, the structural system shows significant displacement in the columns and beams supporting the second floor, but braces and shims installed in the past have resulted in a stable and safe condition. Interior masonry at the window heads shows limited signs of cracks and moisture-related deterioration. Diagonal cracks were visible below some windows and spalling of brick faces was observed in the stairwell at the northwest corner, as well as localized displacement and looseness at joist bearings. Approximately 9 joists were sufficiently compromised by excessive notching and inadequate support. Openings cut for the roller mill equipment in the late 1990s left at least one unsupported opening. While many of the timbers exhibit checking, most of the checks do not affect the strength of the members. However the southwest column showed signs of insect infestation and undercutting. Although the columns on the first floor exhibit a substantial lean to the south and east, the displacement, which is of long standing, appears to have been arrested by the previous placement of braces, support columns below, and other structural modifications. The stairs to the upper floors were repaired and the lower flight rebuilt in the 1940s without regard to historical accuracy. The original stairs formed a east-west dogleg incorporating the existing upper flight.

Short-term recommendations: Areas of joist deterioration should be remedied by engineered sisters or new joists placed between the existing joists. The structural engineers recommend this should be done within a year or when larger loads are anticipated. Areas of insect-related damage should be checked by a wood scientist and remedial treatment performed if recommended.

Improve the finishes and appearance of the interior of the emergency exit stair. Based on period of interpretation chosen, remove mill equipment to reduce load on the floor structure.

Long-term recommendations: Areas of repair, including shims, can be distracting and can detract from the appreciation of the historic form of the mill. The Foundation should explore ways of replacing or partially or wholly masking the blocking, shims, and other added structural elements in order to enhance the experience of the historic interior. The Foundation may want to consider restoring the original form of the stairs in order to make a more convincing appearance and improve the circulation of visitors.

Second Floor

Condition: The second floor is in relatively good condition. None of the secondary problems mentioned here prevent it being used for craft sales as part of the Waterford Fair. Plywood has been placed over the flooring. The plywood flooring serves several purposes: It provides a level, safe walking surface and it prevents material sifting between the floorboards. As observed in the attached structural report, the structural system shows significant displacement in the columns and beams supporting the third floor, but shims installed in the past have resulted in a stable and safe condition. Approximately 9 joists were sufficiently compromised by insect infestation and inadequate fasteners. While many of the timbers exhibit checking, most of the checks do not affect the strength of the members. However the southeast column was compromised by a three-inch horizontal hole.

Short-term recommendations: Areas of joist deterioration should be remedied by engineered sisters or new joists placed between the existing joists within a year or when larger loads are anticipated. Areas of insect-related damage should be checked by a wood scientist and remedial treatment performed if recommended. Improve the finishes and appearance of the interior of the emergency exit stair.

Long-term recommendations: Areas of repair, including shims, can be distracting and can detract from the appreciation of the historic form of the mill. The Foundation should explore ways of replacing or of partially or wholly masking the blocking, shims, and other added structural elements in order to enhance the experience of the historic interior. As part of an overall improvement of the finishes to serve interpretive purposes, it would be good to eliminate the plywood flooring, which is visually intrusive. This could be done by determining whether to restore the existing flooring as the finish floor surface or to add new wood flooring on top of the existing flooring to give an historic appearance without losing the historic information about the building's history over time contained in the existing flooring. The final direction would be determined by removing the plywood and examining the condition of the original flooring. The Foundation may, in addition, want to consider restoring the original form of the stairs in order to make a more convincing appearance and improve the circulation of visitors.

Third Floor

Condition: The third floor is in relatively good condition. None of the secondary problems mentioned here prevent it being used for craft sales as part of the Waterford Fair. Plywood has been placed over the flooring. As observed in the attached structural report, the structural system shows significant displacement in the columns and beams supporting the attic floor, but shims installed in the past have resulted in a stable and safe condition on this floor. Approximately 16 joists were sufficiently compromised by excessive notching, insufficient bearing, and limited connections. 5 more joists show signs of deterioration due to excessive waney edges (areas of bark), shear cracks, and moisture-related deterioration of bearings. While many of the timbers exhibit checking, most of the checks do not affect the strength of the members.

Short-term recommendations: Areas of joist deterioration should be remedied by engineered sisters or new joists placed between the existing joists within a year or when larger loads are anticipated. Areas of insect-related damage should be checked by a wood scientist and remedial treatment performed if recommended. Improve the finishes and appearance of the interior of the emergency exit stair.

Long-term recommendations: Areas of repair, including shims, can be distracting and can detract from the appreciation of the historic form of the mill. The Foundation should explore ways of replacing or of partially or wholly masking the blocking, shims, and other added structural elements in order to enhance the experience of the historic interior. As part of an overall improvement of the finishes to serve interpretive purposes, it would be good to eliminate the plywood flooring, which is visually intrusive. This could be done by determining whether to restore the existing flooring as the finish floor surface or to add new wood flooring on top of the existing flooring to give an historic appearance without losing the historic information about the building's history over time contained in the existing flooring. The final direction would be determined by removing the plywood and examining the condition of the original flooring. The Foundation may, in addition, want to consider restoring the original form of the stairs in order to make a more convincing appearance and improve the circulation of visitors.

Attic

Condition: The attic is in relatively poor condition. Several sections of flooring have been removed at the center and the openings covered by thin plywood sheathing, leading to potentially dangerous conditions. Plywood has been placed over the flooring. As documented in the attached structural report, the structural system shows signs of sagging, but the addition of posts and purlins as well as a limited number of sisters along each side have strengthened the roof framing, creating a roof structure that is generally sound.

Short-term recommendations: The attic should be cleaned out of all material not directly related to its former use as a mill. The dangerous sections of attic flooring should be repaired, doing as little damage as possible to existing flooring but replacing missing sections with matching wood. Areas of insect-related damage to any structural elements should be checked by a wood scientist and remedial treatment performed if recommended.

Long-term recommendations: Area of repair, including shims, can be distracting and can detract from the appreciation of the historic form of the mill. The Foundation should explore ways of replacing or of partially or wholly masking the added structural elements in order to enhance the experience of the historic interior. The Foundation may, in addition, want to consider restoring the original form of the stairs in order to make a more convincing appearance and improve the circulation of visitors.

Finishes

Condition: The building materials are generally unfinished. Paint or whitewash was applied mainly on the first floor walls and ceiling. The added stairway and toilet room in the northwest corner have gypsum wallboard interior finishes and wood boards on the outside. Portions of the second floor were plastered. The finishes are in good condition from an historical point of view. The finishes in the stairway and toilet room could benefit from repainting.

Short-term Recommendations: Repaint the interior of the stair and toilet room, including the section of spalled brickwork in the stairway.

4. Systems

HVAC

Condition: There are no heating or air conditioning systems in the mill.

Short-term recommendations: It is not proposed at this time that any HVAC systems be added, since they are not required by any planned uses and their addition might compromise the historic fabric, with its exposed roof structure, unfinished walls, etc. Ventilation is important, so it is not proposed that any openings be permanently closed, such as archways in the basement. Additional passive ventilation should be added in the attic to prevent excessive heat and humidity build-up throughout the building. This could be accomplished by adding a louvered and screened upper door in the existing doorway in the east gable end in the summer months. Entrance of fresh air at the bottom of the building could be ensured by screening and slightly opening the windows along the south side at the first floor. It would be even better to add the humid basement area to the area being ventilated by providing a louvered penetration between the basement and the first floor.

Electrical

Condition: The mill shows the remains of a knob and tube wiring system of power and lights (mostly in the form of remaining "knobs" attached to structural members. Basic electrical wiring has been added in recent decades with the wiring protected in surface-mounted flexible conduit and junction boxes. Lighting is provided with functional fixtures mounted at regular intervals on the ceiling. Wiring and fixtures are surface mounted and unsightly. The electrical system appears to meet minimum code standards.

Short-term recommendations: Although the electrical system appears to meet minimum code standards, the use of plug-in lighting as part of the annual fair is potentially unsafe. The public areas of the building should be fitted with sufficient light sources to make the use of portable devices unnecessary. Such lighting should be designed to enhance the appearance of the mill and emphasize its historic materials and form. We recommend low voltage LED lighting with less visible remote power or track systems recessed between joists for better visibility.

Long-term recommendations: Consider eventual replacement of electrical wiring and fixtures with a more unobtrusive system. Conduit, outlet, and switches should be carefully placed to minimize visual intrusions.

Plumbing

Condition: The building is without any plumbing except the added toilet under the egress stair. The toilet room and fixtures are unusable by handicapped individuals. The toilet room is cramped and unattractive.

Short term recommendations: The fixtures and finishes in the toilet room should be renewed.

Long-term recommendations: There does not seem to be a location for placing a handicapped-accessible toilet inside the mill building that is compatible with its historic significance. The Waterford Foundation should consider, instead, the long-term project of adding a handicapped accessible toilet facility on the grounds of the mill.

5. Handicapped access

Condition: The mill is accessible by wheelchair-bound individuals only on the first floor. The entrance is not optimum, since there is a grassy area outside the door and a slight step up. There is no handicapped-accessible toilet facility at the mill. This will be needed if the mill is to be made available for social and rental functions.

Short-term recommendations: Handicapped access at the east entrance should be improved to make the first-floor completely accessible by leveling the entrance threshold in order to comply with handicapped accessibility standards and providing a brick path from the road to the door. It is unlikely that the Foundation will ever make the basement or upper floor accessible. As a property listed in the National Register of Historic Places, the building will not be required to fully conform to handicapped regulations as long as the owner makes a good faith effort to provide an interpretive experience of the whole on the first floor.

Long-term recommendations: The Waterford Foundation should consider using an original outbuilding such as the scale house across the road to contain handicapped-accessible toilets. Reconstructing most other outbuildings, including the horse barn that once stood west of the mill, is not possible because the area is subject to regular flooding. The building could hold public, handicapped-accessible toilets for use during mill events and by visitors generally, particularly at the annual fair.

VII. Interpretive Plan

Introduction

One goal of this report has been to provide the Waterford Foundation with an over-arching plan for the mill, including its interpretation. Since its acquisition, the Foundation has lightly used the building to serve civic purposes and has resisted attempts to radically alter it for any other purpose. A heroic restoration of the mill would not be impossible to fund given the historic significance of the village and its industrial past. The building carries sufficient evidence of its historic form to make that possible. Instead, the mill has been carefully tended as an educational reminder of the past, but not as a primary magnet for visitors, like other mills at Aldie, Mount Vernon, and Washington, DC. The Foundation has presented the mill as a living part of the village, but without the heavy infrastructure and daily cost of a working mill, with its races, dams, and many moving parts and without the disruptive parking and safety accommodations required by large-scale visitation. In spite of that carefully chosen path, however, there have been persistent problems unique to the watery environment of water-powered milling. Building subsidence and moisture-related decay have troubled the managers of the mill for the entire 69 years, and undoubtedly concerned the many millers who were responsible for the building before that.

Institutional Goals

The Foundation has articulated a goal to use the building both as a symbol of the history of Waterford, a venue for the ongoing annual fair and rental functions, and as a site from which to interpret the use of the building as a merchant mill. There is no interest in using the mill as anything other than a static display of milling history for the foreseeable future nor is there any interest in promoting the mill as a major tourist destination. A sensitive approach needs to be taken to find the proper balance of restoration, stabilization, and preservation while accommodating an appropriate visitor infrastructure that will allow the Foundation both to use the mill for fund-raising and rental purposes and as a static exhibit outfitted as a fully interpreted, safe, and engaging part of Waterford's heritage.

Period of Interpretation

Most historic properties find it useful to establish a period of interpretation for each building or complex of buildings. A well-developed period of significance aids in making decisions at every level of repair, restoration, and reconstruction. This is based on the degree of historic integrity exhibited by the building. The mill as restored best represents the years from 1855 to 1885 (the west wing was built in the latter year). The milling technology best represented by the surviving building fabric is that developed and popularized by Oliver Evans. This was used from its construction in 1818 until the roller milling equipment was added in 1885.

Option #1

The first option is to select as the period of interpretation the period from 1855 to 1885, during which time the building appeared much as it does today. In the future, a closer focus on the period 1855-1865 might be even more pertinent. The historic significance of the mill to Waterford lies principally during the period before the Civil War, when merchant milling was a key factor in the economy of the village and during the war-time period of military activity on the part of mill-owner Samuel C. Means. The milling mechanism that was in place after 1885 and much of the logic of its arrangement is entirely missing and the large western addition that made it possible is no longer standing.

The roller milling equipment salvaged from the Olive Mill works against the Waterford Foundation's interpretive and programming goals. From an interpretive standpoint, the roller mill equipment was never in place without the western additions that provided the storage needed to adapt to the economics of merchant milling in the late nineteenth century. In addition, the re-installation of salvaged roller milling equipment in 1998 was partial. It has resulted in a mixed interpretive message.

Option #2

The second option involves the roller milling equipment salvaged from the Olive Mill. The intention in adding the roller milling equipment in the late 1990s was to provide a static display of the kind of millling that went on in the period after 1885. Retention of the milling equipment would necessitate more work-much of it is not fully enough installed to effectively represent the roller milling period of the building's history. However, the material is in place, the floor supporting it has been stabilized, and some effective interpretation has been accomplished over the intervening years by dedicated volunteers. Keeping the Olive mill equipent in place is a valid option for the Waterford Foudation to consider, although it has its own associated problems, as does any interpretive program for this much-altered building.

Interpretive and Programming Issues

The structural concerns resulting from the weight of the salvaged milling stands led to the installation of the lally columns and 2 x 14 built-up beams in the basement. These temporary solutions obstruct the basement both visually and functionally and should be removed, if possible, as part of an overall strategy for simplifying and rationalizing the structural issues in the basement in conjunction with the reconstruction of the hurst frame. The hurst frame was not used as a major part of the milling process after the mill was converted to roller milling technology. The flooring on which the roller stands are placed has been altered and raised slightly, removing the central part of the mill from availability for regular use. Similarly the flooring above has been compromised by the installation of the barrel packer and will be further compromised if any additional installation of equipment is contemplated.

Access and Circulation

The mill site is well laid out for use by visitors on foot. A visitor can move around the mill to the south and west to view the mill wheel and wheel pit, avoiding the northeast corner where traffic is dangerous. However, handicapped persons cannot easily use this route, since there is no paving and no way to avoid the steps that descend the bank at the former head race. Parking is provided by a gravel verge on the west side of Main Street at the southeast corner of the mill, but backing out into the traffic can be dangerous since it isn't possible to see what is coming around the mill. Entry to the mill is straightforward on grade from the parking area.

The current stair configuration works well for most purposes of the Foundation. The modern stair in the northwest corner provides code-compliant egress with minimal intrusion into the historic fabric. The historic stair is more complex. Much of its fabric dates from the nineteenth century, but it was significantly altered in the 1940s. The original form was a dogleg as shown on the attached plans. It would be useful to study the stair to see if it could be rebuilt to correspond to its historic form, particularly where it intrudes into the area of the hurst frame on the first floor.

It is unlikely that the upper floors of the mill will ever be made wheelchair accessible. The long-term requirements for handicapped access to the mill will probably be best addressed by the establishment of a comprehensive interpretive program that allows handicapped visitors to understand the entire building while remaining on the first floor, using interpretive panels or video presentations. Other forms of disabilities can be addressed through alternate means.

The interior of the mill is currently occupied by a number of disparate objects. These represent a combination of milling equipment and display counters and other furniture connected with the annual craft fair. The material on the first floor makes it difficult to use the mill for rental purposes, such as wedding receptions. The intrusive seasonally-themed material on the uppers floors makes it difficult to use these areas for interpretive purposes.

We recommend that the Foundation reorganize the interior to make both programming and interpretation more effective. Should the Foundation decide to retain some or all of the roller milling equipment, we recommend that the chutes and elevators be visually attached between the floors, but that no more cutting of historic mill fabric be permitted.

On-site Interpretation of the History of Milling

The interpretation of the history of milling on the site can be addressed in a variety of ways. For a recommended period of interpretation from 1855 to 1865, required work would involve removal of the majority of the roller mill equipment, which would open up the first floor for interpretive (and rental) purposes. Panels or other displays would be set up on the first floor to explicate the building's technological and architectural history. The second and third floors would remain in use for the annual fair, while the attic would only be used for special milling-related tours that were carefully conducted by trained guides. The basement would be accessible only from a platform at the west end, from which the hurst frame and other structural elements could be viewed. The mill set currently in place should be maintained as an example of milling technology. Eventually it could be replaced by a correctly scaled and detailed set of millstones located in a historic position in the restored hurst frame.

Mill Wheel and Tail Race

Resolving the long-standing water infiltration problems involves bringing them under a long-term management strategy. The level of the floor of the gear pit, the level and appearance of the water in the wheel pit, and the future uses planned for the basement all depend on a fully articulated vision for the mill. The mill race and tailrace were filled after the mill ceased operation. The wheel pit and tail race were partially excavated in 1998. This report calls for fully clearing the wheel pit, excavating the tail race, and, if possible, rebuilding the stone retaining walls. This will involve leaving the Fitz wheel in situ. The metal mill wheel will survive a long time, even in its current condition, and serves a valuable purpose as a visual clue to the function of the building. Reconstruction of a functioning wood wheel at some point in the future should not, however, be forestalled. It seems hard to imagine that the village will ever accommodate a restored and working mill race, but it may someday be considered.

The Hurst Frame

We recommend the full restoration of the hurst frame, which is in fragmentary condition, to the point that it interferes with the building's structural integrity. The hurst frame is arguably the most interesting and significant surviving part of the mill. If it is not restored as part of a complete plan for the clearing and draining of the basement, it will be lost to deterioration. We have been able to completely record the visible parts of the frame and, with the help of milllwright Derek Ogden, fully devise a reconstructed frame. Examination of the frame during the restoration process will add to our knowledge and clarify the principal question remaining, the height of the top of the frame in relation to the first floor. It appears most likely that the flooring on the frame and the first floor were level.

Lighting

Lighting systems should be discreet but flexible enough for the Foundation to accommodate a variety of uses within the building. Specialized lighting for the Waterford Fair should also be designed in coordination with exhibit and interpretive planning for both the building and its site. Whenever possible, the lighting should be hidden or minimal in size and the quality of light in the space should not make the space feel "fully lit" but should rather allow light to fall on selected architectural elements and exhibits.

Interpretive panels

StudioAmmons' exhibit design team is prepared to develop exhibits in and around the building. We will ensure that our team's research and findings are clearly coordinated with how the building's history and evolution is communicated to the public.

VIII. Cost Schedule

Overview:

The Waterford Foundation will make decisions about alterations to the property based on the appropriateness of the work and the availability of funds. The following list provides costs for major items organized according to the prioritized recommendations in the previous section.

Short-term:

SITE	
Excavate the Wheel Pit	$ 6,500
Lower the tail race to Catoctin Creek.	5,000
Rebuild the stone retaining walls at the wheel pit,.	24,000
Add new protective fencing along the wheel pit and tail race.	3,500
EXTERIOR	
Repair the wooden blocking at tie rods ends and tighten the tie rods as needed.	1,200
Limited repair at window frames and sills.	2,500
Add connections between framing and masonry to brace the S wall at the 1st floor.	1,500
Procure a geotechnical analysis of the underlying soils.	4,500
Correct the water infiltration in the west wall to the south of the basement entry door.	2,000
Reduce the infiltration of moisture visible on the north wall in the egress stairway.	1,000
Provide termite treatment to soil.	1,500
INTERIOR	
Add engineered sisters or new joists as needed to reinforce compromised members.	3,500
Engage a wood scientist to check insect damage and provide remedial treatment	4,000
Remove all debris and stored material from the basement and attic	1,000
Excavate the gear pit, uncovering original floor drains	18,000
Repoint and replace masonry units at damaged areas on the interior	20,000
Remove and store extra roller mill equipment.	1,500
Repair the hurst frame foundation and the other stone elements in the basement	20,000
Restore the hurst frame and the flooring above	30.000
Improve the finishes and appearance of the interior of the emergency exit stair.	2,500
Repair attic flooring, replacing missing sections to match existing.	7,500

SYSTEMS	
Improve passive ventilation throughout the building	$ 2,500
Replace existing electrical system and add low voltage LED lighting	30,000
The fixtures in the toilet room should be replaced	2,000
HANDICAPPED ACCESS	
Level the entrance threshold to provide handicapped accessibility	350
TOTAL	$ 196,050

Long-term:

SITE	
Provide handicapped toilets in the vicinity of the mill	$ 24,000
Add a parking area to the west of the mill	12,000
Add new access paths	5,000
Add a new wooden wheel and flume if it will assist in the interpretative program	35,000
EXTERIOR	
Replace the concrete sills with long-lasting wood members	15,000
If regularly scheduled testing shows any structural movement, add additional reinforcement as determined by structural engineers	TBD
INTERIOR	
Provide a viewing platform inside the west doorway to the basement	6,500
Replace the brick posts with wood columns and restore the interior more completely	15,000
If the floor loading above is reduced, remove the intermediate beams and lally columns that clutter the basement and require constant maintenance	15,000
Reconstruct one of the original millstone sets as part of the interpretive program	15,000
Replace or mask the blocking, shims, and other added elements through the interior	12,000
Restore the original form of the stairs from the first floor to the attic	20,000
Remove the plywood flooring on the second and third floors and restore the flooring	24,000
TOTAL	$ 198,500

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Appendix A

Comments On Drawings WF02 and WF03 by Derek Ogden November 2012

(Drawing WF01 was issued in 1999 as a flow diagram for the roller mill equipment from the Banco Mill)

Drawing WF02.

1. Almost the first thing I noticed about the size of existing hurst frame was how small it was in height, namely 7ft 6in from floor level to top of Mill Beam. Many old hurst frames are at least 12in. taller and some even more. This requires the gearing to be somewhat smaller than most, although it will not make any difference to the operation or location of the drives to three pairs of millstones.

2. The second important item to be noticed was that the rear sill (4) is at the same elevation as the front sill (3) which makes things difficult but not impossible to accommodate the water wheel shaft (22) and Master Cog Wheel (16) without interfering with the sill. It is more usual to have the rear sill about 12 inches lower than the front sill so that it provides good clearance of shaft and prevents severe cutting out of sill to give adequate clearance. It is quite obvious from the existing timbers, particularly the front and rear sills that they have always been at the same elevation. This is not particularly difficult but it does mean the water wheel shaft (22) must pass above the rear sill (4) and not below it because that would put the counter shafts (20) and (21) totally out of alignment with the hurst frame and make the pit beneath much too deep.

   From evidence we can see on site today it is obvious the front and rear sills were built in these positions. It is difficult to fault the Millwright who constructed the hurst frame and machinery but he must have had his reasons for making such a design. Perhaps it was his first hurst frame !

3. It will be observed that the existing Fitz water wheel shaft is at a much lower level to my wooden water wheel shaft as now drawn, in fact it is about 4ft. 6in. lower. When the original Fitz water wheel was fitted it was arranged to drive the new Roller plant installed in the Mill and had no connection with the early wooden gearing or millstones of the Oliver Evans system. Advantage was taken of the old hurst frame pit and used for the new iron shafts and gearing which would have been accommodated quite conveniently.

4. From my drawing WF02 you will see the wooden gearing and shafts fit very well into the existing dimensions of the hurst frame. It has provided the usual arrangement of three run or pairs of millstones – one driven via a short countershaft (20) and the other two pairs from the long countershaft (21). This is a very typical design as shown and described in the Evans book "The Young Mill-Wright and Miller's Guide."

5. With the wooden water wheel shaft being at a higher level it will dictate that the wheel will be much larger in diameter and as the water supply level is unaltered suggests it would have been about 18ft diameter. The water from the flume would allow the wooden water wheel to be of the High Breast type and rotate in opposite direction to the existing Fitz overshot wheel.

   I am happy with this type of water wheel because it will provide good horsepower to drive three run of millstones. When Waterford Mill was operating as a Merchant Mill it is most likely that only two run of millstones were in constant use while the third pair were being cleaned and dressed. That was always the usual arrangement of things in Merchant Mills producing high quality and long lasting export flour.

6. I have considered the millstones were almost certainly 4ft. 6in. in diameter and all of French burr origin. This diameter would go well with a high breast water wheel running at about or a little below 10 revolutions per minute. It is the peripheral speed of the millstones which is the important factor and this arrangement will suit quite well. Some Merchant Mills used millstones of 6ft and even 7ft diameter in order to slow down the overall speed and thereby constant maintenance of them.

   Therefore, the gearing has been designed to suit a high breast water wheel and 4ft. 6in. millstones. I have given the Master Cog Wheel 72T, the wallowers 19T, Little Cog Wheels 50T and the Stone Nuts 15T. You will notice the driven gears have an odd number of teeth which is good engineering practice and does not allow the teeth to run always in the same opposite teeth.

7. You will note I have added Tomkin Posts (13) together with spur blocks (14) and bearing beams (15) which are necessary to support water wheel shaft and the two countershafts.

8. I have added an auxiliary drive gear (37) and shaft (38) because this is usual for the drives to other machines such as cleaners, dressing machines and hopper boy on the upper floors of the building. I have deliberately shown this feature once on the end elevation because adding it on all of the elevations will obscure other more important features of machinery within the hurst frame.

9. In setting out my drawing WF03 I see a possible solution to the mystery of the two large and three small holes with semi circular arches which are cut into this wall. I believe they were added at the time of the Roller Plant installation, or shortly thereafter, to allow improved ventilation of the basement. This was necessary because having the headrace water come right up to the corner of the Mill at this point does provide a constant leakage from race into

basement. The problem is greatly aggravated because of the drop in elevation from headrace to basement at this corner of the building. No amount of prevention will stop ground water seeping into basement from here.

This was never appreciated in modern times and consequently the hurst frame pit was never cleared of debris and a constantly damp floor in the basement is the result. This is now a problem during times of bad flooding when water will be flowing off highway and not able to get away because of high water in the tailrace. The hurst frame pit must be cleaned out and drainage holes cleared to keep this problem under control.

When looking carefully at the wall of building it can be seen that the brickwork has been altered and repaired many times, particularly in the region where the wooden water wheel shaft entered the building to the hurst frame.

10. The Headgate and Flume are normal design practice for an Oliver Evans Period Merchant Mill. I have omitted the control gate detail on the plan shown on drawing WF02 but it is shown on Elevation WF03.

—Derek Ogden – Millwright
15th November 2012.

Email message, 28 Nov. 2012, from Derek Ogden, Millwright to Gibson Worsham, Architect, StudioAmmons.

Dear Gibson,

Yes I am aware of the discrepancy concerning the stone bearers but thought it best not to say anything about it when I sent you the drawings because I knew you would find it yourself and better appreciate the problems. Stone bearers are usually set about 3 inches below the top of Mill beam so the bedstone can be located inside a cutout to accommodate them but at Waterford they seem not to have done this or appreciated the need for it. The top surface of a Mill beam is normally recessed over half the width to accommodate a 3 inch thick planking which covers the entire surface of the hurst frame and around each bedstone,and it is into this that the top tenons of the two Tomkin posts are located. Then on top of the 3 inch planking is fitted a 1 inch thick finish boarding laid at 90 degrees to the 3 inch planking. You will then see that the hurst frame is very secure and very strong to take the three run of millstones. I hope this description makes sense. As the existing timbers do not show this feature I do not see any problem with you putting the stone bearers level with the top of Mill beam.

With regard top the water wheel shaft cutting through the rear sill, I have seen this problem many times and often the shaft is rounded in this area or even slightly undercut. This does give a little more strength to the sill but I do not like reducing the diameter of this very long shaft because it already has a heavy dead load to take with an 18 ft diameter wooden wheel. Added to this will be the live load when operating and I do feel this hurst frame may have had some issues with regard to vibrations from the wooden gearing being transmitted to areas where we do not want it. The vibrations are not caused by the millstones being out of balance but through human error in not being able to make the gearing of perfect mesh with hand tools. This is also why I have made sure gears with an even number of teeth always drive gears with an odd number of teeth to reduce such vibration and to stop them meshing into the same teeth. But then all mills are different and that is what makes them so interesting plus with a little thought it is sometimes possible to get inside the mind of the original builder to see whether he might be an experienced millwright or perhaps a beginner. I have also thought that anyone trying to get inside my mind over gearing will be in for a few surprises they were not expecting.

Thank you for taking the time to look into these questions as it is such a pleasure for
me to work with someone who appreciates such problems and discrepancies.

My best wishes .... Derek

Appendix B

Glossary of Architectural and Mill Terms

The mill-related terms in this report are based on those used by millwright Derek Ogden for Oliver Evans-type mill gearing and equipment. They may differ from some terms used by others for various types of historic gearing.

American Bond—a brick pattern involving regular courses of stretchers with occasional bond courses of headers.

Architrave—the molding framing a door or window in classical architecture.

Auxiliary Drive Gear—a large gear attached to the Auxiliary Drive Shaft.

Auxiliary Drive Shaft—the vertical shaft powering the machinery in the upper part of the mill, including the Hopper Boy.

Batten Door—a door made up of vertical boards fastened together by two or three horizontal battens on the rear.

Bay—the openings, whether doors or windows, in a facade.

Bead—a small curved molding along the edge of a board.

Bedstone—the bottom of the pair of mill stones. Unlike the upper stone, it does not move.

Breast Wheel—in situations where the fall of water is insufficient for an overshot wheel with a large diameter, a breast wheel was often used. Water fills the buckets of the breast wheel at a point about even with the shaft.

Bridge Posts—the vertical members that support and guide the Bridge Tree.

Bridge Tree—The member that spans the Hurst Frame and carries the bottom of the spindle at each pair of millstones. One end is pinned and the other loose so that the height of the runner stone can be adjusted.

Buhr Stone—a tough, silicified limestone formerly used to make millstones., imported from France.

Circular Sawn—sawn by a mechanical saw with circular blade that leaves curved marks.

Clerestory—continuous windows incorporated into a roof structure that light a room from above.

Collar Beam—part of a roof framing system the ties the rafters together just below the apex, to prevent the rafters from spreading, to which the ceiling of a garret is sometimes attached.

Common Rafters—the slender, usually principal roof members with their feet on the plate and usually lapped and pinned to each other at the apex.

Corbelling— brick or masonry work in courses built with one row projecting slightly beyond the other to create a stacked effect, like a series of corbels.

Countershaft—a horizontal shaft, carrying a Wallower and one or more Little Cog Wheels.

Facade—a principal front of a building or other important architectural elevation.

False Plate—a horizontal timber situated along the top of a wall at the level of the eaves for bearing the ends of joists or rafters.

Flemish Bond—a brick pattern made up of alternating stretchers and headers in an ornamental pattern.

Flume—the wooden structure that conveys the water from the Head Race to the control gate.

Front Sill—the inner bottom beam running of the Hurst Frame running lengthwise.

Gear Pit—the area excavated inside the mill's basement, often corresponding to the Hurst Frame, to make room for the gearing.

Head—the horizontal member at the top of a door or window.

Head Race—the mill race above the Water Wheel.

Header—the short end of a brick laid horizontally.

Hewn—roughly flattened sides of a timber member.

Hopper Boy—an invention of mill innovator Oliver Evans that automatically dried and cooled the meal by means of a revolving rake.

Hurst Frame—the internal framework supporting the gears and mill stones. This isolation prevents damage to the building from the vibrations of the workings.

Jack Arch—a flat arch made of wedge shape bricks or stones that uses the compressive strength of the masonry in the same manner as a curved arch.

Jamb—the side members of a door or window.

Joists—the principal members of a frame building to which the floor or ceiling is attached.

Lap Joint—wood joint in which corresponding inset sections in two members are laid together.

Lintel—a wooden or stone member spanning a door, window, or fireplace opening.

Little Cog Wheel—attached to the Countershaft to transfer power to the Stone Nut below each pair of mill stones.

Master Cog Wheel—attached to the opposite end of the Water Wheel Shaft from the Water Wheel —also called the Pit Gear—it transfers power to the Countershafts by means of the Wallowers and to the Auxiliary Drive Shaft by means of the Auxiliary Drive Gear

Mill Beam—the inner top beam of the Hurst Frame running lengthwise.

Mill Stone Spindle—the axle on which the Runner Beam Turns.

Mortise-and-Tenon— wood joint in which a projecting reduced end of a member is inserted into a corresponding hole in another, often fixed in place with a peg or pin.

Muntin—the slender members separating and supporting the panes in a window.

Overshot Wheel—a vertical waterwheel that is turned by water that shoots over the top filling the buckets and turning the wheel primarily through the weight of the water.

Penciling—narrow white lines added over mortar joints to enhance the appearance of regularity in brick masonry.

Pinned—method of securing wood joints by means of a peg or pin inserted into round hole though the members.

Pit-sawn— sawn by hand with a two-man saw, with one sawyer in a pit dug below the member being reduced, characterized by slightly varying, nearly straight saw marks.

Plates—the topmost horizontal members in the walls of a framed building.

Posts—the principal vertical members in a framed building that carry the most weight, they usually forms the corners, others are spaced at regular and flank the door and window openings.

Purlin—a horizontal beam that provides intermediate support for the common rafters of a roof construction.

Rake Board—the board that descends along the end edge of a roof.

Rear Sill—the outer bottom beam in the Hurst Frame running lengthwise.

Rowlock—a brick laid on the long narrow side with the short end of the brick exposed.

Runner Stone—the upper stone in a pair of millstones. It is carried on a Spindle turned by a small gear called the Stone Nut.

Scarf Joint—a popular way of joining two lengths of timber into a single member.

Sill—the lowest member of a framed building, laid on top of the foundation or spanning piers.

Stone Bearer— the pairs of beams that span across the Hurst Frame and carry each one of the pairs of mill stones.

Stone Nut—a small gear driven by the Little Cog Wheel transferring power from the Countershaft to the Spindle driving each Runner Stone.

Stretcher—the long side of a brick laid horizontally.

Studs—the slender secondary vertical members in a frame building that carry the siding and lath.

Tail Race—the waterway by which water is removed from the Wheel Pit.

Top Rear Rail—The outer top beam of the Hurst Frame running lengthwise next to the exterior wall.

Voussoir— a wedge-shaped stone or brick that is combined with others to construct a jack arch or curved arch.

Wallower—a gear connecting the Countershaft to the Master Cog Wheel or Pit Gear.

Water Wheel—the source of power for a watermill. It is mounted on the Mill Wheel Shaft and transfers the energy from the fall of the water into the rotation of the shaft.

Water Wheel Shaft—carries the water wheel. It can also carry the Master Cog Wheel or Pit Gear at its opposite end.

Waney—descriptive term for sawed lumber with a natural (bark) edge intact.

Weatherboard—siding made up of sawn boards attached horizontally to a framed wall with the lower edges lapped to shed rain.

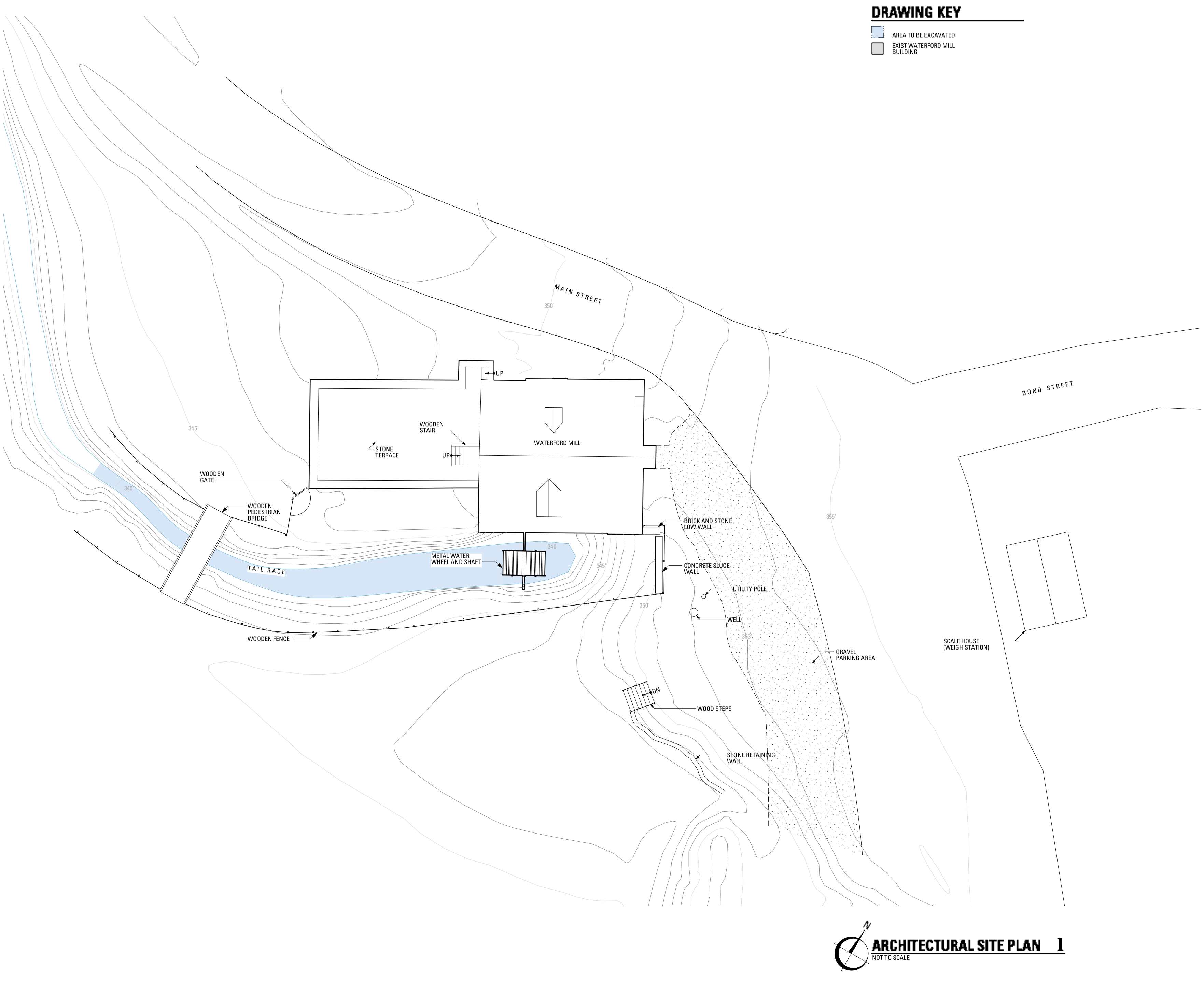
Wheel Pit— the area excavated around the Water Wheel to permit it to turn freely.

Wrought Nails—hand-made nails with a round-shaped head.

Wythe—a continuous vertical section of brick masonry of a single unit in thickness.

Appendix C

Waterford Mill Drawings



ARCHITECTURAL SITE PLAN 1

NOT TO SCALE

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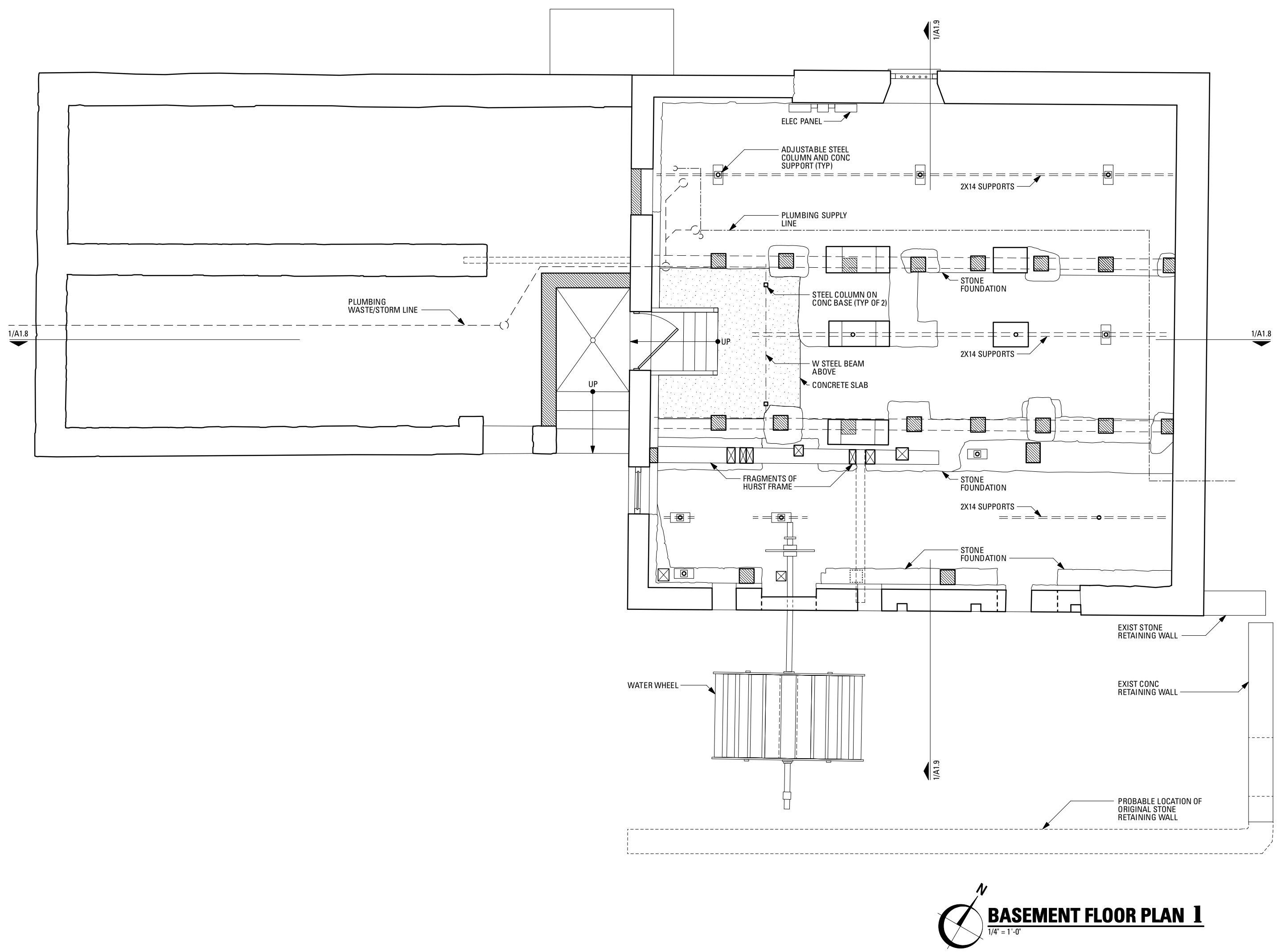

BASEMENT FLOOR PLAN 1
1/4" = 1'-0"

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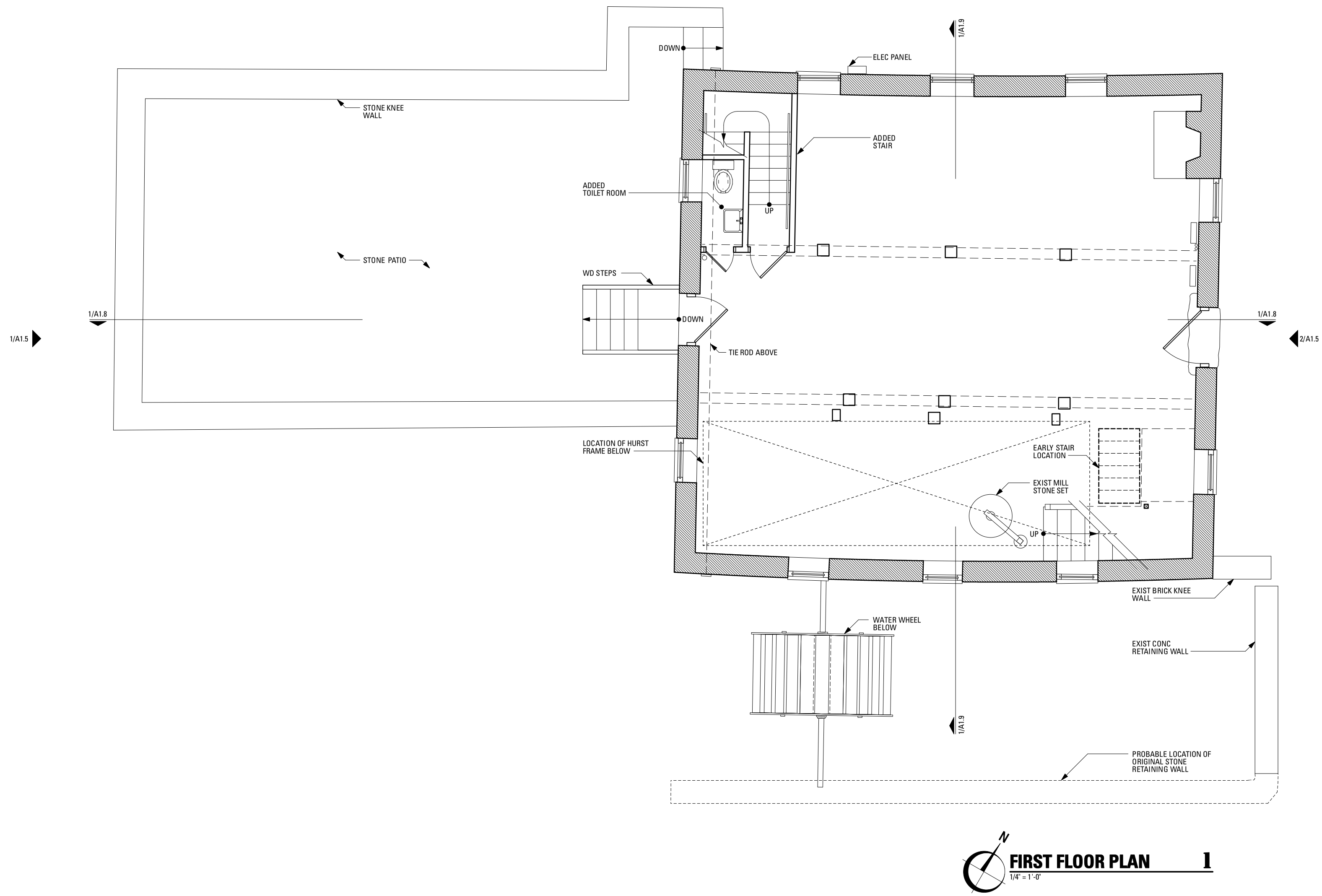

FIRST FLOOR PLAN 1

1/4" = 1'-0"

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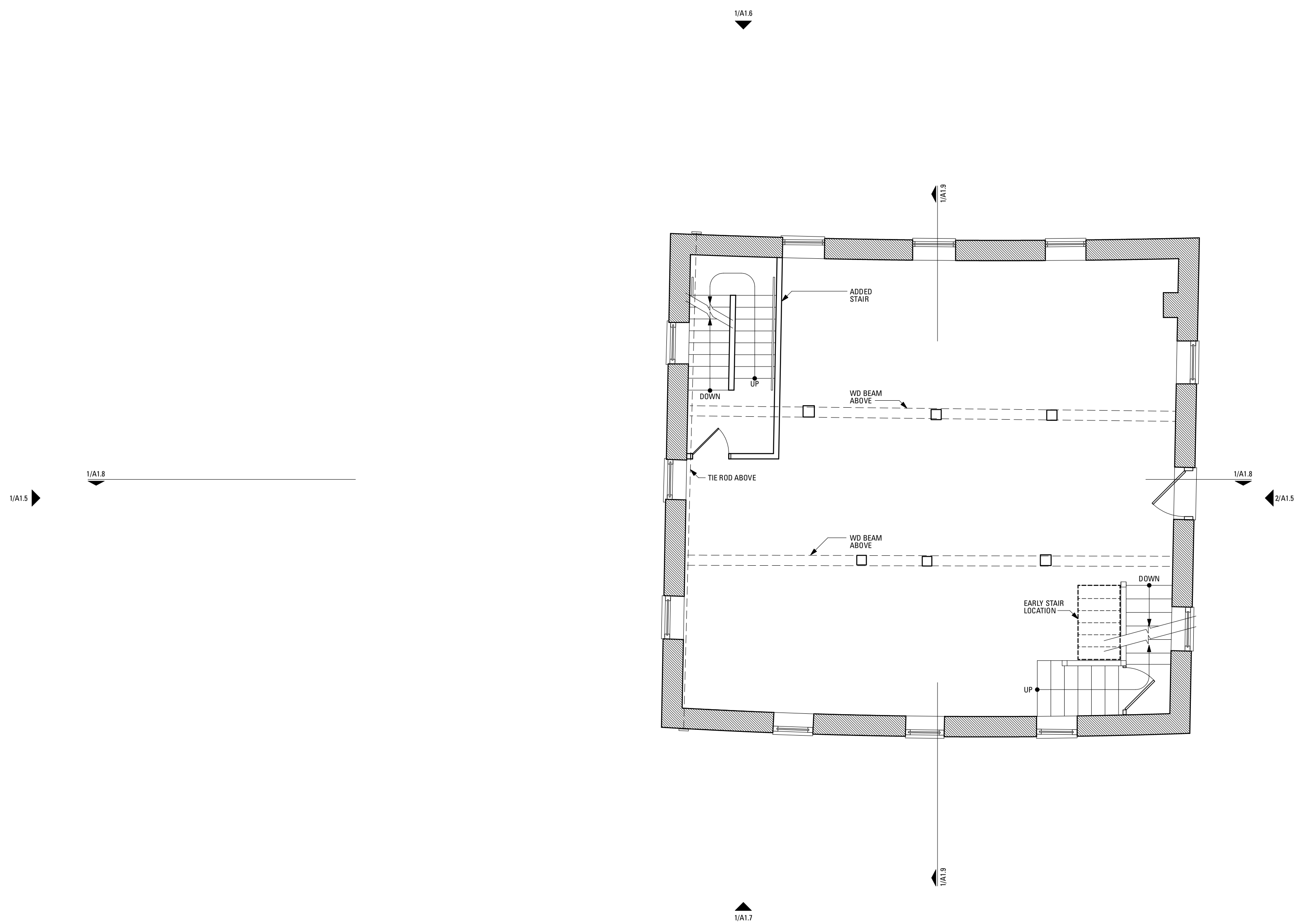

SECOND FLOOR PLAN 1
1/4" = 1'-0"

THE WATERFORD MILL

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SHEET TITLE
EXISTING FLOOR PLAN

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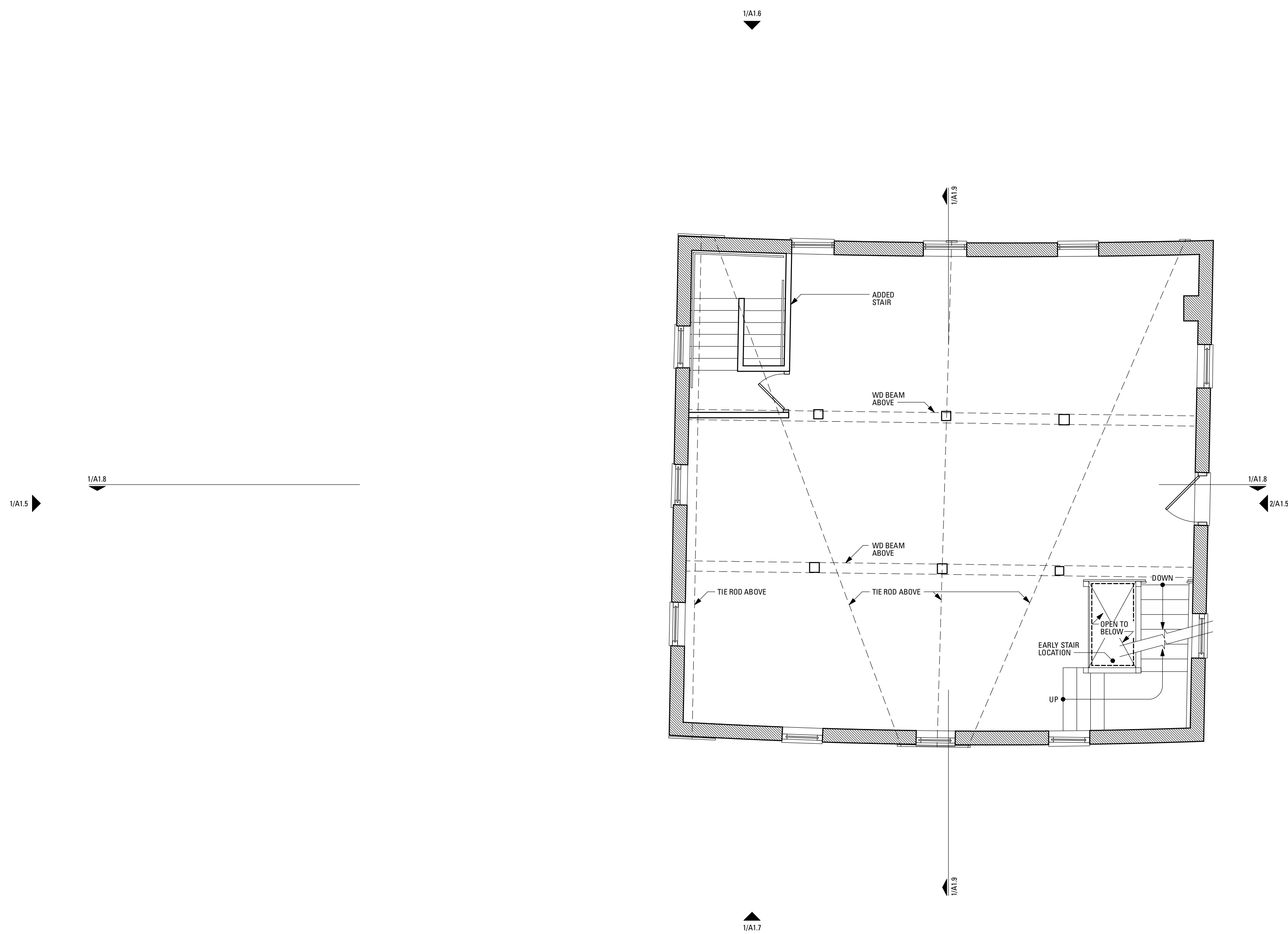

THIRD FLOOR PLAN 1

1/4" = 1'-0"

THE WATERFORD MILL

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SHEET TITLE
EXISTING FLOOR PLAN

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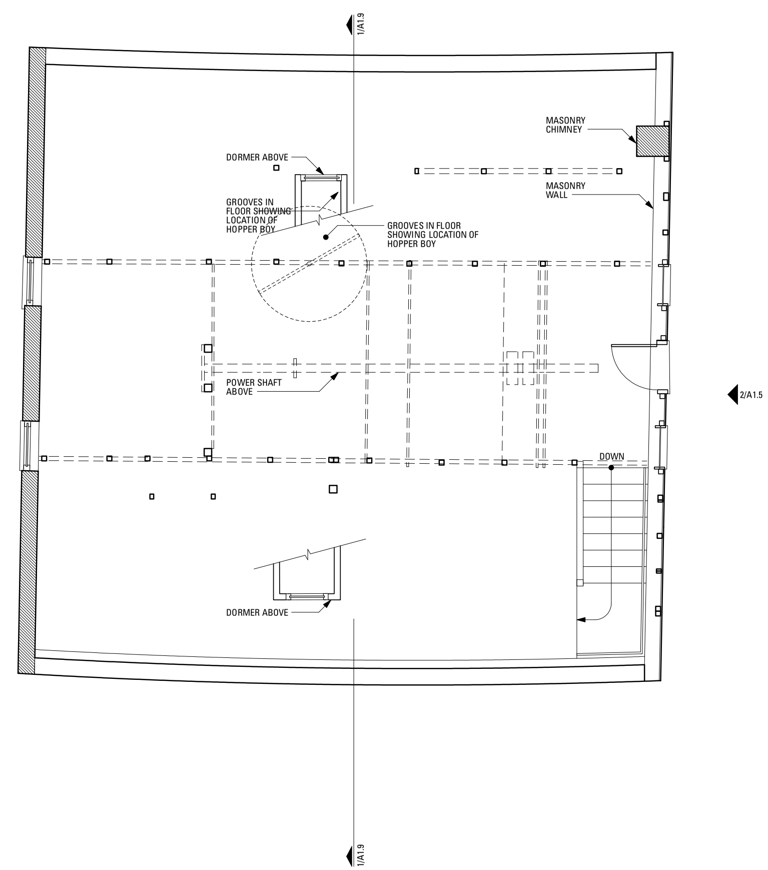

ATTIC FLOOR PLAN 1

1/4" = 1'-0"

THE WATERFORD MILL

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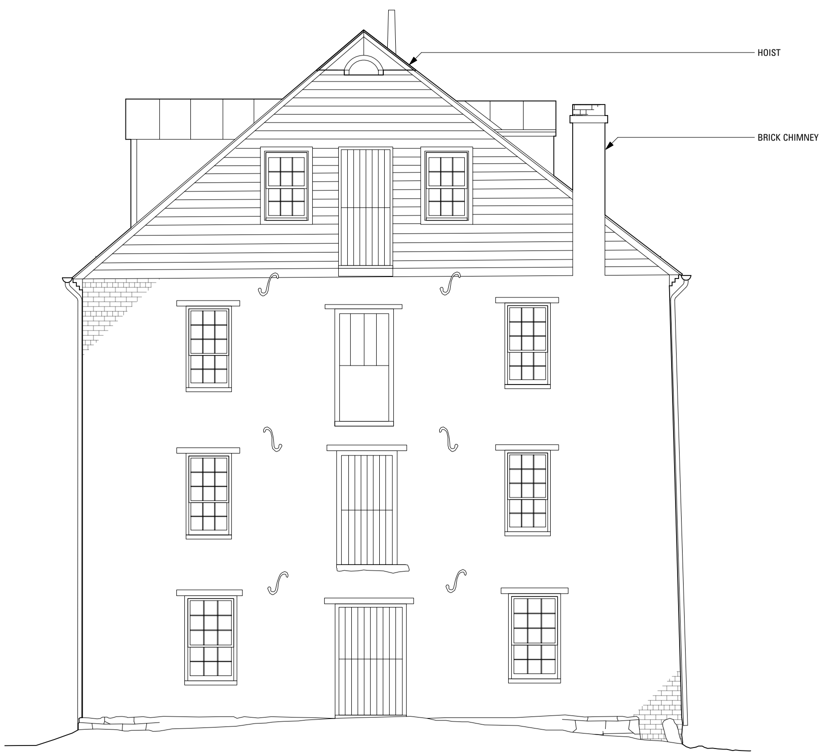
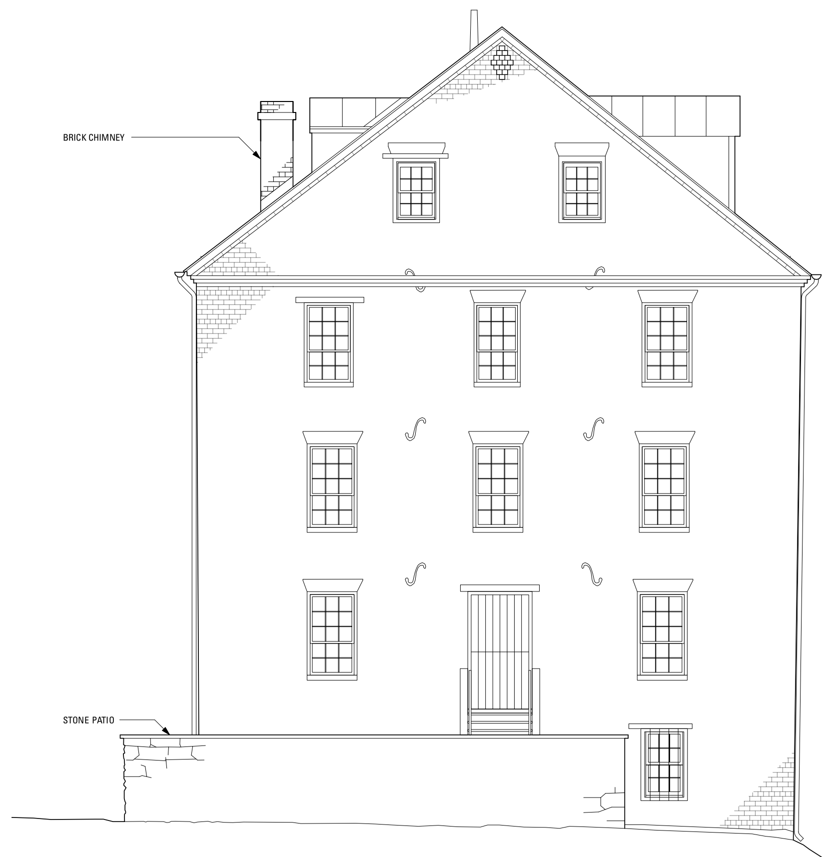
SHEET TITLE
FLOOR PLAN

SHEET NO.
A1.4



EAST ELEVATION 2
1/4" = 1'-0"



WEST ELEVATION 1
1/4" = 1'-0"

THE WATERFORD MILL

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SHEET TITLE
ELEVATIONS

SHEET NO.
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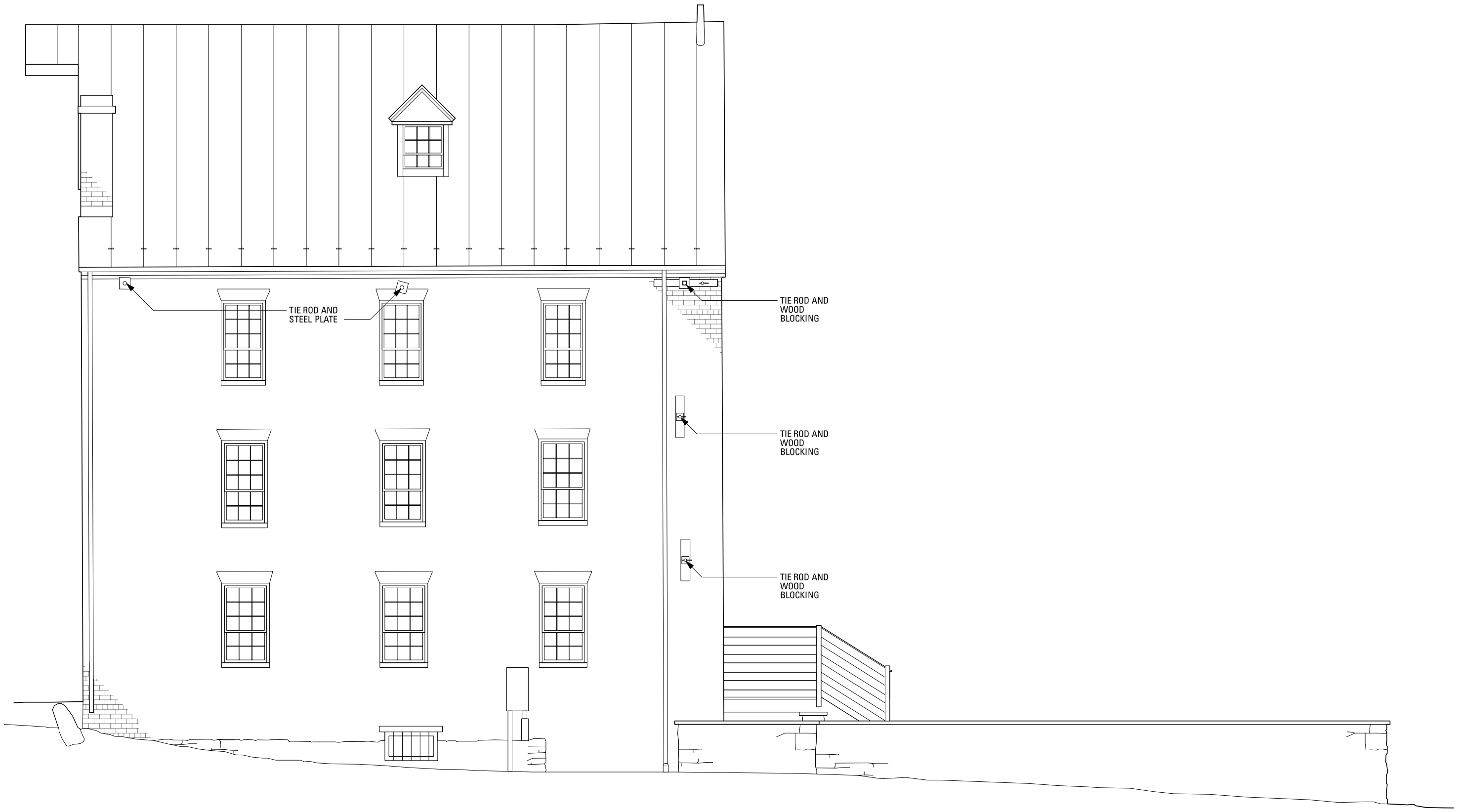

NORTH ELEVATION 1
1/4" = 1'-0"

THE WATERFORD MILL

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SHEET TITLE
ELEVATION

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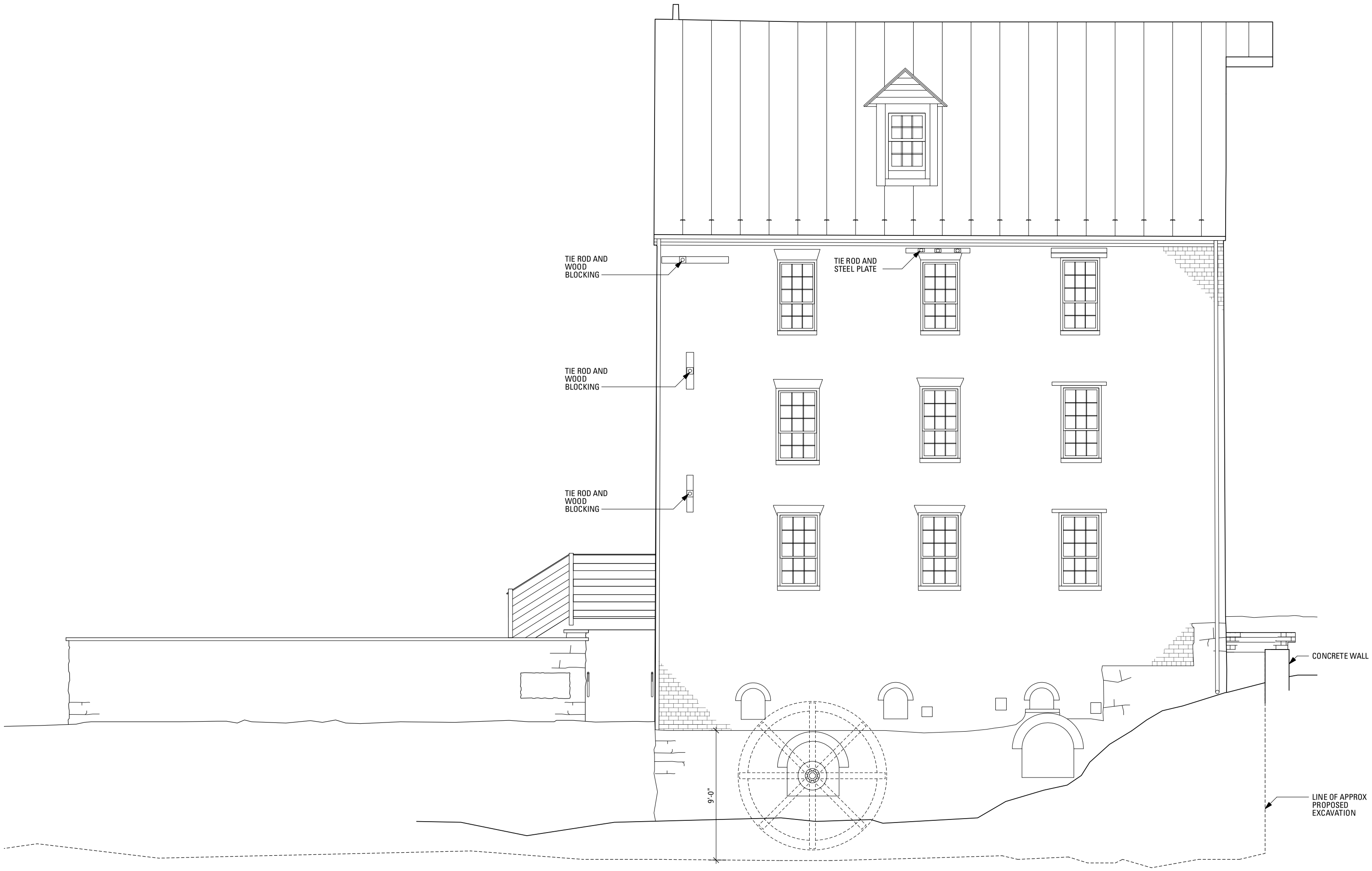

SOUTH ELEVATION 1

1/4" = 1'-0"

THE WATERFORD MILL

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ELEVATION

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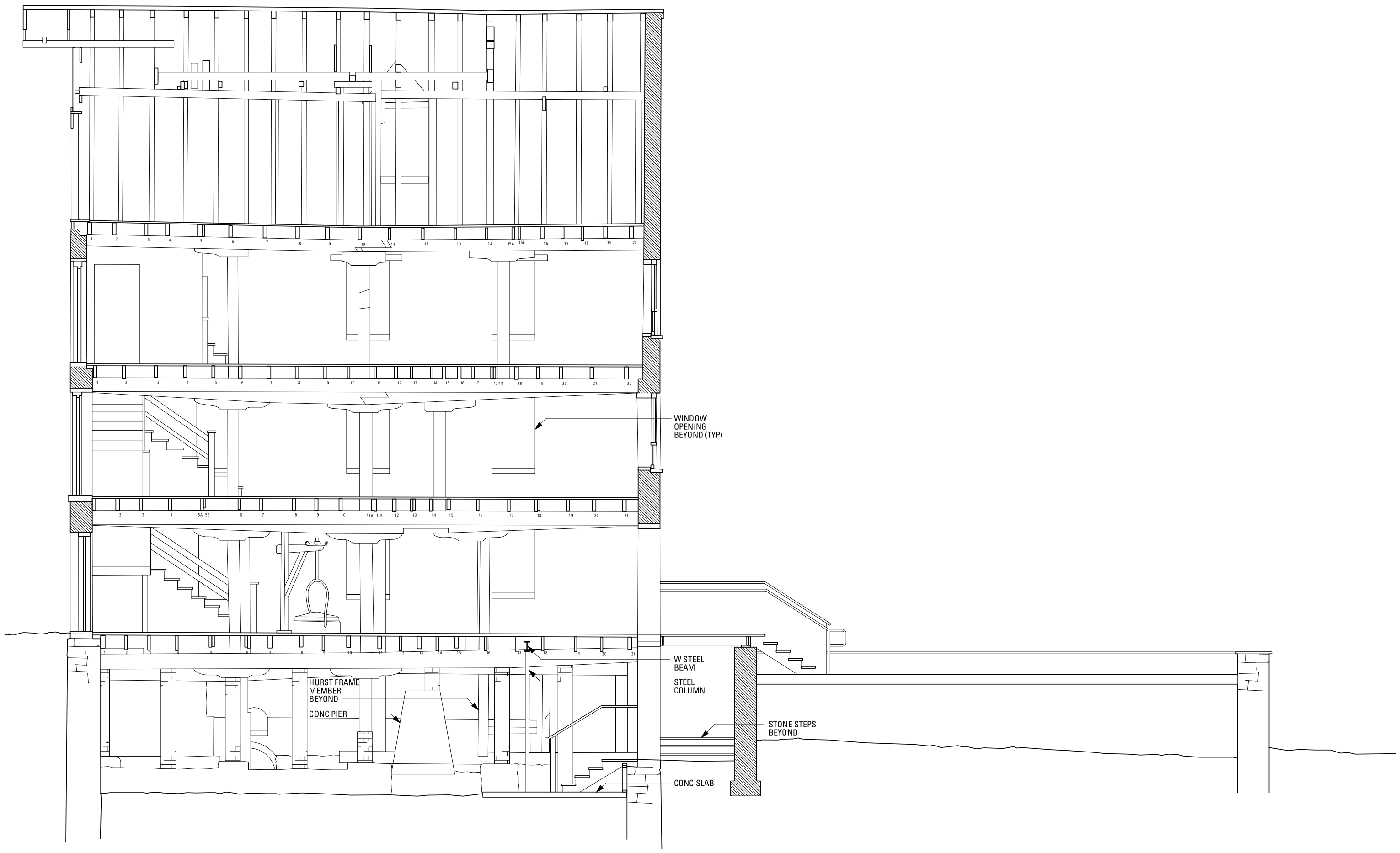

SECTION 1
1/4" = 1'-0"

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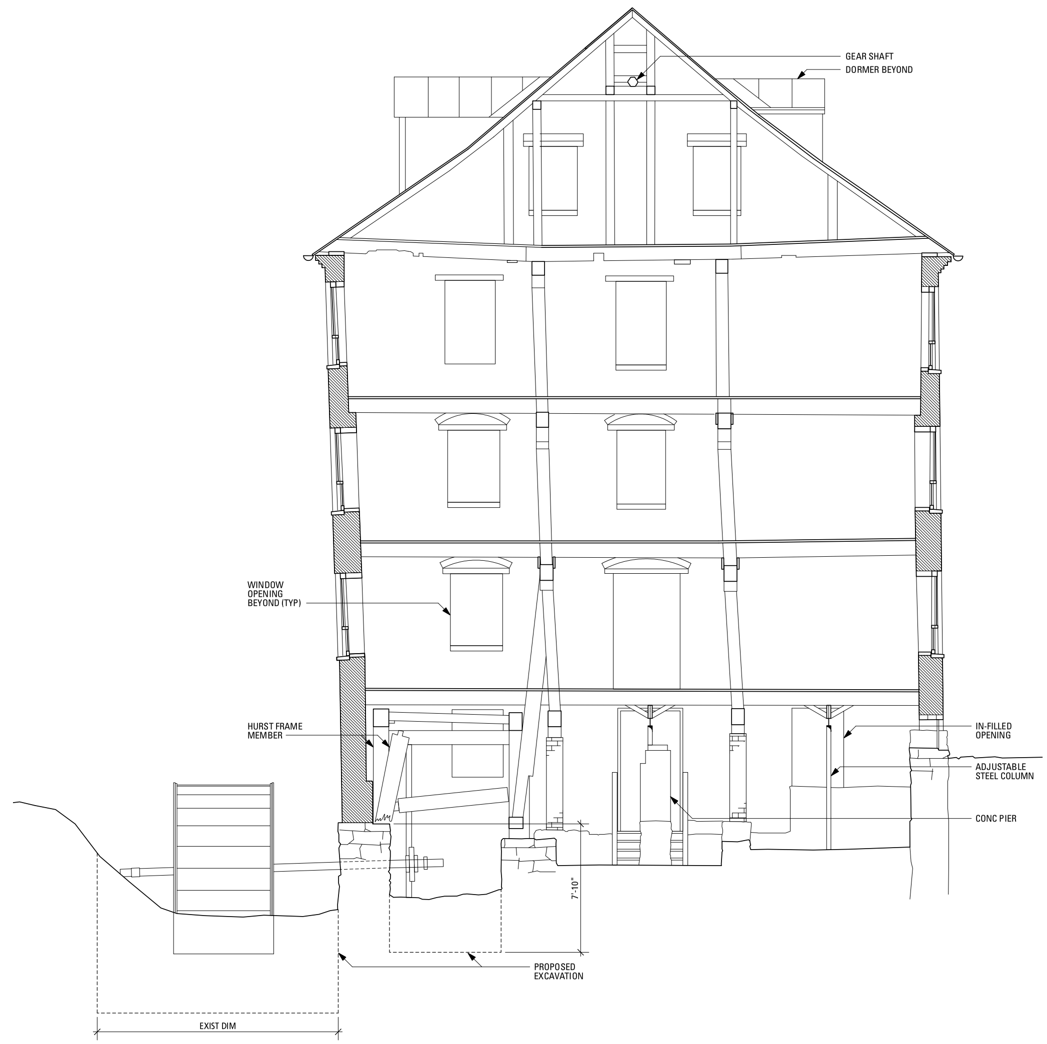

SECTION 1
1/4" = 1'-0"

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A1.9

Appendix D

Waterford Mill Historic Structures Report

Robert Silman Associates, Structural Engineers

ROBERT SILMAN ASSOCIATES
STRUCTURAL ENGINEERS

Waterford Mill Historic Structures Report

RSA PROJECT NO. W2862
November 16, 2012

PREPARED FOR:

StudioAmmons, Inc.
235 North Market Street
Petersburg, Virginia 23803
Attn: Mr. Terry Ammons, AIA

By:
Robert Silman Associates, PLLC
1053 31st Street NW
Washington, DC 20007

TABLE OF CONTENTS

SECTION **PAGE**

Introduction

The Old Waterford Mill building located at 40105 Main Street in Waterford, Virginia dates to 1818-1819. Milling was active within this historic masonry structure, until 1939. The mill was purchased by the Waterford Foundation in 1944, functioning for their operations since that time. Over its long history, the building has experienced structural movement, deterioration due to shifting and flooding, as well as some designed modifications. Robert Silman Associates (RSA) has been retained by StudioAmmons, Inc. (SA) to perform structural engineering services to assist in the preparation of a Historic Structures Report (HSR) of the Waterford Mill.

Project Scope

As part of the Waterford Mill HSR project, RSA's scope includes the following items below. These tasks will be included in this report.

1. Review of previous structural reports and assessment of structural interventions that were made to the building based on these previous studies. Based on our review of this provided information, the laser scanning performed by others as part of the ongoing efforts, and our own independent structural investigation, RSA will attempt to assess if movement in the mill's walls is currently active.

2. Survey of existing conditions and identifying any urgent structural issues that need immediate attention. Additionally, RSA shall make recommendations for the long term stabilization and preservation of the structure.

3. Produce structural drawings which overlay existing framing construction and conditions.

4. Review cost estimate for structural repair scope of both the short term and long term recommended actions.

Investigation

Review of Available Documents

RSA performed a review of the provided available documents to initiate the structural investigation. For a list of the available documentation, see the bibliography in Section 8 of this report. This information, consisting of construction documents and previous millwright and engineering reports, were helpful in obtaining a background to the project and understanding previous investigation and construction efforts (see Building Chronology below for a summary of structural repairs and modifications). Additionally, preliminary structural analyses were performed by others to estimate the allowable live load capacity of the existing roof and floor structure.

Visual Investigation

Following our review of the available documentation, RSA performed a visual structural survey of the Waterford Mill on July 12, 2012. RSA personnel obtained access to the structure thru the Waterford Foundation and ladders were provided for our use. In addition to documenting existing framing conditions (for additional information see Appendix B: Existing Framing Plans), RSA also conducted sampling of selected structural framing members for wood species identification (see Material Testing below and Appendix C for additional information). These samples were reviewed by a wood scientist and provided insight to materials utilized in the mill construction, areas of later modifications and or repairs, and helped to refine the assumptions which are utilized for the estimation of live load capacity.

General Structural Description of Existing Mill

The Waterford Mill is a three-storied early-industrial building with a fully enclosed basement and attic space (Figure 1). In plan, the structure is approximately 36 feet square and is oriented with the cardinal directions -- its gabled roof ridge running east-west. From north to south; the site exhibits a noticeable reduction in grade elevation. Along the south elevation, the mill incorporates a water wheel within an existing raceway (ditch) running from east to west and depositing into the creek just beyond the property line (Figure 2). The exterior walls of the mill are constructed of unreinforced brick masonry. These walls are in-turn supported by unreinforced rubble stone masonry foundation walls below grade. The roof and floor systems are constructed of wood-framing. Typical floor joists and roof rafters span in the north-south direction. Spanning east-west between three pairs of columns, heavy timber beams are set below the joists and divide the space into three bays. Isolated stone foundations provided base support to the interior wood columns. Integral to the mill construction is the Hurst frame. This heavy timber structure supported the mechanical systems of the mill; including the waterwheel drive shaft, associated gearing and grinding wheels.

Roof Framing

The gabled roof is constructed with the ridge spanning in the east-west direction. At the center of the roof, two dormers are constructed. The west gabled end is constructed of brick masonry while the east end is constructed of wood studs. The east gabled end and the dormers are clad with horizontal timber sheathing boards. The roofing consists of galvanized sheeting fastened to wood roof boards (slats). These 7/8"x5-1/2"wood roof boards are spaced at 10" on-center (o.c.) and nailed to the top face of the existing rafters (Figure 3). The rafters were noted to be highly variable in size and cut. The central rafters were generally comprised of small saplings with a diameter up to 6" while the remaining rafters were observed to be sawn to 4"±x4-1/2"± dimensions. Despite the shape differences of the rafters they were noted to be spaced fairly regularly at 2'-0" on-center. The rafters span from the ridge to the north and south exterior walls. No ridge board was noted but rather the adjoining rafters are half-lapped and pinned together with a hard wood peg (Figure 4). From the top, at approximately the third point of the rafter span, a horizontal collar has been face-nailed to the side of the rafters. These collars are widely variable in size, but appear to match the species of the rafters and may be original to the structure. Typically collars placed at this elevation are most likely bracing elements acting in compression rather than ties in tension. This roof framing configuration, where rafters are not supported at the ridge line but rather pin connected to opposing rafters, creates a resulting horizontal thrust or 'kick' at the rafter base which will need to be restrained by the exterior walls or internally by the attic floor framing. At the exterior walls, RSA noted that the rafters are notched to bear against a thrust block which spans horizontally along the tops of the attic joists (Figure 5). These place the attic joists into tension to restrain the outward thrust of the rafter. The use of a thrust block is a common system utilized in historic wood-framed roof structures. A sag in the center of the roof was observed from the exterior which may represent previous excessive roof deflection and or insufficient thrust restraint. This may be the rationale behind the installation of the posts and purlins below the collar connections (Figure 6). These 3-3/4"±x5-5/8"± purlins were observed to span in the east-west direction, notched to seat the rafter (Figure 7) and supported by 4"x4" stud posts placed at every other rafter (approximately 4'-0" o.c.). In our experience, if the purlins were original to the structure, the rafters would have been notched rather than the purlins and the knee wall studs would have been aligned to the floor framing below.

Overall, the condition of the roof framing appears to be sound. RSA noted various repairs, including localized rafters that have been reinforced with new sisters. Additionally, along the northern bearing of the rafters, it appears that a series of stud knee walls have been constructed (Figure 8). These 2-1/4"x4-3/4" studs appear to support the rafters at their bearing, presumably due to deteriorated rafter bearings.

Attic Framing

The attic framing consists of wood floor planks set on three bays of floor joists spanning in the north-south direction. The attic framing does not support a ceiling, similar to all other floors and hence the structure is exposed to view from below. The floor joists were documented to be highly variable in dimension and spacing. An average size and spacing is approximately 2-1/2"x 9-1/4" at approximately 24" o.c. (Figure 9). While supported at the exterior by the brick masonry walls, the joists are supported by two lines of interior supports consisting of 8-1/2"±x9-3/4"± beams set below the joists. The beams are in-turn supported by (3) 8-3/4" square posts spaced at 9'-0" on-center and the east and west gabled end walls. Several shim packs were noted below the joist bearings to accommodate deflection in the timber beams and vertical deflection of the wood columns below. Several joists were noted to be previously reinforced with 2"±x9-1/4"± solid sawn lumber nailed to the side of the existing joist (referred to as sisters).

The longitudinal timber beams were observed to be spliced with the use of 12" long scarf joints and hard wood peg connections. Additionally, at each beam bearing on the columns below, it was observed that the columns are capped with a wood capital (typically 5' long). These capitals appear to contain a mortise into which a column tenon is inserted and holes into which hard wood pegs are driven, a traditional timber framing connection that provides both bearing and tension resistance. These capitals effectively reduce the span of the beams they support and consequently improve their structural capacity. RSA noted that a sister has been installed along the southern longitudinal timber beam at its center post support. This 10' long sister reinforcement is applied to both faces and fastened to each face with (6) 3/4" diameter lag screws (Figure 10).

In line with the bearings of the timber beams on the east and west brick masonry exterior walls, government anchors, metal connections between wood and masonry, were observed. Since the floor joists span parallel to these walls and afford minimal bracing, these S-shaped anchor plates incorporate an iron rod to tie the gabled end walls into the floor diaphragm beyond (Figure 11).

At the west and south walls, RSA noted horizontal, out-of-plane wall displacement. This was most notable between the floor boards and face of the masonry walls. Along the west wall, a 1-1/2" horizontal displacement was measured at the center window. Along the south wall, 2-1/4" and 2" were recorded at the west and east windows, respectively. Apparently to restrain the out-of-plane movement in these exterior walls, a series of tie-rods were set immediately below the attic level. The observed tie-rods appear to represent two different wall reinforcement efforts. First, a 1" square bar tie-rod has been placed in the north-south direction along the face of the west wall (Figures 12 and 13). Secondly, three 1" diameter steel tie rods have been placed at the center of the south wall. One tie rod continues to the center of the north load-bearing wall while the remaining two span diagonally, below the floor plane, to the northwest and northeast corners. These tie-rods appear to restrain out-of-plane movement at the center of the wall and principally transfer these tensile forces to the gabled end shear walls (Figure 14).

At the southeast corner, vertical circulation to the attic space was incorporated with the installation of wood-framed stairs which continue to the first floor level. As the opening takes up the full structural bay to the interior line of support, no use of headers and or trimmers was required.

Overall, the attic framing appears generally sound; however localized areas (16 joist locations) of the attic joists appear to exhibit distress due to previous construction activities, including excessive notching, insufficient bearing and limited connections (Figure 15). Furthermore (5) additional joist locations exhibit deterioration due to excessive waning, horizontal shear cracks, and deteriorated bearings due to moisture intrusion. Additionally, several floor openings and areas of thin plywood sheathing have replaced original flooring boards, creating potential fall hazards to the third floor below.

Third Floor Framing

Similar to the attic framing above, the third floor is constructed of 2-1/2"±x9-1/2"± joists at 24"± on-center, spanning in the north-south direction from the exterior masonry load-bearing walls to two lines of interior supports (Figure 16). No blocking or bridging was observed. The joists were noted to be shimmed up as much as 10" above the longitudinal beams, apparently in response to vertical displacement and maintain the floor levelness (Figures 17 and 18). The longitudinal beams and columns were noted to be slightly larger than those supporting the attic framing above and the 9"x11-3/4" timber beams span to (3) 9" square timber columns with integral capitals spaced at approximately 9'-0" o.c. Similar to the attic above, at the northeast column, RSA noted that the longitudinal timber beam is sistered with solid sawn lumber at each face with (6) 3/4" diameter lag screws. An additional modification noted includes the replacement and relocation of the southwest column approximately 2'-2" to the east of its original location with a 9-3/4" square timber post (Figure 19).

Corresponding to the 1" square bar tie-rod set below the attic framing above, an additional 1" square bar tie rod was observed to be installed below the third floor framing along the west wall. Similarly, government anchors along the gabled end walls were observed to tie these exterior walls at the floor levels.

Vertical circulation to the third floor is provided by the stair in the southeast corner as noted previously, however, as part of a previous renovation effort in the early eighties; an enclosed stair has been inserted at the northwest corner (see Figure 18).

Similar to above, the attic joists generally appear in sound condition; however, localized areas (9 joists) exhibit deterioration due to past powder post beetle infestation and limited fasteners. While the majority of the columns appear sound, the southeast column exhibits localized deterioration around a 3" diameter horizontal hole previously infilled with an epoxy adhesive.

Second Floor Framing

The second floor framing construction is consistent with the framing and wall tie conditions noted above; however the joists were noted to be spaced at 22" o.c. Similarly, the longitudinal beams increased to 10"x12" (Figures 21 and 22). A reduced shim pack was noted to be installed between the 2nd floor joists and timber beams as compared to the third floor above. At the northern longitudinal beams, an average shim thickness of 3" was noted while 6" was observed along the south longitudinal beam (Figure 23). Consistent with above, (2) 2"x11-1/2" reinforcement sisters were installed at the southern longitudinal beam at the center bay. It appears this reinforcement has been installed to provide additional strength and stiffness to the southern longitudinal beam which was exhibiting excessive deflection presumably due to the relocated timber column above, which has placed a concentrated load along the beam span (Figure 24). This relocated post above was noted to be offset approximately 2'-2" to the east of the first floor post below.

Overall, the existing joists exhibit localized deterioration. Similar to the third floor framing, approximately (9) joists exhibit deterioration due to excessive notches and modified support and will require new sisters and or replacement. At the hopper opening within the central bay, the existing joists have been cut and not re-supported with new headers and trimmers and will require localized reframing. Similarly, the longitudinal beams exhibit limited deterioration; however, the west span of the northern beam exhibits excessive notching where a circular hole was cut and reducing the beam depth by half (Figure 25). This appears to correlate to the observed deterioration of the stair landing above to the interior of the structure.

RSA reviewed the condition of the existing columns and it appears that the majority of the timbers are exhibiting checks due to natural shrinkage of the wood. Generally, these shrinkage checks do not affect the strength of the timber, unless they cause a large separation of the timber cross section. The majority of the columns exhibited minimal deterioration however, the southwest column was observed to exhibit damage due to insect infestation (Figure 26). It appears that the south elevation of this post exhibits a 2" loss of section. The current slope of the timber columns supporting the second floor framing was documented. It appears that the columns are principally leaning to the south but also are exhibiting lean to the east. Listed below in Table 1 is a summary of the observed lean of the columns from plumb. It appears that the lean of the posts are principally due to the lateral movement of the south wall and the two center columns are exhibiting the greatest lateral displacement. Thus it appears likely that the (2) 7-1/2"x10" and (1) 10"x10" canted posts along the three southern posts were added to brace the columns against further lateral movement (Figure 27).

Table 1: Interior Column Lateral Displacement		
Column Location	Angle from Plumb (South)	Angle from Plumb (East)
Northwest	2.5 degrees	0.3 degrees
North Center	**3.8** degrees	**3.6** degrees
Northeast	2.7 degrees	1.3 degrees
Southwest	0.4 degrees	1.3 degrees
South Center	**3.0** degrees	**2.3** degrees
Southeast	2.3 degrees	2.0 degrees

Along each brick masonry exterior wall, three window openings are constructed. Flat or 'jack' masonry arches principally support the masonry above the opening, however, timber lintels were utilized in localized areas. Timber lintels were observed at the three windows along the east elevation and the eastern window of the south elevation. Typically, these lintels were observed to be 2-1/2" in depth and with an average bearing length of 6". RSA noted localized masonry deterioration around the timber lintels to include open mortar joints above the opening, loose brick in the masonry below and localized cracking at the lintel bearings and in the wall panel below (Figures 28 and 29). From the interior, the brick masonry arches were also noted to exhibit localized deterioration. This deterioration included localized cracking at spring points, spalled brick under the windows, loose brick, diagonal cracks in wall panel below opening (Figure 30). Additional localized masonry deterioration noted at the interior of the structure, included brick spalling and delamination at the northwest stairwell landing (Figure 31) and localized brick displacement and looseness at joist bearings (Figure 32).

First Floor Framing

The first floor is constructed in a similar manner as the floors above, with (2) rows of interior beams and columns to provide interior support to the joist framing. Unlike the framing above, the first floor framing does not incorporate wall ties to the exterior masonry and does not have penetrations for vertical circulation. The first floor is framed with 3"x10" joists spaced at 22" on-center and spanning to 10"x12" longitudinal beams. These beams originally were supported by two rows of (3) timber columns. These columns have been replaced by 12"x12" brick piers and additional 12"x12" brick piers have been added between the original column locations (Figures 33 and 34). It appears this was performed to reduce the span of the timber beams and reduce the applied loads to the interior columns which may have attributed to vertical deflection due to settlement. Along the center of each of the three joist bays, additional support has been provided in the east-west direction (Figure 35). New doubled solid sawn lumber beams bearing on post shores have been placed to reduce the span of the joist framing. This also reduces the loads applied to the longitudinal beams and associated pier supports. The post shores were observed to exhibit superficial corrosion and be placed on grouted concrete masonry unit (CMU) blocks for base support. Other modifications include the incorporation of joist sisters to re-support the joists along the north wall due to moisture deterioration within their pockets (Figure 36). Along the eastern portions of the north and south wall, brick masonry piers and wood knee walls have been installed to improve the bearing of the joists in these areas, respectively (Figures 37 and 38). Along the south wall, the joists have been re-supported by a 10"x12" horizontal timber of the Hurst frame, however, of the seven vertical posts which support this timber, five have been lost or exhibit significant deterioration (Figure 39). RSA noted that the eastern canted column brace bears on a brick masonry pier (Figure 40), while the central and western canted column braces are currently supported by the lower horizontal timbers of the Hurst frame (Figure 41). These beams are exhibiting severe deterioration due to continued exposure to moisture over a long duration and are currently exhibiting crushing and looseness at their connections to the column braces (Figure 42) and other Hurst framing members (Figures 43, 44 and 45). RSA was able to move the western canted brace by hand.

Overall, the joists and the timber beams in this floor level exhibit localized deterioration due to excessive notches, horizontal shear checks, exposure to moisture and insect infestation. However, the areas identified above which require immediate structural repair include the support of the southern bay joists along the south wall and the base support of the column bracing.

<u>Foundations</u>

Generally, the exterior walls are comprised of brick masonry above grade and stone foundation walls below grade. Hence, while the east wall within the basement space is entirely constructed of stone masonry and the north wall is principally comprised of stone, the west and south walls are principally constructed of brick masonry. Though not observed, it appears highly likely these brick masonry basement walls are supported by stone foundations below the dirt floor.

Overall, the foundation walls appear to exhibit minimal deterioration along the north and east walls, however, the south and west walls were observed to be deteriorated in several areas. It appears that this deterioration is primarily caused by sustained exposure to moisture. Along the south elevation, large areas of masonry have been lost at the south west corner. Additionally, open joints, brick loss, loose bricks and mortar loss was observed along the brick ledge and masonry openings. Above the westernmost wall opening of the south wall, a 3/8" wide vertical crack extends from the keystone of the arch to the masonry of the first floor above (Figure 46). Along the west wall, vertical cracks and spalling brick were noted at the intersection with the north wall (Figure 47). Here, the crack was noted to be 1/8" wide and thru the header bricks. Additionally, at the southern window of the west wall, localized mold growth was observed due to wall saturation, presumably due to poor exterior drainage at the new areaway (Figure 48). Below the window and along the south jamb, the masonry is loose, cracked and spalled (Figure 49).

Materials Testing

As noted above, wood sampling was performed on localized structural members to assist in documentation of the existing structure, provide insight to possible modifications and assist in refining design assumptions for the analysis of the existing structure. Throughout the structure, RSA obtained thirteen (13) wood samples for species identification. These wood samples were shipped to Dr. J. Thomas Quirk of Quirk Consulting Service in Madison, Wisconsin for review (see attached wood species report for additional information). Per their review, it appears that the majority of the floor and roof structure, including posts, beams, joists and rafters; are constructed of Red Oak (Appendix C). The replacement post at the third floor level was identified as Hard Maple. One interesting note, found that the existing posts within the attic space were identified as Southern Yellow Pine. This appears to correlate to a structural modification to the original structure, see below for additional information.

In addition to wood species identification, RSA reviewed the existing framing for approximate size and location of knots and the slope of grain to estimate the grade of timber thru the use of grading software (NCPTT Grading Protocol for Structural Lumber and Timber in Historic Structures). Once the species and estimated grade is known, the allowable stress design values can be obtained and structural analysis performed to estimate an allowable load (see Gravity Live Load Analysis below for additional information).

Building Modifications

Per the review of the existing documentation and our site survey efforts, RSA offers the following summary of the building structure history.

Renovation

The existing mill building appears to be largely intact and largely representative of the original construction; however a few later modifications were noted. These modifications include a reinforced concrete structural slab which has been constructed on top of existing stone foundation walls to the west of the original mill. This area is approximately 40 feet long by 26 feet wide and incorporates a crawlspace below.

In the early 1980s, the interior was remodeled to incorporate a second interior stair system at the northwest corner of the mill, removing the small brick addition and existing exterior stair along the west wall. Structurally, this appears to be a fairly minimal intervention as it had required only the localized removal of floor joists at the second and third floor levels to create the stair opening. Per our review of the available documentation and the existing conditions, it appears that the existing timber girders were left in-tact. In addition to this localized renovation, several cosmetic repairs were performed on the exterior walls. These repairs included the reconstruction of the south wall corbeling at the top of the wall and localized replacement of brick and flashing at the top of the east gabled end. Furthermore, it appears that due to deterioration of the first floor framing and Hurst frame, localized shoring was installed within the basement for stabilization and new support.

Additionally, a localized area at the west end of the mill building has been recently modified (2008) to promote circulation to the above-mentioned patio, to both the mill first floor and entry into the basement from the exterior. This work includes a new masonry opening within the mill's west foundation wall, a concrete areaway slab with CMU retaining walls, and new wood framed stairs (Figure 50). In conjunction with this latest construction, new shoring was installed to support the central bay of the first floor framing along the west wall.

Miscellaneous Repairs

As previously noted the existing mill building retains much of its original structure but has been continuously repaired throughout its lifetime principally to compensate for support settlement and the out-of-plane movement of the south wall. Per our review of the existing available documentation it appears that the first noted repairs were the reconstruction of the east wall and the installation of the S-shaped government anchors in the west and east gabled end walls in the 1850s. These repairs were likely in response to lateral displacement of the gabled end walls. The S-shaped government anchors would have been installed to improve the bracing of the gabled end walls where the original floor system spans parallel to the wall plane (Figure 51). Since the reconstructed east wall does not incorporate a brick masonry east gable but rather one of timber, it appears likely that sometime after this effort, the roof framing was modified to incorporate notched purlins and vertical compression struts at the mid-span of the rafter to possibly reduce deflection and consequently increase rafter capacity. This may correlate to the noted difference in wood species between the roof rafters and the purlin support structure.

Following these repairs, the existing interior columns were installed with canted bracing in the 1880s. It appears that these braces were implemented to provide restraint against lateral movement of the posts and floor framing to the south. These bracing elements were installed to the south line of columns only and span from the second floor to the basement. At the basement level these braces were supported by new rubble pier foundations and the horizontal members of the Hurst frame below. During this time-frame, it appears that iron tie-rods were installed at the second, third and attic floor levels to restrain the south wall from further out-of-plane displacement. These three sets of ties were installed spanning in the north-south direction along the interior face of the west gabled end wall (Figure 52). These vertical plate anchors can still be observed at the north and south elevations (Figure 53). These ties appear to restrain the displacement of the west corner of the south wall by transferring load back to the north end of the west shear wall. No ties were installed along the east wall which may suggest that minimal displacement was occurring along the southeast corner of the structure.

Similar to above, three additional wall ties were installed below the attic floor level to brace the south wall for out-of-plane displacement and buckling in 1948 (Figure 54). It would appear that these were added as a result of continued movement at the center bays of the south wall. While the center tie rod spans from the center of the north and south walls, the tie rods at each end of the north exterior wall span diagonally to the center of the south wall. Hence similar to above, the ties at the ends of the walls help to restrain the south walls out-of-plane movement by transferring these forces to the gabled-end walls. While the central tie rod is less effective it does serve in tying the roof thrust between the south and north walls. Along the north wall, the ties are anchored with the use of three rectangular wall plates while at the south wall the ties are anchored to a single wall plate above the central window of the third floor below.

Though not documented, it appears that in a period between 1983 and 2007, the interior wood columns within the basement were replaced with new brick piers set on the original stone foundations. As part of this effort, it appears that additional brick piers were installed between the existing columns and bear on the existing interior stone foundation walls below.

Gravity Live Load Analysis

Following the findings of the field documentation and material sampling, this information was then incorporated into the structural analysis of the floor and roof structure to determine estimated allowable live load capacities. Two main material factors affect structural capacity of wood framing members: wood species and wood grade. Wood species was verified through testing. Although RSA is not certified as timber graders, average size of knots and slope of grain were documented and the grading was estimated based on these factors. The structural analysis was performed with the following assumed grades: floor joists (Red Oak #2), timber longitudinal beams (Red Oak #1), attic joists (Yellow Popular #2), and rafters (Red Oak #2).

Design Criteria

With the current occupancy of the structure being a mill museum which is opened to the public for discrete days of the year for artisan shows, the code live load requirements are not clearly defined as with new construction, thus the engineer must make judgment of the current loading requirements. Live load, as distinguished from dead load which is the self-weight of the building materials, is the allowable moveable loading which can be placed upon a floor; generally, occupancy type has corresponding live load requirements as prescribed by the governing building code (2009 Virginia Uniform Statewide Building Code). Due to the use of the structure for artisan shows, the building occupancy is similar to that of retail space, thus RSA recommends that the first floor areas should have a live load capacity of greater than 100 pounds per square foot (psf) and the upper floors have a minimum capacity of 75 psf. In review of the roof framing, a minimum live load demand was determined to be 15 psf, due to the relatively steep pitch of the roof and the small tributary area of each rafter. This minimum roof live load superseded the snow load requirements as they were determined to govern the roof design. Per the 30 psf ground snow load of Waterford, Virginia, a minimum design snow load of 13 psf was calculated based on the roof slope and lack of heating of the indoor space during the winter.

Gravity Analysis Methodology

The procedure for developing the allowable load capacity of each individual member is a two part iterative process. First, the system is evaluated based on strength, utilizing the bending and shear design values provided by the National Design Specification for Wood Construction for a given species. The lower of the two governs. After this, a second set of calculations are conducted to review the deflection requirements. Thus two allowable live loads are determined, one for strength and the second for deflection requirements. In this study, both values will be provided; however, the lesser of these two capacities will govern, as detailed below.

TABLE 2: ALLOWABLE LIVE LOAD CAPACITIES					
System/Location	Member Size	Bending (psf)	Shear (psf)	Deflection (Live)	Deflection (Total)
First Floor Joists	3”x9½”@22”	>100	>100	>100 psf (L/360)	>100 psf (L/240)
First Floor Beam	10”x12”	>100	>100	-- (L/240)	-- (L/180)
Second Floor Joists	2½”x9”@22”	71	>100	98 psf (L/360)	>100psf (L/240)
Second Floor Beams	10”x12”	>100	>100	-- psf (L/360)	-- psf (L/240)
Third Floor Joists	2½”x9”@24”	53	>100	75 psf (L/360)	>100 psf (L/240)
Third Floor Beam	9½”x11”	>70	>100	-- psf (L/360)	-- psf (L/240)
Attic Floor Joists	2”x9¼”@24”	39	>100	76 psf (L/360)	>100psf (L/240)
Attic Floor Beam	8 ½”x9”	62	>100	-- psf (L/360)	--psf (L/240)
Roof Rafters Currently	3¾”x4⅛”@27”	13	>20	-- psf (L/360)	> (L/240)
Roof Rafters Originally	3¾”x4⅛”@27”	5	>20	-- psf (L/360)	> (L/240)

Calculated Live Load Capacity of Structural Elements

Overall, the capacity of the existing mill structure is suitable for the current use of the space. Typically, the floor and attic capacities were governed by the joists in flexure (bending). As highlighted in Table 2 above, areas of structural deficiency were noted in select framing members. While the live load capacity of the first floor and second floor levels exceed the minimum requirements for retail occupancy, the third floor appears to be mildly insufficient. Here the joists were noted to have a live load capacity of approximately 53 psf and governed by bending (flexure). The attic is sufficient in capacity for non-residential attics without storage. In our review of the roof framing, it appears that the original roof configuration can only support the dead load of the roof system itself (Figure 55). Thus it appears likely that the purlins and posts were added to reduce the span of the rafters and increase capacity (Figure 56). Per our review of the current roof system, the live load capacity is sufficient for snow loads but mildly overstressed for the governing minimum roof live load requirements.

Lateral Load Analysis

Design Criteria and Design Lateral Forces

The lateral wind load analysis was performed based on the requirements of the 2009 Virginia Uniform Statewide Building Code. The applied wind load pressures were generally observed to be relatively low, since the existing structure is located within the boundaries of the 90 mph basic wind speed, having a relatively low roof height and being within a zone of reduced exposure. The resulting maximum design wind pressure was determined to be 15 psf (Zone A-wall corner) with the roof corner (Zone B) calculated as 10 psf and the remaining portions of the wall and roof exhibiting a design wind pressures of 12 psf (Zone C) and 8 psf (Zone D), respectively.

Description of Lateral Force Resisting System

The brick walls are the main component of this structure lateral load system which also includes floor framing and to some extent the interior columns. The interior columns are mainly gravity load components but the lateral displacement observed in these members would suggest that they have engaged the rest of the structure as part of the lateral load path, particularly between the foundation level and the second floor, most likely due to the lack of wall bracing along the south wall by the 1st floor framing. The building lateral stiffness is mainly provided by the brick wall engaging the lateral load path of the structure as shear walls. The capacity of the building against lateral load is also mainly driven by the shear walls.

Preliminary analysis results indicate that even with the existing out-of-plane movement of the south wall, secondary bending effects, and even with the thrust at the top of the north and south walls induced by the roof rafters, these walls are able to undergo out-of-plane loads as long as they remain properly braced by the floor framing (Figure 57).

Stability of Existing Exterior Walls

The stability of the existing exterior walls rely heavily on their self-weight and also on the bracing by the wood floor diaphragm at each level. The friction between the floor joists as they bear on the brick wall is what provides the bracing that reduces the unbraced length of these walls to the height between floors. At the first floor level, the first floor framing is not properly bracing the wall and preliminary analysis indicates that the forces at this level are the highest because of the extended unbraced height, from basement to second floor (Figure 57).

Review of Exterior Wall Laser Survey & Monitoring

RSA performed a review of the laser scanning survey performed as part of this investigation effort. Per our review of the provided images, the laser scans have identified a maximum out-of-plane displacement (lateral drift) of 0.599 feet or 7.2 inches. This maximum drift occurs at the top of the south wall's central bay. Additionally, at top of the west corner of the south wall, a lateral displacement of 0.299 feet or 3.6 inches is reported. In reviewing the provided three-dimensional wall survey images of the south wall, this data suggests that the majority of the documented out-of-plane lateral movement is concentrated at the upper stories of the wall.

The allowable story drift for masonry shear wall structures (such as Waterford Mill) permitted by current codes is less than the maximum recorded displacement along the south wall (central bay). Similarly, the west corner condition noted above also exceeds the allowable drift limits specified by the current code. Although the present geometry does not satisfy the code for new construction, there is no current imperative to meet these requirements, and the record of the recent structural performance of the building informs our assessment. Per our review of the previous investigation and monitoring reports (prepared by others) and comparing this information with the recent laser scanning, the data suggests that the historic mill structure has not experienced additional lateral movements. This is corroborated by the relatively small amount of significant cracking in the masonry walls.

The recorded displacements and observation of previous framing deterioration portray a structural history that has had periods of physical weakness and impacts, but overall represents a structural history where the mill, through intervention of sustained stewardship, has maintained stability and its ability to support the loads imposed on the structure. To assure this continued structural health for the future, and to assure that the past movements are no longer active, RSA recommends performing regularly-scheduled (biannually) structural building monitoring to document movement activity and confirm that the existing ties/bracing assembly is effectively restraining the exterior shear walls from further movement until the recommended repairs are incorporated. Due to the recent high wind speed event (Hurricane Sandy) which affected the region in late October of this year (following laser survey recording of this investigation effort), there is a possibility that additional wall displacement occurred as a result of these lateral forces. RSA recommends the building monitoring program be initiated within the next three months, while the structure is largely unoccupied during the winter, to verify if no additional displacement has occurred. Such monitoring program can be incorporated with the use of conventional electronic survey (total station) and preselected benchmarks located at key positions along the exterior walls and shall be performed by a licensed surveyor in the Commonwealth of Virginia. RSA recommends that these survey efforts have the ability to record three-dimensional data (horizontal and vertical in-plane and out-of-plane) in all four exterior walls to a tolerance of 0.01 feet or 0.125 of an inch.

If additional movement is recorded by the above mentioned monitoring program, RSA recommends performing structural analyses on these affected areas to verify that the structure remains in a stable condition or if localized shoring, reinforcement or upgrades need to be considered to the floor diaphragms and or shear walls to improve their performance for future lateral loads. These upgrades may involve adding horizontal ties at the attic and lower floor levels to increase floor stiffness and improve distribution of lateral loads to the exterior walls (in-keeping with the existing retrofit floor bracing) and or providing additional vertical bracing.

Prioritized Repairs

Stabilization

The main area requiring immediate structural intervention includes the framing members currently supported by the Hurst frame, located at the southwest corner of the structure. As noted above, the Hurst frame is heavily deteriorated due to prolonged exposure to moisture and is compromising the integrity of the existing south bay of the first floor joists and the canted column braces. RSA recommends that the current shoring within the basement space be augmented to support the south end of the floor joists and members of the Hurst frame, including providing adequate support at the base of the (2) canted post braces (see Appendix D for Conceptual Stabilization Sketches). This should be performed prior to group access by the public.

Another area requiring intervention is the bracing of the walls by floor framing girders and joists, particularly at the first floor. This should include a retrofit of the existing detail to improve their bracing capacity to the wall and provide a long term strengthening of the structure to resist both gravity and lateral loadings.

It appears that settlement that has caused the sagging of the floor framing girders and consequently wall instabilities are not active as evidenced by the relative uncracked condition of the brick masonry. However, it is important to study the underlying soils to verify if settlement is active to determine if any further load reduction or foundation improvement measures are to be taken.

Reinforcement

Areas of joist deterioration due to excessive notching, insufficient connections, limited blocking and bearing degradation due to exposure to moisture were noted above. While these do not represent an emergency requiring immediate repair, RSA recommends that these areas be reinforced with new engineered sisters within the next year or when larger occupancy or equipment installations are forecasted.

Similarly, if the third floor is to be used as retail, the capacity can be increased with engineered sisters or with new joists let in between the current joist bays. Alternatively, a certified wood grader can review the existing framing conditions to provide a more accurate grade of the timbers and RSA can review our analysis. If the joists are determined to be of a higher grade than our assumptions, the live load capacity would increase. Additionally, it is recommended that a wood scientist review the extent of insect infestation and deterioration of the columns and recommend treatment options, as necessary.

Masonry Repairs

Localized masonry repairs are required for the long-term preservation of the historic structure. The exterior masonry walls have moved significantly over the lifetime of the mill, and have undergone multiple repair campaigns. Most significantly, tie rods have been installed at the 2^{nd}, 3rd and attic floor levels to restrain the southward bowing of the south wall. The canted post braces have also been installed to address this history of displacement. The distribution of tie rods appears to be an effective bracing scheme. Some sagging was observed in a tie rod along the west wall. The exterior bearings of the tie rods appear relatively intact, although repair to wood blocking may be recommended. Although some repairs, including localized repointing and tie rod tightening, will be recommended, no emergency stabilization is recommended at this time.

Additionally, masonry deterioration was noted along the south and west foundation walls within the basement. Deep repointing and or brick replacement will be required at existing cracks. Additionally, localized reconstruction will be required along the south elevation where openings have lost brick masonry.

Conclusions and Recommendations

The exterior walls have moved significantly over the lifetime of the mill and the interior framing has exhibited vertical deflection and settlement. There appears to be a correlation between the brick wall out-of-plane movement and the interior columns support settlement. The various tie rod installations appear to have minimized additional lateral movement in the walls and the installation of the longitudinal beam reinforcement and additional column and post supports below appear to have successfully eliminated further vertical deflection of the floor framing. There are clear signs that settlement and out-of-plane movement of the exterior walls are no longer active. However, due to the recent high-wind speed event and the possibility of additional vertical displacement, RSA recommends performing regular scheduled building survey monitoring to verify if the recorded displacements have been affected by Hurricane Sandy and monitor the structure until the recommended repairs are instituted.

Preliminary calculations indicate that the maximum bearing pressure exerted upon underlying soil by the existing foundations is about 4,000 psf at the exterior walls and 3,000 psf at the interior columns. This likely represents an overstressed condition for the existing soils; however soils testing should be performed to confirm this. RSA recommends a geotechnical study of the underlying soils to verify soil type and capacity and also to determine whether the soil would settle further under future loads. Additionally, the geotechnical investigation should review the effects of frequent flooding of the structure and means to minimize this occurrence.

Given the importance of the wall bracing provided by the floor framing on the overall behavior of the walls, it is recommended to improve the connection between the floor framing and the walls.

Gravity load analysis indicates that existing floor framing has a live load capacity of at least 50 psf, pending implementation of localized repairs. This capacity, when considering the proportions of accessible floor area, will be adequate for most retail uses.

APPENDIX A: FIGURES

Figure 1: East elevation of Waterford Mill

Figure 2: View of southwest corner of Waterford Mill

Figure 3: Roof framing with rafters, collars and purlins on stud posts.

Figure 4: Roof rafter pin connection at ridge

Figure 5: Roof rafter bearing at top of masonry wall. Note use of thrust block.

Figure 6: Roof purlin and post support

Figure 7: Purlin notch around existing rafter

Figure 8: Intermediate support of rafters

Figure 9: Attic joists on longitudinal beam below. Note leveling shim pack and column capital.

Figure 10: Attic level longitudinal beam sister reinforcement

Figure 11: Attic level longitudinal beam bearing and government anchor wall tie

Figure 12: Attic level square tie rod along west gable end

Figure 13: Attic level square tie rod connection

Figure 14: Attic level tie rods at northwest corner of mill

Figure 15: Attic floor framing modifications

Figure 16: Third floor joists

Figure 17: Third floor beam deflection

Figure 18: Third floor beam deflection

Figure 19: Third floor relocated column and beam deflection

Figure 20: Third floor post deterioration

Figure 21: Second floor joist framing

Figure 22: Tie rod at west gable wall

Figure 23: Second floor joist and leveling shims

Figure 24: Second floor longitudinal beam sister reinforcement.

Note misalignment of post above and post below at left.

Figure 25: Second floor longitudinal beam notch

Figure 26: Second floor southeast corner column deterioration

Figure 27: Second floor canted column brace

Figure 28: Cracking in masonry above first floor window along west wall

Figure 29: Spalling of masonry below first floor window opening along south wall

Figure 30: Diagonal cracking within mortar joints below first floor window opening along west wall

Figure 31: Brick spalling within northwest stairwell landing

Figure 32: Second floor joist bearing deterioration at exterior masonry pocket

Figure 33: First floor beam re-supported on new masonry piers

Figure 34: First floor shoring and new masonry pier support

Figure 35: First floor shoring within northern joist bay

Figure 36: First floor joist bearing deterioration at northern masonry wall

Figure 37: First floor northern joist masonry pier support

Figure 38: First floor southern joist wood knee wall

Figure 39: First floor joist supported on Hurst frame

Figure 40: First floor canted brace masonry pier support

Figure 41: Canted brace with deteriorated Hurst frame support

Figure 42: Canted brace bearing deterioration on Hurst frame

Figure 43: Hurst frame beam with loss of supporting post and cracked masonry at opening to left

Figure 44: Hurst frame bearing deterioration and looseness in masonry below

Figure 45: Hurst frame deterioration

Figure 46: Vertical crack in masonry at west window of south elevation

Figure 47: Vertical crack in brick masonry above stone foundation wall at northwest corner

Figure 48: Saturation of brick masonry above west foundation wall

Figure 49: Deterioration of brick masonry at southern window of west foundation wall

Figure 50: Installation of new first floor and basement entry along west wall

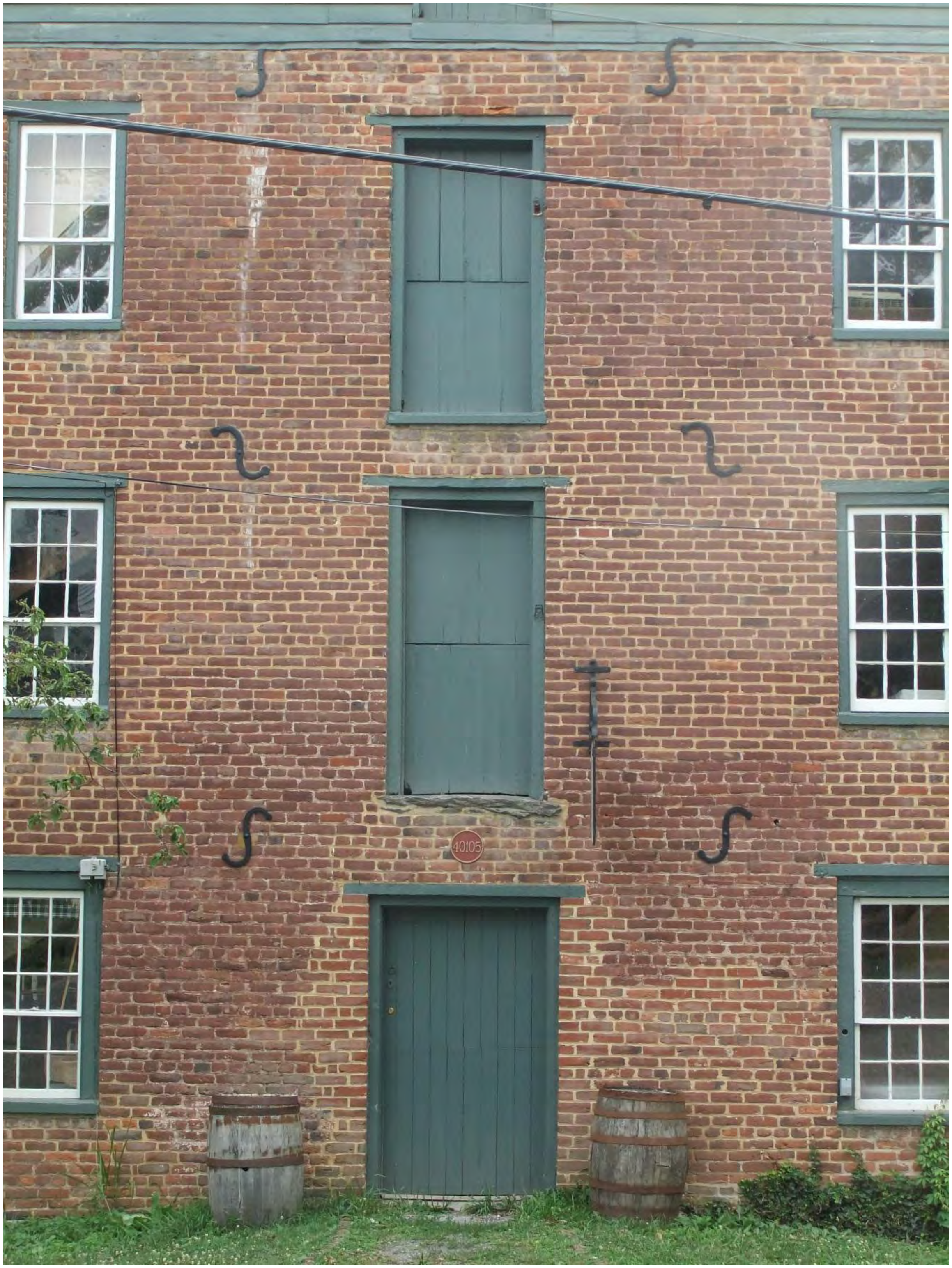


Figure 51: Gabled end wall with S-shaped government anchors

Figure 52: Tie rods at west end of south wall

Figure 53: Tie rod anchorage at west end of south wall

Figure 54: 20th century tie rod anchorage below attic level

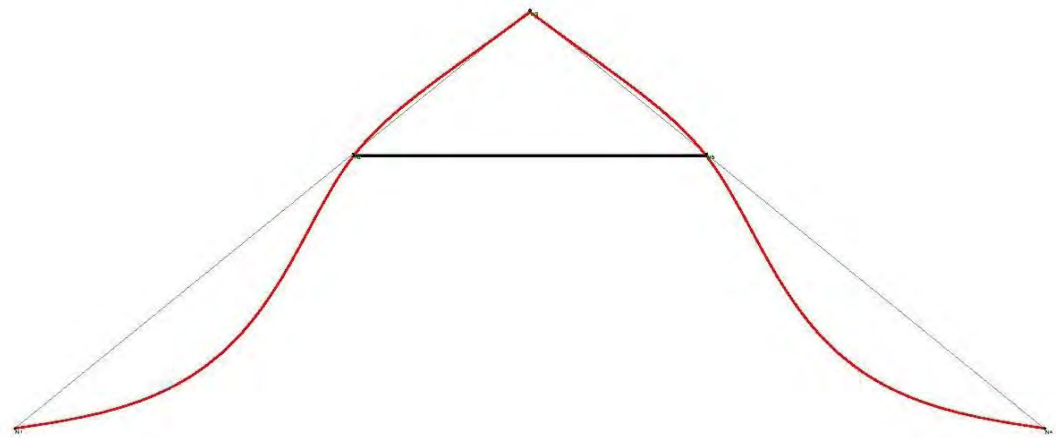


Figure 55: Exaggerated anticipated roof deflection with opposing rafters and collar

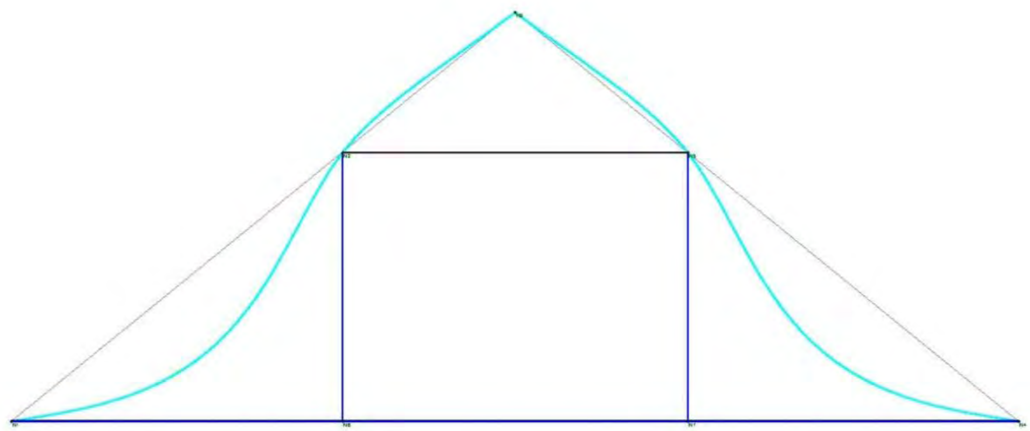


Figure 56: Exaggerated anticipated roof deflection with current roof system which Incorporate purlins and post supports onto attic beams below

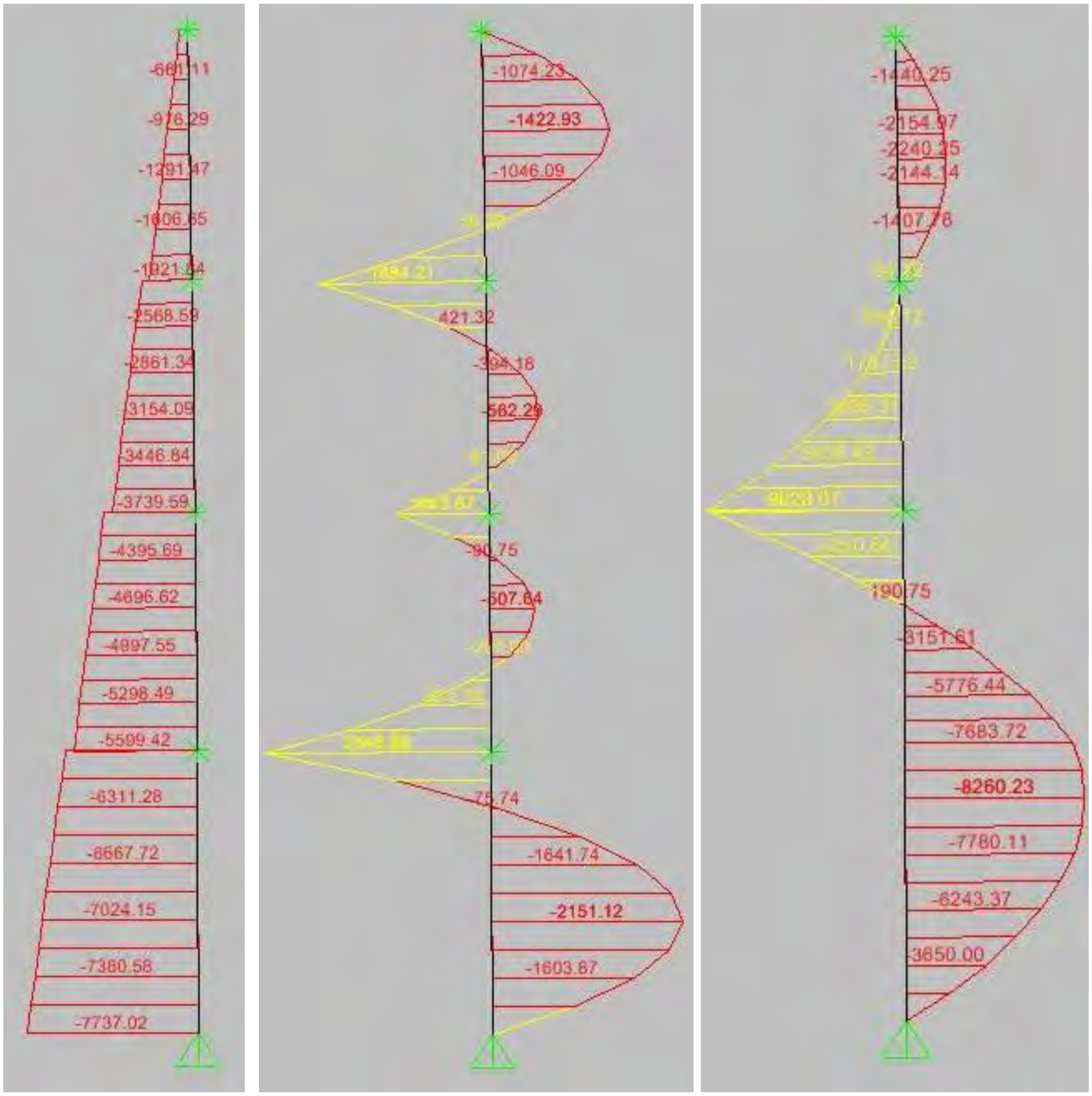
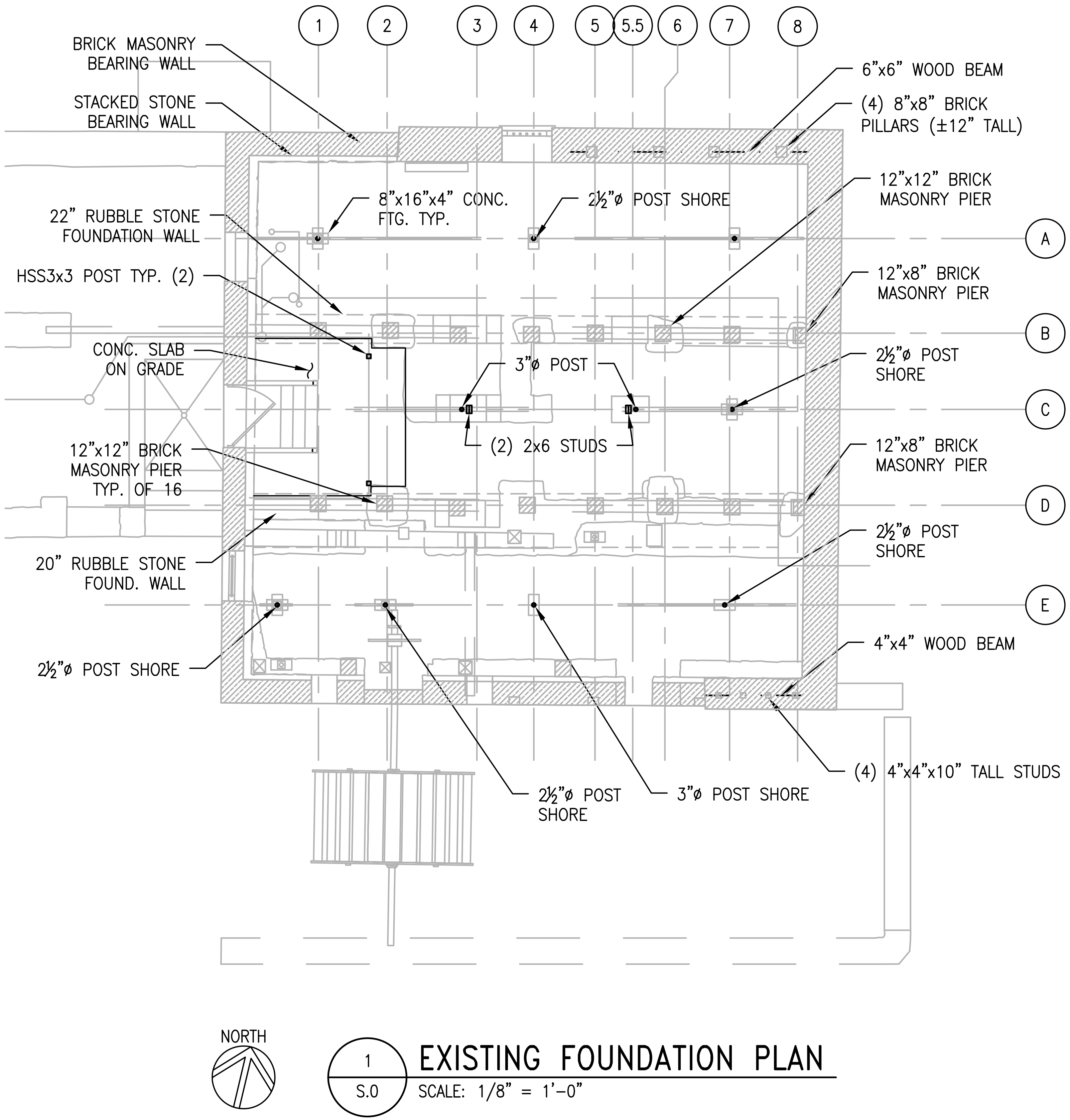


Figure 57: Applied axial load to south load-bearing masonry wall (pounds per linear foot) at left. Induced bending moment (pounds-inch) in south exterior wall due to lateral wind load and out-of-plane displacement when braced at each floor level by floor framing (center). At right, shown is the induced bending moment (pounds-inch) in south wall due to lateral wind load and out-of-plane displacement when braced at all floors except first floor (current condition).

APPENDIX B: EXISTING FRAMING PLANS



1 / S.0 **EXISTING FOUNDATION PLAN**

SCALE: 1/8" = 1'-0"

FOUNDATION SCHEDULE					
COLUMN	W_T	W_B	D	H	MATL.
B-2	29"	--	25"	11"	STONE
B-3	28"	51½"	21"	64"	CONC.
B-4	24"	--	20"	11"	STONE
B-5.5	27"	33"	21"	18"	CONC.
B-6	26"	--	24"	10"	STONE
B-8	25"	--	18"	9"	STONE
C-3	27"	51"	21"	65"	CONC.
C-5.5	28½"	39½"	21"	29"	CONC.
D-2	25"	--	30"	7"	STONE
D-3	26"	51"	21"	62"	CONC.
D-4	28"	--	32"	4"	STONE
D-5	12"	12"	--	--	BRICK
D-6	22"	33"	33"	6"	STONE
D-8	18"	--	30"	9"	STONE

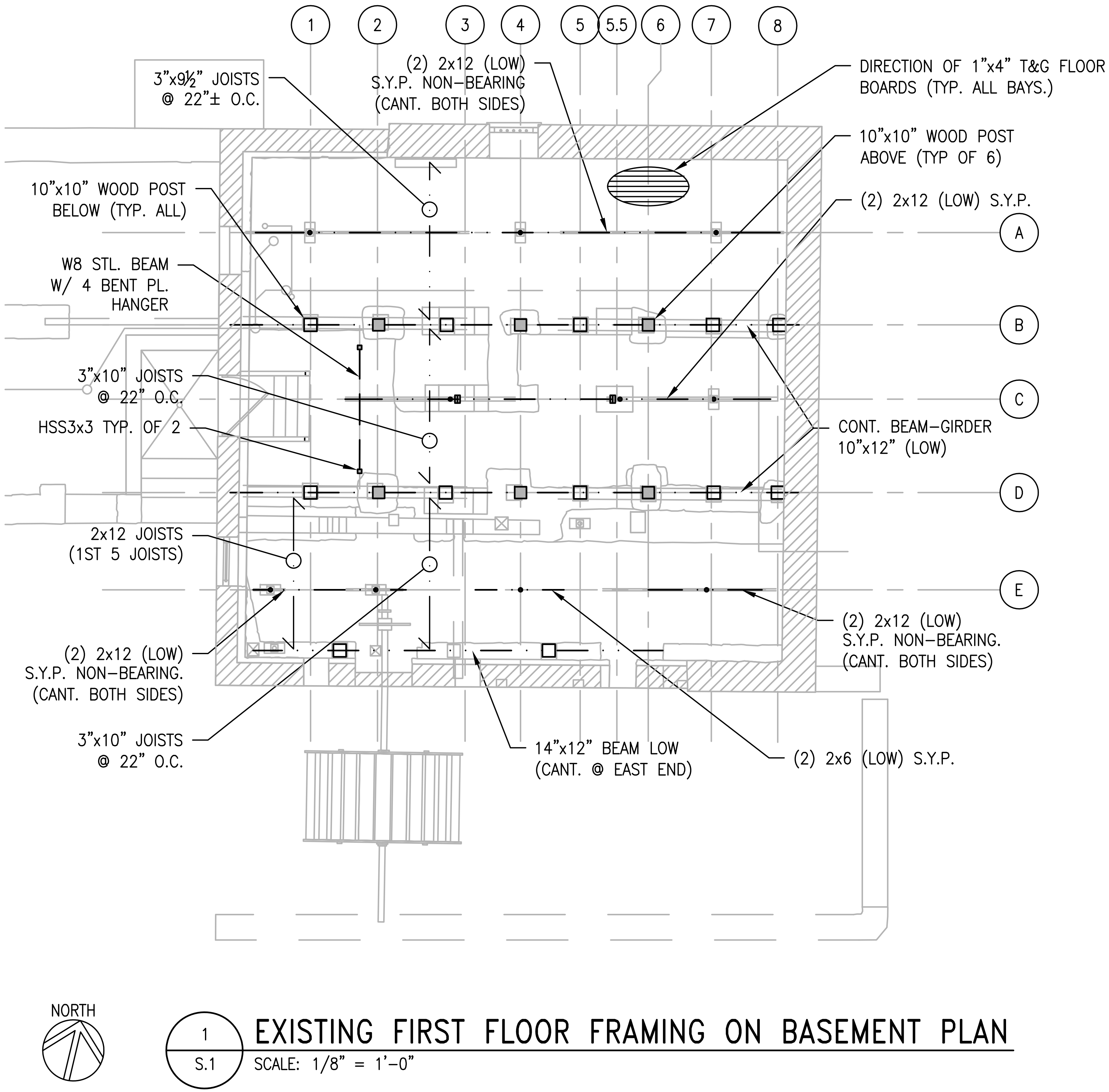
Title: EXISTING FOUNDATION PLAN

Job Title: WATERFORD MILL
HISTORIC STRUCTURES REPORT

ROBERT SILMAN ASSOCIATES
STRUCTURAL ENGINEERS
1053 31st Street NW
Washington, DC 20007
P 202.333.6230 F 202.318.3015

Date: 08/21/2012
Scale: AS NOTED
Job Number: W2862

S.0



1 / S.1 EXISTING FIRST FLOOR FRAMING ON BASEMENT PLAN

SCALE: 1/8" = 1'–0"

NOTE: EXISTING FIRST FLOOR FRAMING HAS AN ESTIMATED ALLOWABLE LIVE LOAD OF 100 PSF ASSUMING JOIST. BEAMS, & FLOOR BOARDS ARE IN AN UNDETERIORATED STATE. CAPACITY IS ESTIMATED ASSUMING AN UNLOADED FLOOR.

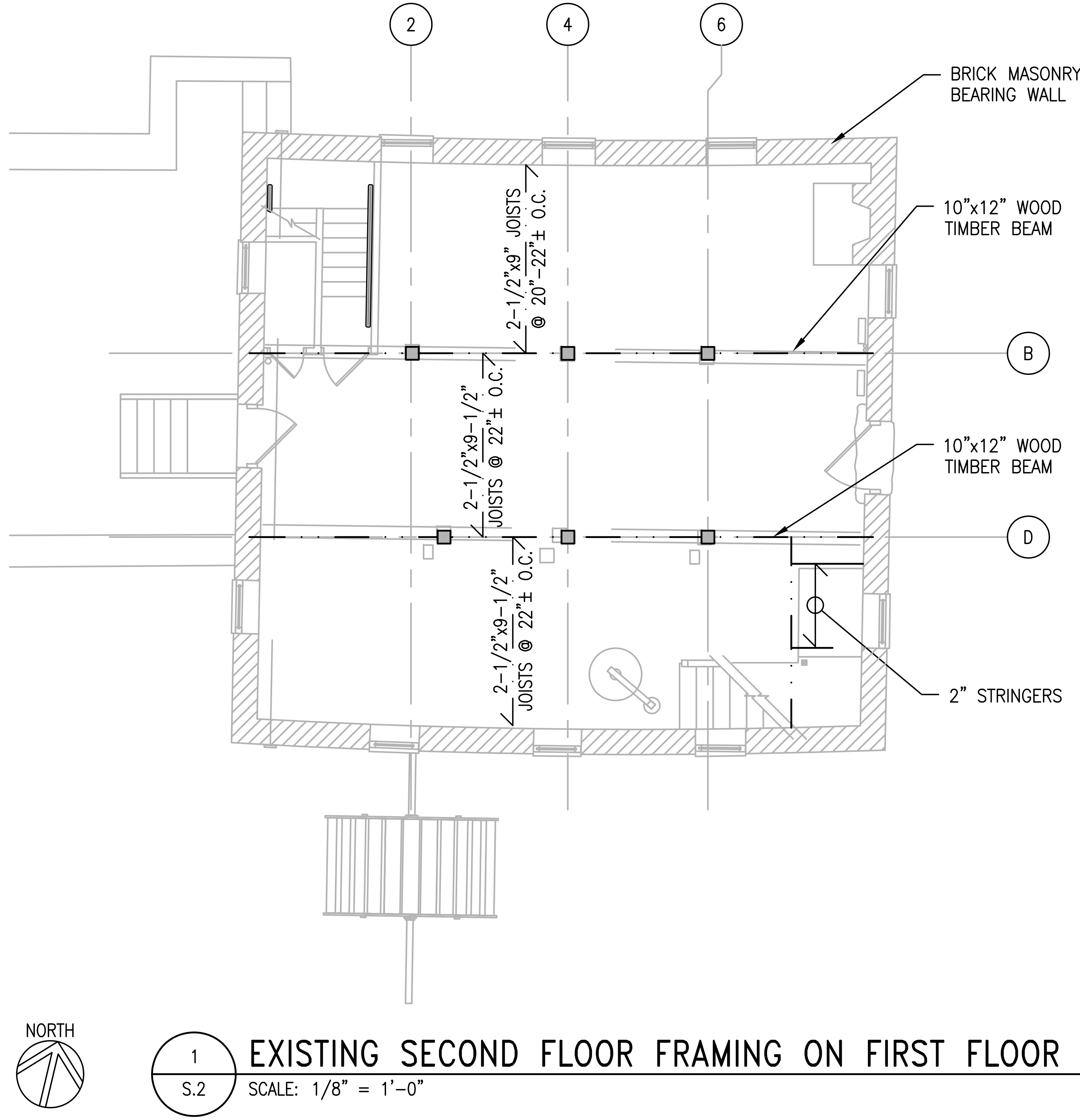
Title: EXISTING FIRST FLOOR FRAMING ON BASEMENT PLAN

ROBERT SILMAN ASSOCIATES
STRUCTURAL ENGINEERS
1053 31st Street NW
Washington, DC 20007
P 202.333.6230 F 202.318.3015

Job Title: WATERFORD MILL
HISTORIC STRUCTURES REPORT

Date: 08/21/2012
Scale: AS NOTED
Job Number: W2862

S.1



1 / S.2 EXISTING SECOND FLOOR FRAMING ON FIRST FLOOR PLAN

SCALE: 1/8" = 1'-0"

COLUMN SCHEDULE			
COLUMN	W	D	CORNER
B-2	9"	10"	1½" CHAMFER
B-4	10"	10"	1½" CHAMFER
B-6	10"	10"	1½" CHAMFER
D-2	10½"	10"	1¾" CHAMFER
D-4	9"	10"	1¾" CHAMFER
D-6	9½"	9½"	1½" CHAMFER
D-2 BRACE	7½"	10"	1½" CHAMFER
D-4 BRACE	10"	10"	1½" CHAMFER
D-6 BRACE	7½"	10"	1½" CHAMFER

NOTE: EXISTING SECOND FLOOR FRAMING HAS AN ESTIMATED ALLOWABLE LIVE LOAD OF 71 PSF ASSUMING JOIST. BEAMS, & FLOOR BOARDS ARE IN AN UNDETERIORATED STATE. CAPACITY IS ESTIMATED ASSUMING AN UNLOADED FLOOR.

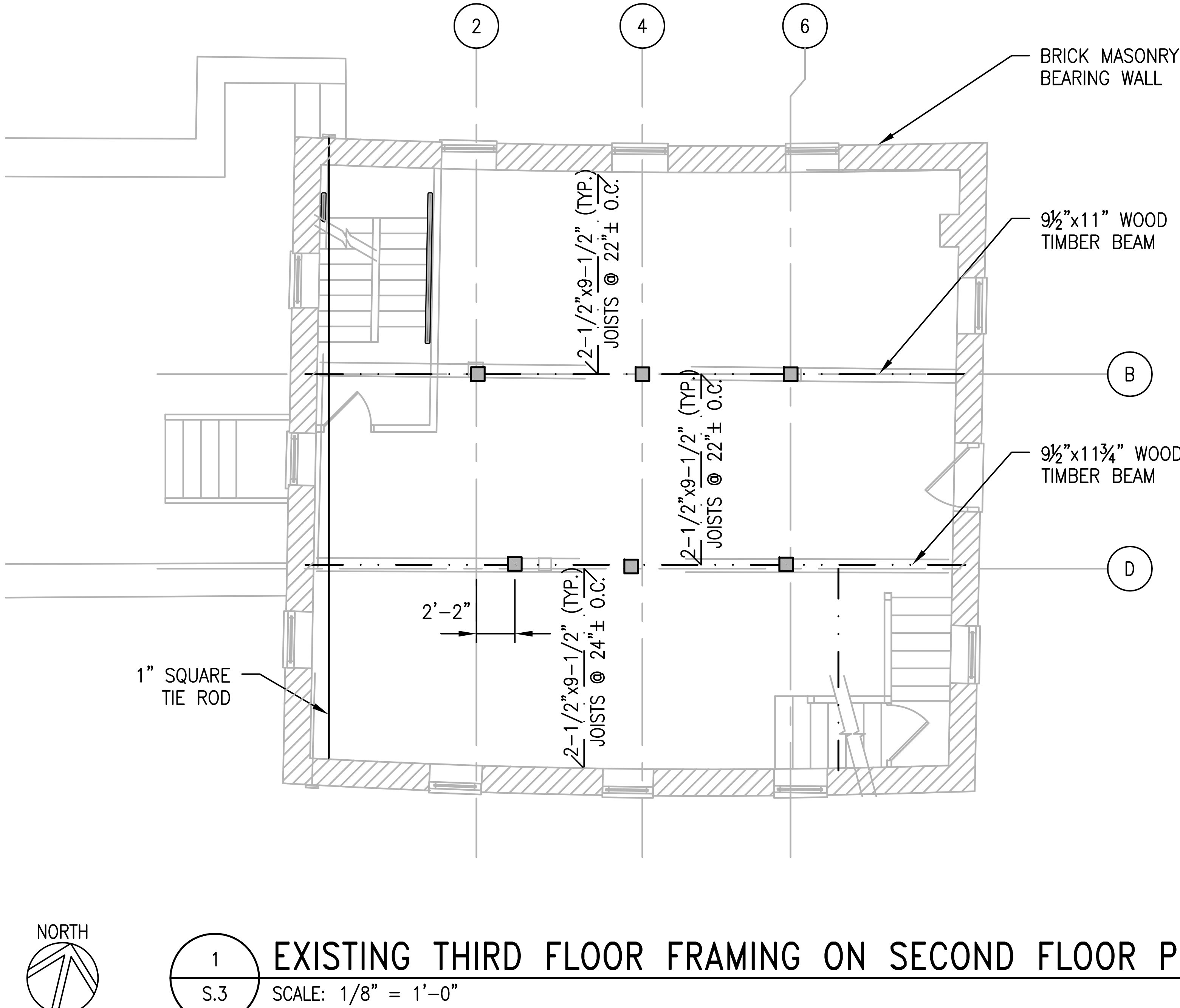
Title: EXISTING SECOND FLOOR FRAMING ON FIRST FLOOR PLAN

ROBERT SILMAN ASSOCIATES
STRUCTURAL ENGINEERS
1053 31st Street NW
Washington, DC 20007
P 202.333.6230 F 202.318.3015

Job Title: WATERFORD MILL
HISTORIC STRUCTURES REPORT

Date: 08/21/2012
Scale: AS NOTED
Job Number: W2862

S.2



COLUMN SCHEDULE		
COLUMN	W	D
B-2	9¼"	9½"
B-4	9"	9"
B-6	9⅛"	9½"
D-2	9¾"	9¾"
D-4	8¾"	8⅞"
D-6	9½"	9½"

NOTE: EXISTING THIRD FIRST FLOOR FRAMING HAS AN ESTIMATED ALLOWABLE LIVE LOAD CAPACITY OF 53 PSF ASSUMING JOIST. BEAMS, & FLOOR BOARDS ARE IN AN UNDETERIORATED STATE. CAPACITY IS ESTIMATED ASSUMING AN UNLOADED FLOOR.

1 / S.3 EXISTING THIRD FLOOR FRAMING ON SECOND FLOOR PLAN

SCALE: 1/8" = 1'-0"

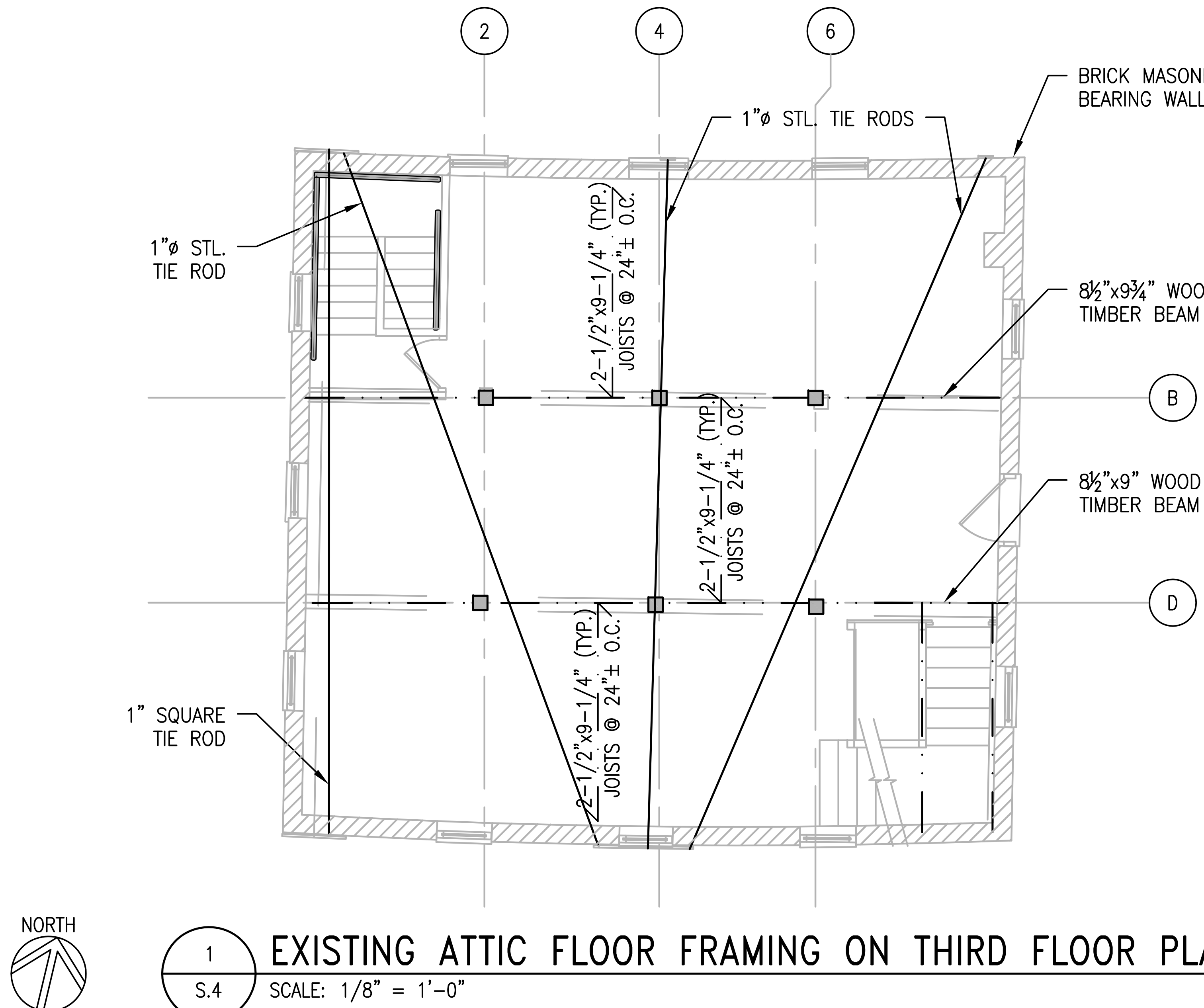
Title: EXISTING THIRD FLOOR FRAMING ON SECOND FLOOR PLAN

ROBERT SILMAN ASSOCIATES
STRUCTURAL ENGINEERS
1053 31st Street NW
Washington, DC 20007
P 202.333.6230 F 202.318.3015

Job Title: WATERFORD MILL
HISTORIC STRUCTURES REPORT

Date: 08/21/2012
Scale: AS NOTED
Job Number: W2862

S.3



EXISTING ATTIC FLOOR FRAMING ON THIRD FLOOR PLAN

1 / S.4 — SCALE: 1/8" = 1'-0"

COLUMN SCHEDULE		
COLUMN	W	D
B-2	8¼"	8¼"
B-4	9½"	9"
B-6	8¼"	9½"
D-2	7¾"	8½"
D-4	8¾"	8¾"
D-6	8¾"	9¼"

NOTE: EXISTING ATTIC FLOOR FRAMING HAS AN ESTIMATED ALLOWABLE LIVE LOAD CAPACITY OF 39 PSF ASSUMING JOIST. BEAMS, & FLOOR BOARDS ARE IN AN UNDETERIORATED STATE. CAPACITY IS ESTIMATED ASSUMING AN UNLOADED FLOOR.

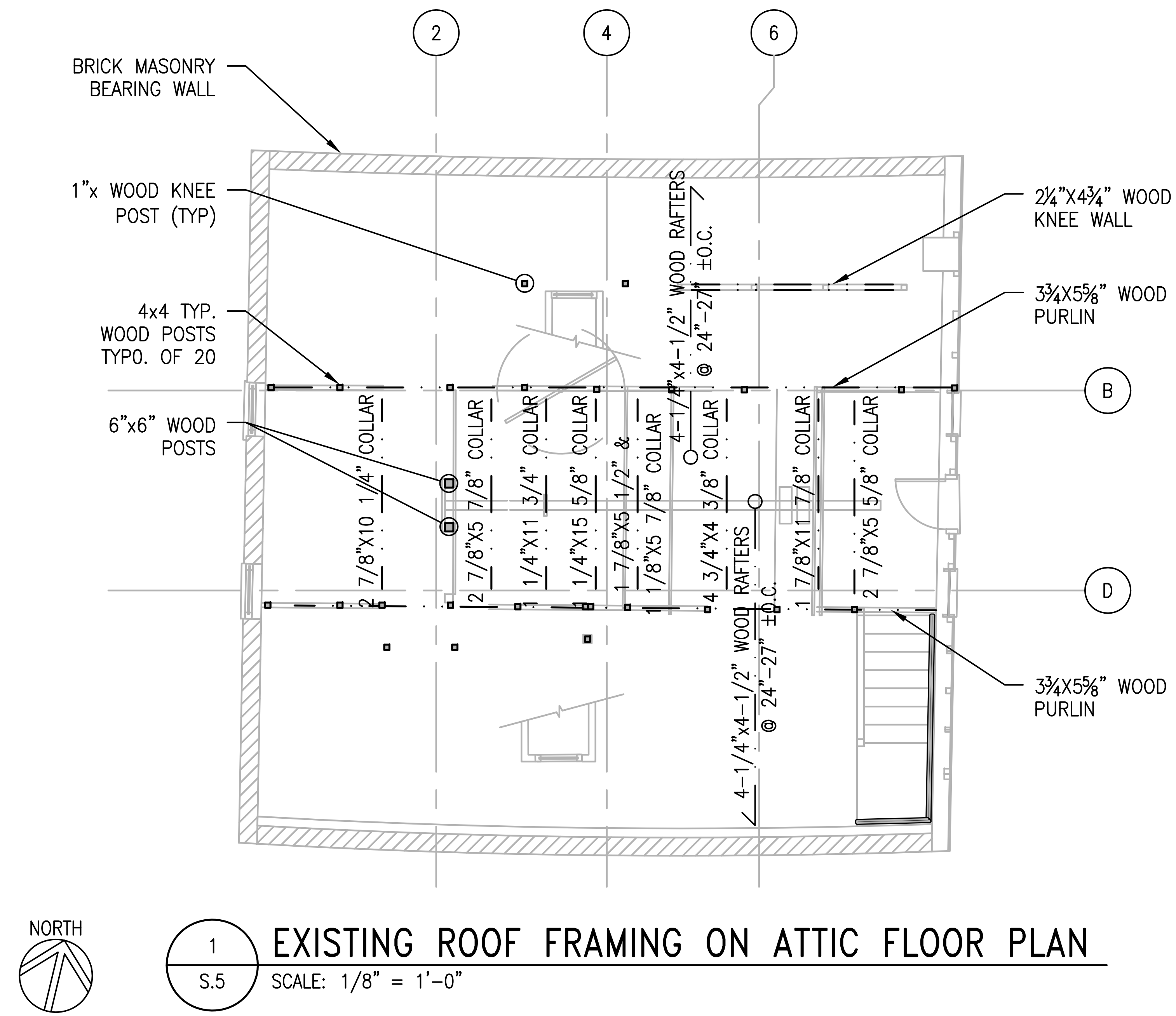
Title: EXISTING ATTIC FLOOR FRAMING ON THIRD FLOOR PLAN

ROBERT SILMAN ASSOCIATES
STRUCTURAL ENGINEERS
1053 31st Street NW
Washington, DC 20007
P 202.333.6230 F 202.318.3015

Job Title: WATERFORD MILL
HISTORIC STRUCTURES REPORT

Date: 08/21/2012
Scale: AS NOTED
Job Number: W2862

S.4



1
S.5

EXISTING ROOF FRAMING ON ATTIC FLOOR PLAN

SCALE: 1/8" = 1'-0"

NOTE: EXISTING ROOF FRAMING HAS AN ESTIMATED ALLOWABLE LIVE LOAD CAPACITY OF 13 PSF ASSUMING RAFTERS & SUPPORTING MEMBERS ARE IN AN UNDETERIORATED STATE. CAPACITY IS ESTIMATED ASSUMING AN UNLOADED ROOF.

Title: EXISTING ROOF FRAMING ON ATTIC FLOOR PLAN

ROBERT SILMAN ASSOCIATES
STRUCTURAL ENGINEERS
1053 31st Street NW
Washington, DC 20007
P 202.333.6230 F 202.318.3015

Job Title: WATERFORD MILL
HISTORIC STRUCTURES REPORT

Date: 08/21/2012
Scale: AS NOTED
Job Number: W2862

S.5

APPENDIX C: WOOD SPECIES IDENTIFICATION REPORT

07/18/2007 11:42 6082382225 PAGE 02

QUIRK
CONSULTING
Wood Identification and Problem Analysis
J. Thomas Quirk, Ph.D.

July 18, 2012

ATTN. Mike Kostick
Robert Silman Associates
1053 31st Street NW
Washington DC 20007

RSA project – waterford mill

Dear Mr. Kostick,
The 13 wood samples that you sent to me for identification both are as follows #1,2,3,4,5,6,7,8,9&11 all are Red Oak Group. **(Quercus sp.).** On the basis of anatomy alone the various species of this group cannot be separated.

#10 is Hard Maple group. **(Acer sp.).**

#12 is Yellow Poplar **(Liriodendron tulipifera).**

#13 is Southern Yellow Pine Group **(Pinus sp.).** On the basis of anatomy alone the various species of this group cannot be separated

Thank you for the opportunity to be of assistance.

Regards,

J. Thomas Quirk, Ph.D.
Wood Technologist.

Enclosure - invoice # 1730

117 N. Franklin Avenue • Madison, WI 53705 • Phone/Fax (608) 238-2225

07/18/2007 11:42 6082382225 PAGE 03

Quirk Consulting Service

J. Thomas Quirk, Ph.D., Wood Technologist.

Federal ID# 39-1538482

Invoice #1730

July 18, 2012

ATTN. Mike Kostick
Robert Silman Associates
1053 31st Street NW
Washington DC 20007

RSA project – waterford mill

Wood identifications

1. joist – red oak
2. beam - red oak
3. post - red oak
4. post - red oak
5. joist - red oak
6. beam - red oak
7. joist - red oak
8. sister - red oak
9. beam - red oak
10. post – hard maple
11. attic roof rafter - red oak
12. joist – yellow poplar
13. post (attic) – Southern Yellow Pine group.

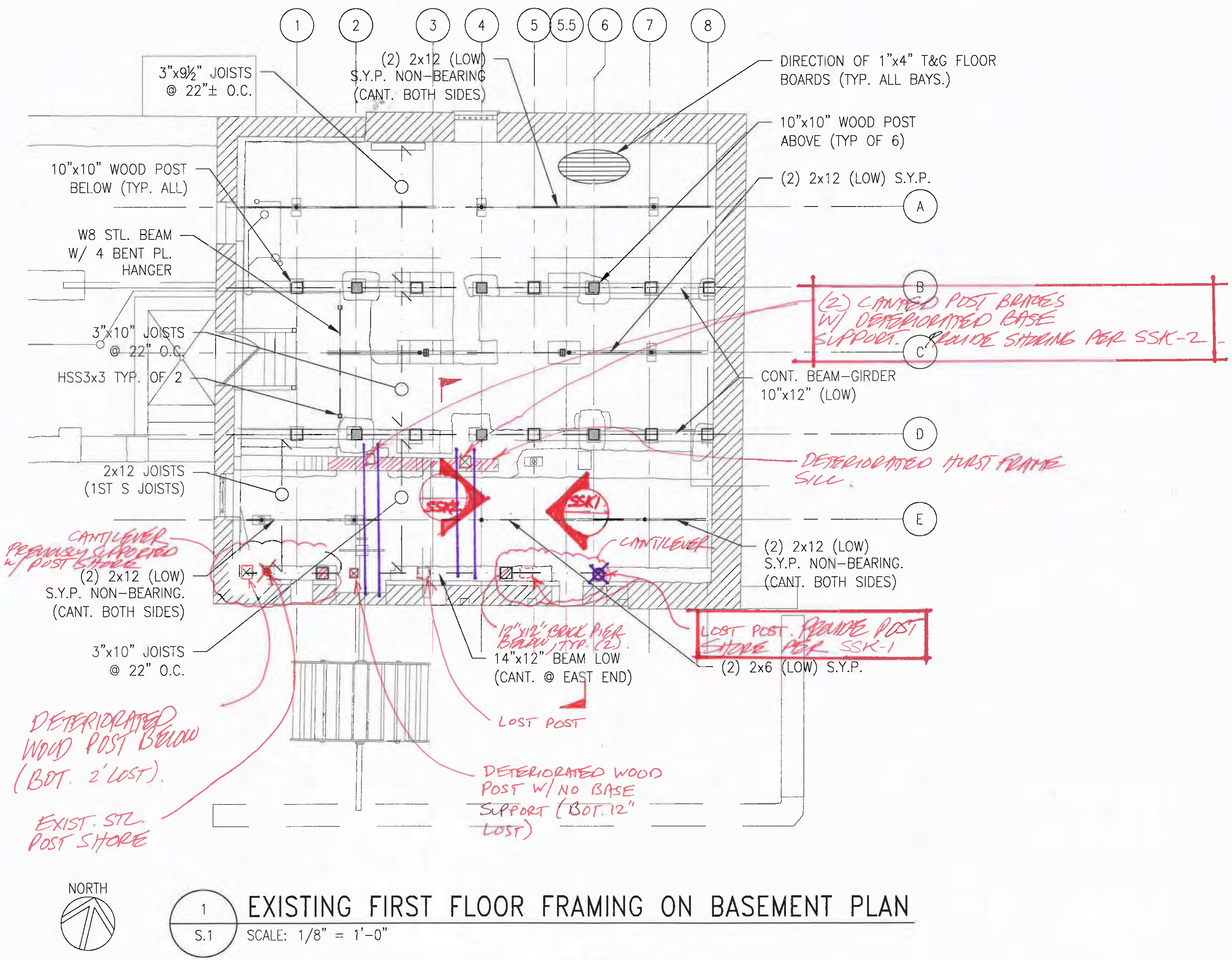
13 samples @ $30.00/sample = $390.00

Remit to: J. Thomas Quirk, Ph.D.
117 N. Franklin Avenue
Madison, WI 53705

Terms: payment in full required in 30 days.

Phone/FAX (608) 238-2225 E-mail TANDBQUIRK@AOL.COM

APPENDIX D: CONCEPTUAL STABILIZATION SKETCHES



1
S.1

EXISTING FIRST FLOOR FRAMING ON BASEMENT PLAN

SCALE: 1/8" = 1'-0"

8.29.2012

Title: EXISTING FIRST FLOOR FRAMING ON BASEMENT PLAN

Job Title: WATERFORD MILL
HISTORIC STRUCTURES REPORT

ROBERT SILMAN ASSOCIATES
STRUCTURAL ENGINEERS
1053 31st Street NW
Washington, DC 20007
P 202.333.6230 F 202.318.3015

Date: 08/21/2012
Scale: AS NOTED
Job Number: W2862

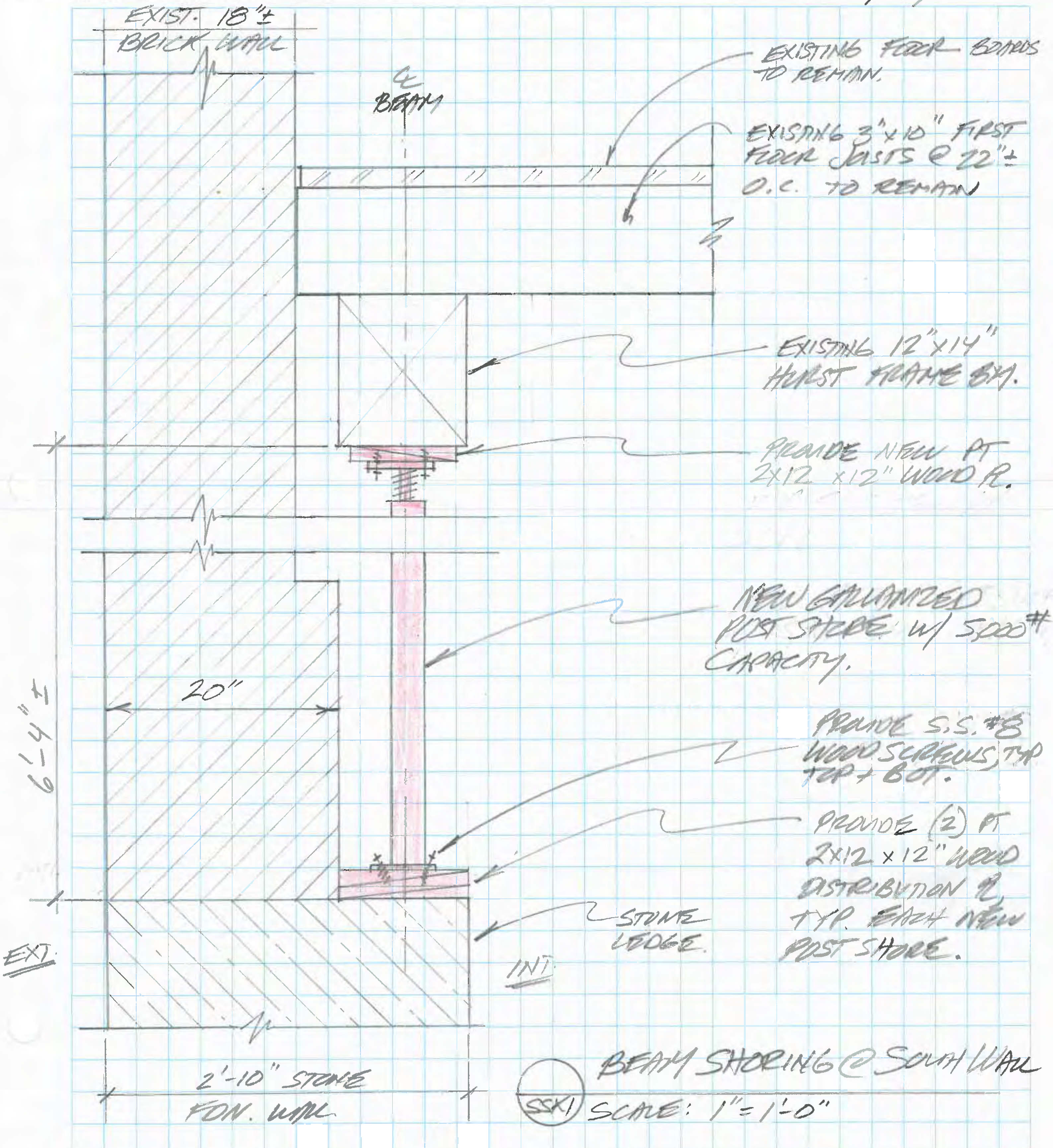
S.1

1/3

ROBERT SILMAN ASSOCIATES
STRUCTURAL ENGINEERS
1053 31st Street, NW Washington, DC 20007

PROJECT WATERFORD MILL JOB NO. W2862 PAGE SSK-1

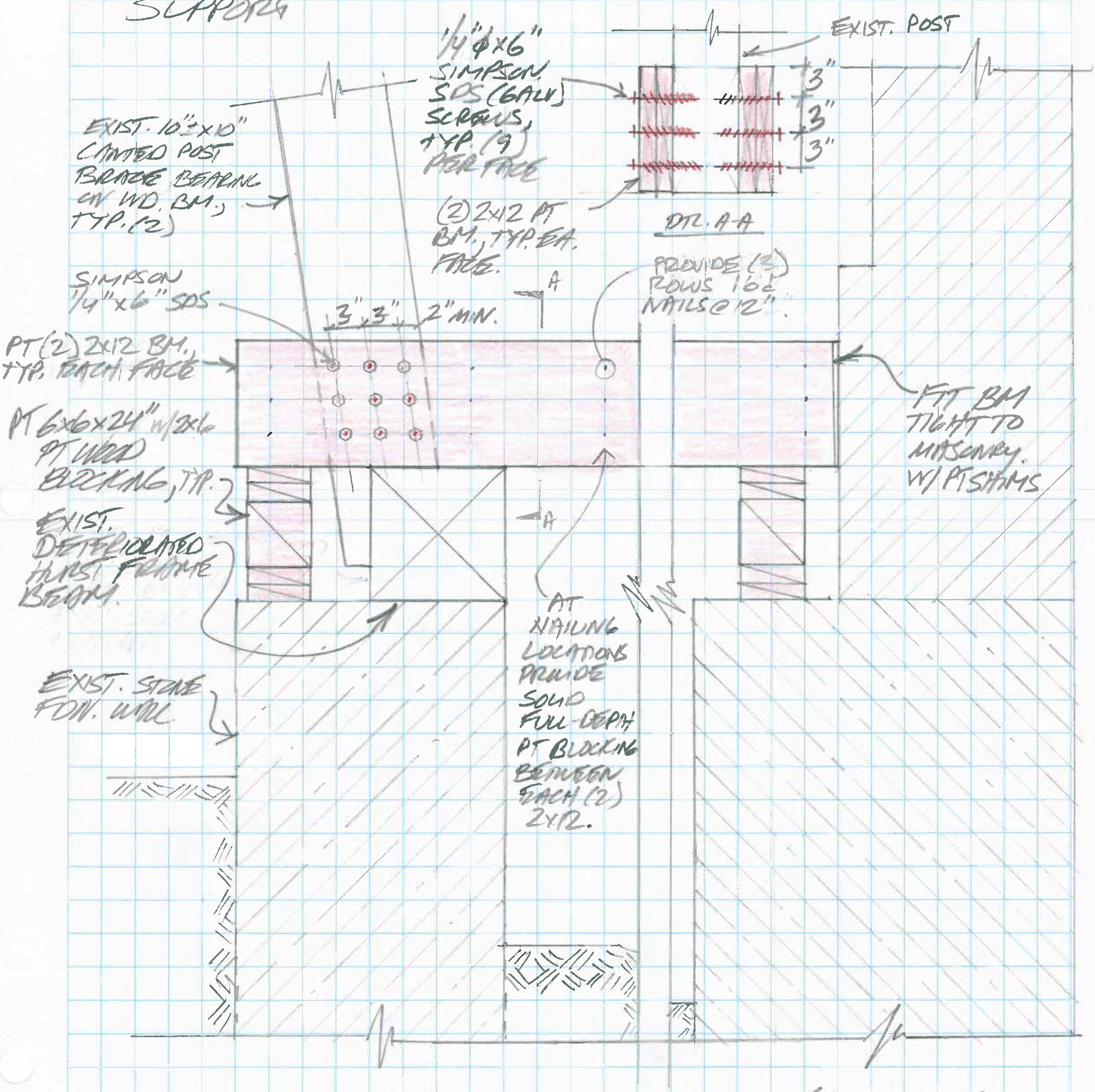
SUBJECT SHORING CONCEPT BY JO DATE 8/29/12



ROBERT SILMAN ASSOCIATES
STRUCTURAL ENGINEERS
1053 31st Street, NW Washington, DC 20007

PROJECT: WATERFORD MILL
JOB NO.: W2862
PAGE: SSK-2

SUBJECT: CANTED BRACE SUPPORT
BY: JD
DATE: 8/29/12



SSK2 — CANTED BRACE SUPPORT @ (2) WEST POSTS
SCALE: 1"=1'-0"

Appendix E

Environmental Report

Applied Environmental Inc.

February 6, 2014

Mr. Terry Ammons
Principal
StudioAmmons, Inc.
235 North Market Street
Petersburg, Virginia

Re: Asbestos-Containing Materials Survey and Lead-Containing Surface Coating Screening Survey – Waterford Mill, Waterford, Virginia

Dear Mr. Ammons:

Per your request, Applied Environmental conducted an asbestos survey and lead-containing (LC) surface coating screening survey of the Waterford Mill, located in Waterford, Virginia, on January 24, 2014. The surveys were conducted by Gary Lewis, an Environmental Protection Agency (EPA) accredited, and Commonwealth of Virginia licensed asbestos and lead based paint inspector. Survey areas were limited to those specified by the client. Mr. Lewis' licenses are provided in Appendix A "Inspector Licenses."

ASBESTOS-CONTAINING MATERIAL SURVEY

The asbestos survey was completed in accordance with the EPA Standard 40 CFR 763, Subpart E, Asbestos Hazard Emergency Response Act (AHERA), and Occupational Safety and Health Administration (OSHA) Standard 29 CFR 1926.1101 inspection and sampling protocols.

All of the collected bulk samples were submitted to the Aerobiology Laboratory Associates (ALA) for analysis by Polarized Light Microscopy (PLM) in accordance with EPA Method for the Determination of Asbestos in Bulk Insulation Samples (EPA 600M4-82-020). ALA is accredited by the U.S. Department of Commerce, National Institute of Standards and Technology, and the National Voluntary Laboratory Accreditation Program for bulk asbestos identification by PLM.

11 representative bulk samples were collected from the materials suspected to contain asbestos. The asbestos laboratory report is provided in Appendix B, "Asbestos Laboratory Reports". The laboratory reported "No Asbestos Detected" in all samples analyzed.

Homogeneous Materials List

MATERIAL DESCRIPTION	Friable (yes/no)	LOCATION	SAMPLE NUMBERS	ACM	Approx. Quantity
Plaster Wall	No	Rear stairwell, 3rd floor	01,02,03,04,05	No	-
Brown and tan pattern linoleum flooring and brown associated mastic	No	1st floor restroom	06,07,08,09	No	-
Drywall and joint compound	No	Rear stairwell	10,11	No	-

200 Fairbrook Drive, Suite 201 • Herndon, Virginia 20170 • 703-648-0822 • Fax 703-648-0575
www.appenv.com

LEAD-CONTAINING SURFACE COATING SCREENING SURVEY

Applied Environmental conducted a lead paint screening survey of the interior and exterior of the facility to identify building components coated with lead. The survey consisted of testing the lead concentrations of 18 surfaces.

The lead survey was performed using a Niton XLp 300A spectrum analyzer, which is an X-Ray Fluorescence (XRF) analyzer unit. The Niton XLp 300A is a hand held, portable lead detector, capable of immediately determining lead concentrations of tested surfaces in a non-destructive manner. The detection level of the Niton XLp 300A XRF is 0.1 milligrams of lead per square centimeter (mg/cm^2) of area tested. Please note that there may be concentrations of lead below this detection limit present throughout the facility. Painted surfaces measuring below 0.1 mg/cm^2 should be considered LC paint until paint chip samples analyzed by a laboratory confirm that lead concentrations are below detectable limits. The XRF calibration was validated in accordance with the manufacturer's instructions.

XRF analysis detected lead readings in excess of the unit detection limit on the following building component:

- Green interior and exterior door components (wood),
- White walls (brick),
- White columns (wood),
- White ceiling (wood), and
- White window components (wood).

Additional information regarding these components is presented in Attachment C, "Lead-Containing Components".

As the survey was a screening survey, Applied Environmental recommends that the component identified with the LC surface coating in a specific area of the building be assumed to have similar surface concentrations of lead throughout the rest of the building, and be handled in accordance with OSHA's lead standard until additional XRF testing or paint chip analysis proves otherwise. Since lead-containing paint was detected in this structure, Applied Environmental recommends that all painted surfaces be considered as LC in regard to performing work impacting these surfaces, and recommends using lead-safe work practices in accordance with OSHA.

A complete data table presenting results of the XRF testing is provided for your reference in Attachment D, "XRF Lead Testing Results". The "Floor" and "Room" columns define the location of the tested surfaces. Individual building components tested are listed under "Component"; the substrate on which the paint film is applied is noted under "Substrate"; the condition of the tested component is noted under "Condition"; the color of the top layer of paint is noted under "Color" to assist in determining the location of the building components tested. The actual concentration of lead is recorded in the "PbC" column in the noted units, mg/cm^2. The accuracy of each test is noted in the "PbC" column.

XRF analyzers provide a fast and reliable method for classifying many painted surfaces. However, some XRF test results may be inconclusive (neither positive nor negative), therefore necessitating laboratory testing of a paint chip sample. The laboratory paint chip result supersedes an XRF test result. A confirmatory paint chip sample was collected of the exterior green rear window frame to verify an inconclusive XRF measurement, and was submitted to AMA Laboratories, Inc. of Lanham, Maryland for analysis via EPA Method 600/R-93/200(M)-7000B. The laboratory reported the sample as having a lead concentration of <0.01% micrograms, which is less than the detectible level, and the window frame is not considered LC. The laboratory report is presented in Appendix E, "Lead Laboratory Results".

LEAD-CONTAINING SURFACE COATING SCREENING RECOMMENDATIONS

All construction activities that involve lead are regulated by the OSHA Lead in Construction Standard 29 CFR 1926.62. The standard currently does not define a specific concentration of lead that must be present within paint for it to be considered LC. Therefore, painted surfaces that contain detectable concentrations of lead must be handled in accordance with the OSHA Lead in Construction Standard. Any contractor performing work that could impact paint films with detectable concentrations of lead, should be informed of the testing results, and take appropriate actions to comply with OSHA Standard 29 CFR 1926.62. These appropriate actions include performing air monitoring to measure worker exposure, ensuring that the workers are provided with adequate respiratory protection, and the appropriate training.

Disposal of lead paint abatement waste is regulated under EPA Standard 40 CFR Part 261, and involves characterization of the waste as hazardous or non-hazardous, by Toxicity Characteristic Leaching Procedure (TCLP) testing. TCLP testing was not included in the scope of work. This test should be performed on a representative waste stream, to determine proper disposal methods.

Thank you for allowing us to provide these services for you. If you need any other assistance, please do not hesitate to call.

Sincerely,

Gary Lewis
Project Manager
Field Services Division

Attachments
Ref.: 2251-14-0028

Appendix A

Inspector Licenses

DEPARTMENT OF PROFESSIONAL AND OCCUPATIONAL REGULATION
COMMONWEALTH OF VIRGINIA

9960 Mayland Dr., Suite 400, Richmond, VA 23233
Telephone: (804) 367-8500

EXPIRES ON
02-28-2014

NUMBER
3303 002808

VIRGINIA ASBESTOS LICENSE
INSPECTOR LICENSE

GARY JAMES LEWIS
2703 PINECREEK PLACE

DISTRICT HEIGHTS, MD 20747

Gordon N. Dixon, Director

ALTERATION OF THIS DOCUMENT, USE AFTER EXPIRATION, OR USE BY PERSONS OR FIRMS OTHER THAN THOSE NAMED MAY RESULT IN CRIMINAL PROSECUTION UNDER THE CODE OF VIRGINIA.

(SEE REVERSE SIDE FOR NAME AND/OR ADDRESS CHANGE)

DEPARTMENT OF PROFESSIONAL AND OCCUPATIONAL REGULATION
COMMONWEALTH OF VIRGINIA

9960 Mayland Dr., Suite 400, Richmond, VA 23233
Telephone: (804) 367-8500

EXPIRES ON
08-31-2014

NUMBER
3356 000751

VIRGINIA LEAD LICENSE
LEAD RISK ASSESSOR
LICENSE

GARY JAMES LEWIS
2703 PINECREEK PLACE

DISTRICT HEIGHTS, MD 20747

Gordon N. Dixon, Director

ALTERATION OF THIS DOCUMENT, USE AFTER EXPIRATION, OR USE BY PERSONS OR FIRMS OTHER THAN THOSE NAMED MAY RESULT IN CRIMINAL PROSECUTION UNDER THE CODE OF VIRGINIA.

(SEE REVERSE SIDE FOR NAME AND/OR ADDRESS CHANGE)

Appendix B
Asbestos Laboratory Results

Aerobiology Laboratory Associates, Incorporated
Celebrating 15 Years

Certificate of Analysis

43760 Trade Center Place
Suite 100
Dulles, VA 20166
(877) 648-9150
www.aerobiology.ne

Applied Environmental
200 Fairbrook Dr.Suite 201
Herndon, VA 20170
Attn: Gary Lewis
Client Project Name: #2251-14-0028; Waterford Mill

NVLAP LAB CODE 200829-0

Date Collected: 01/24/14
Date Received: 01/27/14
Date Analyzed: 01/28/14
Date Reported: 01/30/14
Project ID: A14 0070
Job ID: 14001233

Test Requested: **3002, Asbestos in Bulk Samples**
Method: EPA-600/M4-82-20: Interim Method for the Determination of Asbestos in Bulk Insulation Samples - NVLAP Scope of Accreditation

Sample Identification		Client's Physical Description of Sample;	Homo-geneous (yes/no)	Number of Layers	Percent of Sample (%)	Asbestos Detected		Non-Asbestos Fibers (area %)	Non-Fibrous Material (area %)	Matrix Material (composition)
Client	Lab Sample Number					Chrysotile (%)	Amphibole (%)			
GL140124-01	A14 0070-001	Plaster Wall: 3rd Fl Main Area	Yes	1	100	ND1	ND1		>99	Q. C. OP. G
GL140124-02	A14 0070-002	Plaster Wall: 3rd Fl Main Area	Yes	1	100	ND1	ND1	CELL (Trace)	>99	Q. C. OP. G
GL140124-03	A14 0070-003	Plaster Wall: Stairwell	Yes	1	100	ND1	ND1	CELL (Trace)	>99	Q. C. OP. G
GL140124-04	A14 0070-004	Plaster Wall: Stairwell	Yes	1	100	ND1	ND1		>99	Q. C. OP. G
GL140124-05	A14 0070-005	Plaster Wall: Stairwell	Yes	1	100	ND1	ND1		>99	Q. C. OP. G
GL140124-06	A14 0070-006a	Linoleum Flooring, Brown and Tan Pattern: 1st Fl Restroom Brown and Tan Sheet Flooring	Yes	1	50	ND1	ND1		>99	C. B. OP
	A14 0070-006b	Linoleum Flooring, Brown and Tan Pattern: 1st Fl Restroom Beige Fibrous Backing	Yes	1	50	ND1	ND1	CELL (85) FBG (5)	10	C. OP
GL140124-07	A14 0070-007	Brown Underlying Mastic 1st Fl. Restroom	Yes	1	100	ND1	ND1	CELL (Trace)	>99	C. B. OP
GL140124-08	A14 0070-008a	Linoleum Flooring, Brown and Tan Pattern: 1st Fl Restroom Brown and Tan Sheet Flooring	Yes	1	50	ND1	ND1		>99	C. B. OP
	A14 0070-008b	Linoleum Flooring, Brown and Tan Pattern: 1st Fl Restroom Beige Fibrous Backing	Yes	1	50	ND1	ND1	CELL (85) FBG (5)	10	C. OP

A = Amosite
AC = Actinolite
AN = Anthophyllite
CR = Crocidolite
TR = Tremolite
ND1 = None Detected
Trace = Less Than 1%

CELL = Cellulose
MW = Mineral Wool
FBG = Fiberglass
SYN = Synthetic
WO = Wollastonite
NTR = Non-Asbestiform TR
NAC = Non-Asbestiform AC
FT = Fibrous Talc
AH = Animal Hair

Q = Quartz
C = Carbonates
V = Vermiculite
G = Gypsum
M = Mica
T = Tar
P = Perlite
O = Organic
B = Binder
OP = Opaques
D = Diatoms

Leah Peyton
Laboratory Analyst

Cathleen Piccione
Technical Supervisor

43760 Trade Center Place, Suite 100, Dulles, VA 20166 (877) 648-9150

Aerobiology Associates, Laboratory Incorporated
Celebrating 15 Years

43760 Trade Center Place
Suite 100
Dulles, VA 20166
(877) 648-9150
www.aerobiology.net

Certificate of Analysis

Applied Environmental
200 Fairbrook Dr.Suite 201
Herndon, VA 20170
Attn: Gary Lewis
Client Project Name: #2251-14-0028; Waterford Mill

NVLAP
NVLAP LAB CODE 200829-0

Date Collected: 01/24/14
Date Received: 01/27/14
Date Analyzed: 01/28/14
Date Reported: 01/30/14
Project ID: A14 0070
Job ID: 14001233

Test Requested: **3002, Asbestos in Bulk Samples**
Method: EPA-600/M4-82-20: Interim Method for the Determination of Asbestos in Bulk Insulation Samples - NVLAP Scope of Accreditation

Sample Identification		Client's Physical Description of Sample:	Homo-geneous (yes/no)	Number of Layers	Percent of Sample (%)	Asbestos Detected		Non-Asbestos Fibers (area %)	Non-Fibrous Material (area %)	Matrix Material (composition)
Client	Lab Sample Number					Chrysotile (%)	Amphibole (%)			
GL140124-09	A14 0070-009	Brown Underlying Mastic 1st Fl. Restroom	Yes	1	100	NDI	NDI	CELL (Trace)	>99	C, B, OP
GL140124-010	A14 0070-010	Drywall and Joint Compound: Stairwell 2nd Fl.	No	2	100	NDI	NDI	CELL (3) FBG (1)	96	C, OP, G, M
GL140124-011	A14 0070-011	Drywall and Joint Compound: Stairwell 1st Fl.	No	2	100	NDI	NDI	CELL (1) FBG (Trace)	99	C, OP, G, M

Leah Peyton
Laboratory Analyst

Cathleen Piccione
Technical Supervisor

A = Amosite
AC = Actinolite
AN = Anthophyllite
CR = Crocidolite
TR = Tremolite
NDI = None Detected
Trace = Less Than 1%

CELL = Cellulose
MW = Mineral Wool
FBG = Fiberglass
SYN = Synthetic
WO = Wollastonite
NTR = Non-Asbestiform TR
NAC = Non-Asbestiform AC
FT = Fibrous Talc
AH = Animal Hair

Q = Quartz
C = Carbonates
V = Vermiculite
G = Gypsum
M = Mica
T = Tar
P = Perlite
O = Organic
B = Binder
OP = Opaques
D = Diatoms

Aerobiology Associates, Laboratory Incorporated
Celebrating 15 Years

43760 Trade Center Place
Suite 100
Dulles, VA 20166
(877) 648-9150
www.aerobiology.net

Certificate of Analysis

Applied Environmental
200 Fairbrook Dr.Suite 201
Herndon, VA 20170
Attn: Gary Lewis
Client Project Name: #2251-14-0028; Waterford Mill

NVLAP
NVLAP LAB CODE 200829-0

Date Collected:	01/24/14
Date Received:	01/27/14
Date Analyzed:	01/28/14
Date Reported:	01/30/14
Project ID:	A14 0070
Job ID:	14001233

General Notes

- **ND1** indicates no asbestos was detected; the method detection limit is 1%.
- **Trace or "<1"** indicates asbestos was identified in the sample, but the concentration is less than the method detection limit of 1%.
- All regulated asbestos minerals (i.e. chrysotile, amosite, crocidolite, anthophyllite, tremolite, and actinolite) were sought in every layer of each sample, but only those asbestos minerals detected are listed. Amosite is the common name for the asbestiform variety of the minerals cummingtonite and grunerite. Crocidolite is the common name used for the asbestiform variety of the mineral riebeckite.
- Tile, vinyl, foam, plastic, and fine powder samples may contain asbestos fibers of such small diameter (< 0.25 microns in diameter) that these fibers cannot be detected by PLM. For such samples, more sensitive analytical methods (e.g. TEM, SEM, and XRD) are recommended if greater certainty about asbestos content is required. Semi-quantitative bulk TEM floor tile analysis is accepted under the NESHAPS regulations.
- Samples identified as inhomogeneous (containing more that one layer) shall be divided into individual layers and each layer tested separately. The results for each individual layer shall be listed separately on the report.
- These results are submitted pursuant to Aerobiology's current terms and conditions of sale, including the company's standard warranty and limitation of liability provisions. No responsibility or liability is assumed for the manner in which the results are used or interpreted.
- Unless notified in writing to return the samples covered by this report, Aerobiology Laboratory will store the samples for a minimum period of 3 months before discarding. A shipping and handling charge will be assessed for the return of any samples.
- This report must not be used by the client to claim product certification, approval, or endorsement by NVLAP, NIST, or any agency of the Federal Government.
- This test report relates only to the items tested or calibrated.
- This report is not valid unless it bears the name of a NVLAP-approved signatory.
- Any reproduction of this document must include the entire document in order for the report to be valid.

Appendix C

Lead-Containing Components

StudioAmmons
Waterford Mill
Waterford, Virginia

Lead Containing Components

Index	Time	Floor	Room	Component	Substrate	Condition	Color	PbC	Units
8	2014-01-24 10:10	FIRST	MAIN ENTRANCE	DOOR	WOOD	FAIR	GREEN	0.40 ± 0.10	mg / cm ^2
9	2014-01-24 10:11	FIRST	MAIN ENTRANCE	DOOR FRAME	WOOD	FAIR	GREEN	2.20 ± 0.30	mg / cm ^2
10	2014-01-24 10:13	FIRST	MAIN ENTRANCE	WALL	BRICK	POOR	WHITE	0.70 ± 0.40	mg / cm ^2
12	2014-01-24 10:16	FIRST	MAIN	COLUMN	WOOD	POOR	WHITE	0.40 ± 0.30	mg / cm ^2
13	2014-01-24 10:17	FIRST	MAIN	CEILING	WOOD	POOR	WHITE	0.40 ± 0.30	mg / cm ^2
14	2014-01-24 10:19	FIRST	MAIN	WINDOW FRAME	WOOD	POOR	WHITE	1.50 ± 0.30	mg / cm ^2
22	2014-01-24 10:33	ATTIC	STAIR CASE	HANDRAIL	WOOD	POOR	BROWN	0.40 ± 0.20	mg / cm ^2
23	2014-01-24 10:35	ATTIC	MAIN AREA	CROSS BOARDS	WOOD	POOR	BROWN	0.40 ± 0.20	mg / cm ^2
26	2014-01-24 10:39	THIRD	MAIN	WINDOW FRAME	WOOD	POOR	WHITE	6.60 ± 0.50	mg / cm ^2
31	2014-01-24 10:51	SECOND	MAIN	DOOR	WOOD	FAIR	GREEN	0.50 ± 0.10	mg / cm ^2
38	2014-01-24 11:02	EXTERIOR	REAR	DOOR FRAME	WOOD	FAIR	GREEN	0.40 ± 0.30	mg / cm ^2

Appendix D
XRF Lead Testing Results

StudioAmmons
Waterford Mill
Waterford, Virginia

XRF Lead Results Table

Index	Time	Floor	Room	Component	Substrate	Condition	Color	PbC	Units
1	2014-01-24 10:04	CALIBRATION						1.00 ± 0.10	mg / cm ^2
2	2014-01-24 10:04	CALIBRATION						1.00 ± 0.10	mg / cm ^2
3	2014-01-24 10:05	CALIBRATION						1.10 ± 0.10	mg / cm ^2
4	2014-01-24 10:05	CALIBRATION						1.10 ± 0.10	mg / cm ^2
5	2014-01-24 10:06	CALIBRATION						1.10 ± 0.10	mg / cm ^2
6	2014-01-24 10:09	VOID	MAIN ENTRANCE	DOOR	WOOD	FAIR	GREEN	1.20 ± 0.40	mg / cm ^2
7	2014-01-24 10:09	VOID	MAIN ENTRANCE	DOOR	WOOD	FAIR	GREEN	1.30 ± 0.30	mg / cm ^2
8	2014-01-24 10:10	FIRST	MAIN ENTRANCE	DOOR	WOOD	FAIR	GREEN	0.40 ± 0.10	mg / cm ^2
9	2014-01-24 10:11	FIRST	MAIN ENTRANCE	DOOR FRAME	WOOD	FAIR	GREEN	2.20 ± 0.30	mg / cm ^2
10	2014-01-24 10:13	FIRST	MAIN ENTRANCE	WALL	BRICK	POOR	WHITE	0.70 ± 0.40	mg / cm ^2
11	2014-01-24 10:15	VOID	MAIN	COLUMN	WOOD	POOR	WHITE	0.01 ± 0.02	mg / cm ^2
12	2014-01-24 10:16	FIRST	MAIN	COLUMN	WOOD	POOR	WHITE	0.40 ± 0.30	mg / cm ^2
13	2014-01-24 10:17	FIRST	MAIN	CEILING	WOOD	POOR	WHITE	0.40 ± 0.30	mg / cm ^2
14	2014-01-24 10:19	FIRST	MAIN	WINDOW FRAME	WOOD	POOR	WHITE	1.50 ± 0.30	mg / cm ^2
15	2014-01-24 10:22	FIRST	RESTROOM	DOOR	WOOD	POOR	TAN	0.00 ± 0.03	mg / cm ^2
16	2014-01-24 10:23	FIRST	RESTROOM	DOOR	WOOD	POOR	TAN	0.00 ± 0.02	mg / cm ^2
17	2014-01-24 10:24	FIRST	RESTROOM	DOOR FRAME	WOOD	POOR	TAN	0.02 ± 0.02	mg / cm ^2
18	2014-01-24 10:31	VOID	STAIR CASE	HANDRAIL	WOOD	POOR	BROWN	0.01 ± 0.02	mg / cm ^2
19	2014-01-24 10:32	VOID	STAIR CASE	HANDRAIL	WOOD	POOR	BROWN	0.02 ± 0.02	mg / cm ^2
20	2014-01-24 10:32	VOID	STAIR CASE	HANDRAIL	WOOD	POOR	BROWN	0.03 ± 0.03	mg / cm ^2
21	2014-01-24 10:32	VOID	STAIR CASE	HANDRAIL	WOOD	POOR	BROWN	0.01 ± 0.02	mg / cm ^2
22	2014-01-24 10:33	ATTIC	STAIR CASE	HANDRAIL	WOOD	POOR	BROWN	0.40 ± 0.20	mg / cm ^2
23	2014-01-24 10:35	ATTIC	MAIN AREA	CROSS BOARDS	WOOD	POOR	BROWN	0.40 ± 0.20	mg / cm ^2
24	2014-01-24 10:36	ATTIC	MAIN AREA	WALL	WOOD	POOR	BROWN	0.03 ± 0.02	mg / cm ^2
25	2014-01-24 10:36	ATTIC	MAIN AREA	WALL	WOOD	POOR	BROWN	0.03 ± 0.02	mg / cm ^2
26	2014-01-24 10:39	THIRD	MAIN	WINDOW FRAME	WOOD	POOR	WHITE	6.60 ± 0.50	mg / cm ^2
27	2014-01-24 10:43	THIRD	VOID	WALL	DRYWALL	FAIR	WHITE	0.00 ± 0.02	mg / cm ^2
28	2014-01-24 10:43	THIRD	VOID	WALL	DRYWALL	FAIR	WHITE	0.00 ± 0.02	mg / cm ^2
29	2014-01-24 10:44	THIRD	VOID	WALL	DRYWALL	FAIR	WHITE	0.00 ± 0.02	mg / cm ^2
30	2014-01-24 10:45	THIRD	STAIRWELL	WALL	DRYWALL	FAIR	WHITE	0.00 ± 0.02	mg / cm ^2
31	2014-01-24 10:51	SECOND	MAIN	DOOR	WOOD	FAIR	GREEN	0.50 ± 0.10	mg / cm ^2
32	2014-01-24 10:53	SECOND	MAIN	WINDOW SILL	CONCRETE	FAIR	WHITE	0.01 ± 0.02	mg / cm ^2
33	2014-01-24 10:54	SECOND	MAIN	WINDOW SILL	CONCRETE	FAIR	WHITE	0.01 ± 0.02	mg / cm ^2

XRF Lead Results Table

Index	Time	Floor	Room	Component	Substrate	Condition	Color	PbC	Units
34	2014-01-24 10:58	VOID	REAR	HANDRAIL	WOOD	FAIR	GREEN	0.00 ± 0.02	mg / cm ^2
35	2014-01-24 10:59	VOID	REAR	HANDRAIL	METAL	FAIR	BLACK	0.00 ± 0.03	mg / cm ^2
36	2014-01-24 10:59	VOID	REAR	HANDRAIL	METAL	FAIR	BLACK	0.02 ± 0.03	mg / cm ^2
37	2014-01-24 11:00	EXTERIOR	REAR	HANDRAIL	METAL	FAIR	BLACK	0.01 ± 0.02	mg / cm ^2
38	2014-01-24 11:02	EXTERIOR	REAR	DOOR FRAME	WOOD	FAIR	GREEN	0.40 ± 0.30	mg / cm ^2
39	2014-01-24 11:03	EXTERIOR	REAR	WINDOW FRAME	WOOD	FAIR	GREEN	0.00 ± 0.02	mg / cm ^2
40	2014-01-24 11:04	EXTERIOR	REAR	WINDOW FRAME	WOOD	FAIR	GREEN	0.01 ± 0.02	mg / cm ^2
41	2014-01-24 11:04	EXTERIOR	REAR	WINDOW FRAME	WOOD	FAIR	GREEN	0.00 ± 0.02	mg / cm ^2
42	2014-01-24 11:13	CALIBRATION						1.10 ± 0.10	mg / cm ^2
43	2014-01-24 11:14	CALIBRATION						1.10 ± 0.10	mg / cm ^2
44	2014-01-24 11:14	CALIBRATION						1.10 ± 0.10	mg / cm ^2
45	2014-01-24 11:14	CALIBRATION						1.10 ± 0.10	mg / cm ^2

Appendix E
Lead Laboratory Results

AMA Analytical Services, Inc.
A Specialized Environmental Laboratory

CERTIFICATE OF ANALYSIS

AIHA LAP, LLC ACCREDITED LABORATORY
INDUSTRIAL HYGIENE, ENVIRONMENTAL LEAD & ENVIRONMENTAL MICROBIOLOGY
ISO/IEC 17025:2005
www.aihaaccreditedlabs.org
LAB #100470

Client:	Applied Environmental, Inc.	**Job Name:**	Waterford Mill	**Chain Of Custody:**	227820
Address:	200 Fairbrook Drive, Suite 201	**Job Location:**	Waterford, VA	**Date Submitted:**	1/27/2014
	Herndon, Virginia 20170	**Job Number:**	2251-14-0028	**Person Submitting:**	Gary Lewis
		P.O. Number:	Not Provided	**Date Analyzed:**	1/28/2014 **Report Date:** 1/28/2014
Attention:	Gary Lewis				

Summary of Atomic Absorption Analysis for Lead

AMA Sample Number	Client Sample Number	Analysis Type	Sample Type	Air Volume (L)	Area Wiped (ft²)	Reporting Limit	Total ug	Final Result	Comments
14027769	GL140124-01	Flame	Paint Chip	****	N/A	0.01 %Pb		<0.01 %Pb	

Analysis Method for Flame: Air, Wipes, Paints, and Soil/Solids: EPA 600/R-93/200(M)-7000B; Water: SM-3111B
Analysis Method For Furnace: Air, Wipes, Paints, and Soil/Solids : EPA 600/R-93/200(M)-7010; Water: SM-3113B
N/A = Not Applicable mg/Kg = parts per million (ppm) on a dry weight basis mg/L = parts per million (ppm)
%Pb = percent lead on a dry weight basis ug = micrograms ug/L = parts per billion (ppb)
Note: All samples were received in good condition unless otherwise noted.
Note: All results have two significant digits. Any additional digits shown should not be considered when interpreting the result.

Air and Wipe results are not corrected for any blank results

Final results for air and wipe samples are based on client supplied information nor verified by this laboratory.

All results are to be considered preliminary and subject to change unless signed by the Technical Director or Deputy.

See QC Summary for analytical results of quality control samples associated with these samples.

Analyst: Kimberly Lukus

Technical Manager: G Edward Carney

AMA Analytical Services, Inc.
Focused on Results www.amalab.com
AIHA (#100470) NVLAP (#101143-0) NY ELAP (10920)
4475 Forbes Blvd. • Lanham, MD 20706
(301) 459-2640 • (800) 346-0961 • Fax (301) 459-2643

CHAIN OF CUSTODY

(Please Refer To This Number For Inquires) 227820

Mailing/Billing Information:
1. Client Name: Applied Environmental, Inc.
2. Address 1: 200 Fairbrook Dr.
3. Address 2: Suite 201
4. Address 3: Herndon, Va 20170
5. Phone #: 7/648-8822 Fax #: 7/648-0575

Submittal Information:
1. Job Name: Waterford Mill
2. Job Location: Waterford Va
3. Job #: 2251-14002E P.O. #:
4. Contact Person: Gary Lewis @ phone# 571-282-6516
5. Submitted by: Gary Lewis Signature: [signature]

Reporting Info (Results provided as soon as technically feasible). If no TAT/Reporting Info is provided, AMA will assign defaults of 5-Day and email/fax to contacts on file.

AFTER HOURS (must be pre-scheduled)	NORMAL BUSINESS HOURS	REPORT TO:
☐ Immediate Date Due: ☐ 24 Hours Time Due: Comments:	☐ Immediate ☐ Next Day ☐ 2 Day ☒ 3 Day ☐ 5 Day + Date Due: 1/30/14 ☐ Results Required By Noon	☒ Include COC/Field Data Sheets with Report ☒ Email: glewis @ appenv.com ☐ Fax: ☐ Verbals:

Asbestos Analysis
*PCM Air – Please Indicate Filter Type:
- ☐ NIOSH 7400 ____ (QTY)
- ☐ Fiberglass ____ (QTY)

TEM Air* – Please Indicate Filter Type:
- ☐ AHERA ____ (QTY)
- ☐ NIOSH 7402 ____ (QTY)
- ☐ Other (specify ____) ____ (QTY)

PLM Bulk
- ☐ EPA 600 – Visual Estimate ____ (QTY)
- ☐ EPA Point Count ____ (QTY)
- ☐ NY State Friable 198.1 ____ (QTY)
- ☐ Grav. Reduction ELAP 198.6 ____ (QTY)
- ☐ Other (specify ____) ____ (QTY)

MISC
- ☐ Vermiculite
- ☐ Asbestos Soil PLM__(Qual) PLM__(Quan) PLM/TEM__(Qual) PLM/TEM__(Quan)

*It is recommended that blank samples be submitted with all air and surface samples

TEM Bulk
- ☐ ELAP 198.4/Chatfield ____ (QTY)
- ☐ NY State PLM/TEM ____ (QTY)
- ☐ Residual Ash ____ (QTY)

TEM Dust*
- ☐ Qual. (pres/abs) Vacuum/Dust ____ (QTY)
- ☐ Quan. (s/area) Vacuum D5755-95 ____ (QTY)
- ☐ Quan. (s/area)Dust D6480-99 ____ (QTY)

TEM Water
- ☐ Qual. (pres/abs) ____ (QTY)
- ☐ ELAP 198.2/EPA 100.2 ____ (QTY)
- ☐ EPA 100.1 ____ (QTY)

☒ All samples received in good condition unless otherwise noted. (TEM Water samples ____ °C)

If field data sheets are submitted, there is no need to complete bottom section.

Metals Analysis
- ☒ Pb Paint Chip 1 (QTY)
- ☐ *Pb Dust Wipe (wipe type ____) ____ (QTY)
- ☐ *Pb Air ____ (QTY)
- ☐ Pb Soil/Solid ____ (QTY)
- ☐ Pb TCLP ____ (QTY)
- ☐ Drinking Water ☐ Pb ____ (QTY) ☐ Cu ____ (QTY) ☐ As ____ (QTY)
- ☐ Waste Water ☐ Pb ____ (QTY) ☐ Cu ____ (QTY) ☐ As ____ (QTY)
- ☐ Pb Furnace (Media ____) ____ (QTY)

Fungal Analysis
Collection Apparatus for Spore Traps/Air Samples:
Collection Media
- ☐ *Spore-Trap ____ (QTY)
- ☐ *Surface Swab ____ (QTY)
- ☐ *Surface Tape ____ (QTY)
- ☐ Other (Specify ____) ____ (QTY)
- ☐ Surface Vacuum Dust ____ (QTY)
- ☐ Culturable ID Genus (Media ____) ____ (QTY)
- ☐ Culturable ID Species (Media ____) ____ (QTY)

CLIENT ID #	SAMPLE INFORMATION SAMPLE LOCATION/ ID	DATE/ TIME	VOL (L)/ Wipe Area	TEM	PCM	PLM	LEAD	MOLD	AIR	BULK	DUST	WATER AND OTHER	SPORE TRAP	TAPE	SWAB
GL140124-01	Ext. Rear Window Frame	1/24/14					X								

CLIENT CONTACT (LABORATORY STAFF ONLY)

Date/Time:	Contact:	By:
Date/Time:	Contact:	By:
Date/Time:	Contact:	By:

LABORATORY STAFF ONLY: (CUSTODY)
1. Date/Time RCVD: 1 / 27 / 14 @1500 Via: Courier By (Print): WEM Sign: [signature]
2. Date/Time Analyzed: ___ / ___ / ___ @ ___ By (Print): ___ Sign: ___
3. Results Reported To: ___ Via: ___ Date: ___ / ___ / ___ Time: ___ Initials: ___
4. Comments: