8.0 ANALYSIS AND DISCUSSION

The Jones Site contained evidence of an ephemeral historical occupation used on at least one occasion for making brick, as well as possibly having been used for keeping livestock and other agricultural activities. The site is therefore related to overlapping themes of rural manufacturing processes and rural landscape. No domestic occupation locale was identified within the boundaries of the Jones Site, although a tenant house was likely present nearby, beyond the right-of-way, for portions of the late 18th through the mid-19th centuries.

The brick clamp complex in the northern portion of the site (Block A) represents a discrete manufacturing location for brick; however, the clamp itself is relatively small suggesting, perhaps, limited production, limited manpower, a single episode, or all three. The archaeological remains in the southern portions of the site (Blocks B and C) suggest outlying features associated with a more extensive occupation beyond the project area, though it is not impossible that some of the features in the southern portion of the site may be a supporting extension of the brick manufacturing activities occurring in the northern portion. The major focus of our research was to examine variables of site selection related to the activity areas, to identify the interrelationships between the two activity areas whether they were industrial, domestic, a combination of both or neither, to demonstrate the types of archaeological and chemical signatures associated with small ephemeral historical rural sites, and to define the research parameters of such sites. Basic analyses to address the interwoven research issues of rural manufacturing and rural landscapes include feature, artifact and spatial analyses.

8.1 SITE ARTIFACTS: SITE CHRONOLOGY AND FUNCTION

8.1.1 Summary of Artifacts from Site Evaluation

This subsection briefly summarizes the artifact assemblage from the site evaluation phase at the Jones Site. Site evaluation investigations at the Jones Site produced a total of 6,936 artifacts. Of this number, 6,893 were historical; the remaining 43 were prehistoric (Table 8-1). The assemblage of prehistoric artifacts included temporally diagnostic points. These points include bifurcates dating to the Archaic period and a triangle point dating to the Woodland II period (Appendix B). The American Indian component assemblage also included debitage, flake tools, a hammerstone, and thermally altered stone.

Historical artifacts recovered during site evaluation investigations demonstrated a range of historical activities. By far, the Architectural items, especially brick, constituted a majority of the historical assemblage. Of the 7,094 historical artifacts, almost 91 percent (n=6,444) were architectural. In total, 6,297 brick fragments were recovered, accounting for almost 89 percent of the total assemblage and nearly 98 percent of the Architectural assemblage. Other artifacts, primarily historical ceramics and bottle glass, but also including iron pot fragments, indicated limited food preparation, storage, and/or consumption. Other artifact types included Personal items, such as tobacco pipes, and

faunal remains, oyster shell and bone. Additionally, fuel materials and byproducts, specifically coal and clinker might derive from industrial use in the heat signature (brick clamp) identified at the Jones Site, or more likely from activities of later occupants of the property.

Diagnostic historical artifacts consist mostly of historical ceramics but also include certain glass and nail types. Collectively, the artifacts indicate a fairly long historical land use. The earliest historical artifacts indicate a mid-to-late-18th century occupation and include creamware, German blue decorated stoneware (Westerwald), and white salt glazed stoneware (English). Continued occupation through the mid-19th century was identifiable through the recovery of pearlware, ironstone, early whitewares, machine cut nails, and mold-blown bottle glass. The most recent artifacts reflect a late-19th through early-20th century deposition and include decal-decorated whitewares, Albany slipped/Bristol glazed stonewares, machine-made bottle glass, and wire nails.

Table 8-1. Artifacts Recovered During Site Evaluation by Testing Strategy.

8.1.1.1.1.1.1.1 TEST	*8.1.1.1.1.1.1.2 Prehistoric*	**Historical**	**Total**
Shovel Test	23	967	990
Test Unit	16	2,256	2,272
Feature	4	3,659	3,663
General Surface Collection	--	11	11
Total	43	6,893	6,936

8.1.2 Artifact Analysis

For the remainder of this chapter, the site evaluation (Phase II) and data recovery (Phase III) assemblages from the Jones Site will be combined. Combined site evaluation and data recovery investigations yielded a total of 8,495 artifacts (Table 8-2). Over 8,300 historical artifacts representing activity, agricultural, architectural, armaments, clothing, domestic, faunal remains, personal, and miscellaneous categories were identified (Table 8-3). The remaining 191 artifacts reflecting American Indian occupation are discussed in Appendix B. In addition, 210 historical and 34 prehistoric artifacts, lacking vertical and/or horizontal provenience, were retained as general site collection.

Table 8-2. Artifact Counts by Stage of Investigation.

	Prehistoric	***Historical***	***Total***
Site Evaluation			
Shovel Test	23	967	990
Test Unit	16	2,256	2,272
Feature	4	3,659	3,663
Surface Collection	--	11	11

	Prehistoric	***Historical***	***Total***
Data Recovery			
Feature (incl. test units)	114	1,212	1,325
Surface Collection	34	199	233
Total	191	8,304	8,495

Table 8-3. Historical Artifacts Recovered from the Jones Site

Group	***Material***	***Artifact***	***Count***			
			Surface Collection	***Shovel Test***	***Unit***	***Feature***
Activity	Iron	Bucket	--	--	--	36
		Horseshoe	1	--	--	1
	Terra Cotta	Flowerpot	2	3	1	--
Agriculture	Iron	Plow	--	1	--	1
	Lime	Fertilizer	--	--	--	1
Architectural	Iron	Bolt	2	--	--	--
		Hinge	--	--	--	5
		Hoop	--	--	--	4
		Wire Nails	1	--	--	11
		Cut Nails	14	11	5	65
		Wrought Nails	2	--	--	15
		Unidentified Square	1	13	14	187
		Unidentified Nails	--	--	1	6
		Eye Hook	--	1	--	--
		Latch	1	--	--	--
		Wrought Pintle	1	--	--	--
	Glass	Window Glass	6	28	19	6
	Brick		34	695	2,017	4,066
	Mortar		--	1	--	--
	Sandstone	Building Stone	1	--	--	--
	Slate	Fragment	--	--	--	1
	Terra Cotta	Drainpipe	--	8	1	10
		Tile	4	--	--	--
	Stoneware	Drainpipe	1	--	--	--
	Wood	Barrel Stave	--	--	--	44
		Barrel Caskhead	--	--	--	10
		Peg	--	--	--	4
		Plank	--	--	--	1
		Stake	--	--	--	3
		Well Collar	--	--	--	1
		Unidentified	--	1	--	8
Armaments	Lead	Bullet	--	--	1	--
Clothing	Porcelain	Button	--	--	1	--
	Glass	Button	1	--	--	--
	Cupreous Alloy	Button	--	--	--	1
		Shoe Grommet	--	--	1	--

Group	***Material***	***Artifact***	***Count***			
			Surface Collection	***Shovel Test***	***Unit***	***Feature***
Domestic	Earthenware	Creamware	1	3	3	5
		Ironstone	8	10	9	--
		Jackfield-like	3	3	11	1
		Pearlware	4	19	8	6
		Redware	37	62	44	25
		Whiteware	4	12	9	3
		Unrecognized	--	3	1	--
		Yellowware	--	1	1	2
	Porcelain	Chinese	4	1	1	1
		Bone China	1	--	1	--
		Hard Paste	6	2	--	3
	Stoneware	Albany Slip	6	3	--	--
		American Salt Glazed Stoneware	3	3	--	--
		Westerwald	1	--	--	--
		White Salt Glazed Stoneware	--	2	2	3
	Glass	Vessel Fragments	4	8	11	--
		Machine Made Bottle	2	1		--
		Mold Blown Bottle	16	19	18	2
		Free Blown Bottle			2	--
		Unidentified Bottle	11	28	5	1
		Mold Blown Fruit Jar/ Fruit Jar Lid Liner	3	--	--	--
		Unidentified Fruit Jar/ Fruit Jar Lid Liner	3	3	1	--
		Lamp Glass	1	5	3	1
	Iron	Cooking Pot	--	1	--	12
	Graphite	Battery Rod	--	1	--	--
Faunal	Bone	Bird	--	--	--	1
		Mammalian	3	--	--	1
		Unidentified	--	--	--	1
	Tooth	Cow	--	--	--	9
	Mussel shell		--	1	--	--
	Turtle Shell		--	--	--	19
	Oyster shell		3	--	2	--
Fence Related	Iron	Barbed Wire	--	--	--	1
		Fence Staple	1	--	--	3
Floral	Charcoal		--	1	--	4
	Peach Pit		--	--	--	35
	Seed		--	--	--	1
	Stem		--	--	--	1
	Wood		--	--	--	--
Fuel	Clinker		--	1	18	7
	Coal		--	1	33	26
	Slag		--	1	5	--
Personal	Glass	Bead	1	--	--	--
	Porcelain	Doll Head	1	--	--	--

Group	*Material*	*Artifact*	*Count*			
			Surface Collection	*Shovel Test*	*Unit*	*Feature*
	White Metal	Harmonica	--	--	1	--
	White Ball Clay	Tobacco Pipe	--	3	--	3
Miscellaneous	Clay		--	5	--	78
	Glass		1	1	4	--
	Leather	Unidentified	--	--	--	3
	Copper	Unidentified Alloy	--	--	--	3
	Quartz	Cobble	--	--	--	4
	Quartzite	Cobble	--	--	--	23
	Sandstone	Cobble	--	--	--	9
	Lead	Unidentified	--	--	--	1
	Iron	Unidentified	10	1	2	86
TOTAL			**210**	**967**	**2,256**	**4,871**
						8,304

In total, 271 features were recorded during the Jones Site archaeological investigations (see Section 7.2 Data Recovery Feature Summary). Out of the 271 identified features, 125 features were determined to be non-cultural or not culturally significant and included plowscars, tire ruts, natural soil changes, rodent burrows and tunnels, tree and root molds and burns; 146 cultural features were defined from both the Phase II and Phase III archaeological investigations.

Block A Artifacts- The Brick Clamp Complex

Over 58 percent of the Block A artifact assemblage was recovered from features (Table 8-4); the majority of the rest of the assemblage was identified in the plow zone with only eight artifacts occurring in sub-plow zone contexts. Temporally diagnostic artifacts (ceramics, nails, glass) were recovered from the plow zone representing a late-18th through early-19th century occupation with a single fragment of solarized amethyst glass from the late-19th-to-early 20th century time frame.

Table 8-4. Artifact Distribution by Stratum and Features for Block A

Provenience	*Artifact Count*	*Frequency*
Plow Zone	2,725	41%
Sub-Plow Zone	8	<1%
Features	3,861	58%
Total	6,594	

Over 6,500 artifacts were recovered from excavations in Block A representing agriculture, architecture, domestic, faunal and floral remains, fuel, personal items and miscellaneous materials (Table 8-5). Over 96 percent of the assemblage was architecture related (n=6,360) with 95 percent of that total comprising brick fragments. Of these, approximately 26% by weight appeared to have been under or misfired based on color and texture. This pattern helps confirm that people made bricks on this part of the site.

The rest of the architecture related artifacts included nails, window glass, a slate fragment and fragments of a terra cotta drainpipe that appear to date much later than the episode of brick making.

Table 8-5. Historical Artifacts Recovered from Block A

Group	*Material*	*Artifact Type*	*Count*	*Frequency*
Agriculture	Lime	Fertilizer	2	<1%
Architecture	Iron	Cut Nails	2	<1%
		Square Shanked (Cut or Wrought) Nails	11	<1%
		Wrought Nails	4	<1%
		Unidentified Nails	1	<1%
	Glass	Window Glass	5	<1%
	Brick		6,319	96%
	Slate	Fragment	1	<1%
	Terra Cotta	Drainpipe	16	<1%
	Wood	Possible Building Material	1	<1%
Domestic	Earthenware	Creamware	1	<1%
		Pearlware	1	<1%
		Ironstone	1	<1%
		Jackfield-like	12	<1%
		Redware	51	<1%
	Stoneware	German Stoneware (Westerwald)	1	<1%
		White Salt Glazed Stoneware	6	<1%
	Glass	Vessel Fragments	1	<1%
		Blown-in-mold Bottle	4	<1%
		Unidentified Bottle	6	<1%
		Lamp Glass	1	<1%
Faunal	Bone	Mammal	4	<1%
	Tooth	Cow	6	<1%
	Mussel shell		1	<1%
Floral	Charcoal		3	<1%
Fuel	Clinker		18	<1%
	Coal		20	<1%
	Slag		6	<1%
Personal	Ball Clay	Tobacco Pipe stem	1	<1%
Miscellaneous	Clay		81	1%
	Iron	Unidentified	5	<1%
	Iron	Unidentified (possible utensil fragment)	1	<1%
	Lead	Plug	1	<1%
Total			**6,594**	

Block A yielded only 85 domestic artifacts consisting of earthenwares, stonewares and glass fragments. The earthenwares included generally small sherds of undecorated redware, creamware, pearlware, and Jackfield-like ceramics related to food consumption, serving, preparation or storage. Redware included some identifiable pieces of hollowware

and milk pans. Milk pan fragments were lead-glazed with a trailed slip decoration; one had a piecrust rim edge. Stoneware artifacts consisted of German (Westerwald) stoneware, and white salt glazed stoneware. Several fragments of the same white salt glazed saucer were recovered. Aqua, olive, clear, solarized (amethyst) glass fragments included bottle, vessel and lamp chimney glass. Two lip/shoulder fragments of a paneled pharmaceutical bottle indicate medicinal needs. Two olive glass body fragments were from a blown-in-mold liquor bottle. One fragment of lamp chimney glass represents household furnishings.

Faunal remains from Block A consisted of six tooth fragments from cattle, four large mammal bones and one fragment of mussel shell. Floral remains were three pieces of charcoal. Fuel activities were represented by eighteen pieces of clinker, twenty fragments of coal and six fragments of slag.

The only personal artifact recovered from Block A was an undecorated ballclay tobacco pipe stem with a 5/64 inch diameter opening. Pipe stems of this bore diameter most likely date to the 1710 to 1750 time period, although instances of manufacture as early as 1680 or as late as 1800 are also known (Noel Hume 1969a:298). Miscellaneous artifacts include clay fragments, unidentified iron fragments including a possible utensil piece, and a lead plug.

Temporally diagnostic artifacts recovered from Block A consisted of ceramics, glass and nails (Table 8-6). These artifacts suggest a mid-18th to early-19th century occupation (creamware, pearlware, Jackfield ceramics, white salt glazed stoneware, Westerwald stoneware, cut and wrought nails) and a later mid to late-19th century occupation based on the blown in mold bottle glass and solarized amethyst glass.

Table 8-6. Temporally Diagnostic Artifacts from Block A.

Artifact	***Type***	***Primary Manufacture Location***	***Manufacturing Dates***	***Terminus Post Quem***	***Reference***
Ceramic	Creamware, plain	England	1762-ca.1820	1762	Noel Hume 1969a: 125-128
	Ironstone, plain	England, USA	1813-present	1813	Noel Hume 1969a: 131
	Jackfield	England	ca.1745-1790	1745	Noel Hume 1969a:123
	Pearlware, plain	England	ca.1770s-1830	1770s	Price 1979:10; Noel Hume 1969a: 128-129; Seidel 1990:93
	Stoneware, White Salt Glazed	England	1720-1805	1720	Noel Hume 1969a: 115-117
	Stoneware, Westerwald	Germany	1650-1775	1650	Noel Hume 1969a: 280-281
Glass	Blown in Mold	USA, Various	Ca. 1840-1920	Ca. 1840	Jones and Sullivan 1985: 39

Table 8-6. Temporally Diagnostic Artifacts from Block A.

Artifact	*Type*	*Primary Manufacture Location*	*Manufacturing Dates*	*Terminus Post Quem*	*Reference*
	Solarized (amethyst)	USA	ca. 1880-1914	1880	Munsey 1970:55
Nail	Cut	USA, Various	ca.1790-present	1790	Noel Hume 1969a: 253;Edwards and Wells 1993:6-16
	Wrought	USA, Various	pre-ca. 1790	pre-1790	Noel Hume 1969a: 253; Edwards and Wells 1993:6-16

Blocks B and C Artifacts – The Wells and Fenceposts

About 59 percent of the artifact assemblage from Blocks B and C were associated with features; the remaining assemblage was related to general surface collections, plow zone, sub-plow zone and shovel tests beneath the spoilpile contexts (Table 8-7). Temporally diagnostic artifacts from plow zone contexts consisted of barbed wire, ceramics, enamelware, glass and nails representing 18th century through early-20th century materials.

Table 8-7. Artifact Distribution by Provenience for Blocks B and C

Provenience	*Artifact Count*	*Frequency*
General Collection	201	12%
Plow Zone	350	20%
Sub-Plow Zone	25	1%
Shovel Tests under Spoil pile	124	7%
Features	1,010	59%
Total	**1,710**	

Over 1,700 artifacts were recovered from excavations in Blocks B and C representing activity, agriculture, architecture, armaments, clothing, domestic, faunal and floral remains, fence, fuel, personal items and miscellaneous materials (Table 8-8). Artifacts designated as activity related include two bolts, 36 fragments of a graniteware bucket and two horseshoes. Two plowshare fragments indicate agricultural activity. Over 56 percent of the assemblage was architecture related (n=965) with 51 percent of that total comprising brick fragments. This contrasts with the high percentage in Block A. Some apparently miss-fired bricks were found in Blocks B and C, but the percentage (by weight) is much lower than in Bock A (9% of the Block B brick by weight). There is no indication that bricks were also fired in this part of the site, so presumably these misfired fragments must originally have been deposited in Block A, and subsequently moved.

The rest of the architecture related artifacts included nails, window glass, mortar and fragments of terra cotta and stoneware drainpipes, and wooden barrels. A pintle and latch represent structural hardware. A single lead bullet was recovered was also recovered.

Clothing and personal items recovered from Blocks B and C include shank glass and metal buttons, a four-hole porcelain button, a shoe grommet, a glass bead, a porcelain doll head, a harmonica reed, and five pieces of undecorated ballclay tobacco pipe stem (n=2) and bowl (n=3) fragments. Two stem fragments exhibit 4/64 inch and 5/64 inch diameter openings. Pipe stems with a bore diameter of 5/64 inch most likely date to the 1710 to 1750 time period, although instances of manufacture as early as 1680 or as late as 1800 are also known. For 4/64-inch bore diameters, most pipes tend to date between 1750 and 1800, although manufacture between 1710 and 1750 has been found as well (Noel Hume 1969a:298).

Table 8-8. Historical Artifacts Recovered from Blocks B and C

Group	*Material*	*Artifact*	*Count*	*Frequency*
Activity	Iron	Bolt	2	>1%
		Bucket (Graniteware)	36	2%
		Horseshoe	2	>1%
	Terra Cotta	Flowerpot	6	>1%
Agriculture	Iron	Plowshares	2	>1%
Architecture	Brick		493	29%
	Cupreous alloy	hinge	5	>1%
	Glass	Window	54	3%
	Iron	Cut nails	93	5%
		Cut/wrought (square shanked)	204	12%
		Wire nails	12	1%
		Wrought nails	13	1%
		Unidentified nails	6	>1%
		Eye Hook	1	>1%
		Hoop	4	>1%
		Latch	1	>1%
		Wrought pintle	1	>1%
	Mortar		1	>1%
	Sandstone	Building stone	1	>1%
	Stoneware	Drainpipe	1	>1%
	Terra Cotta	Drainpipe	3	>1%
		Tile	4	>1%
	Wood	Barrel-bung/plug	1	>1%
		Barrel-cask head	10	1%
		Barrel-stake	3	>1%
		Barrel-peg	4	>1%
		Barrel-stave	41	2%
		Barrel-strap	1	>1%
		Barrel-unidentified	5	>1%
		Plank	1	>1%
		Well collar	1	>1%
		Unidentified	1	>1%
Armaments	Lead	Bullet	1	>1%

Table 8-8. Historical Artifacts Recovered from Blocks B and C

Group	*Material*	*Artifact*	*Count*	*Frequency*
Clothing	Cupreous Alloy	Button	1	>1%
		Shoe grommet	1	>1%
	Glass	Button	1	>1%
	Porcelain	Button	1	>1%
Domestic	Earthenware	Creamware	11	1%
		Ironstone	27	2%
		Jackfield-like	6	>1%
		Pearlware	36	2%
		Redware	117	7%
		Whiteware	27	2%
		Yellowware	3	>1%
		Unidentified	4	>1%
	Glass	Blown in mold	54	3%
		Free blown	2	>1%
		Machine made	3	>1%
		Bottle/vessel	68	4%
		Lamp chimney	9	1%
	Graphite	Battery Rod	1	>1%
	Iron	Cooking Pot	13	1%
	Porcelain	Bone China	2	>1%
		Chinese	7	>1%
		Hard paste	11	1%
	Stoneware	Albany Slip	2	>1%
		American Salt Glazed	13	1%
		White Salt Glazed	1	>1%
Faunal	Bone	Bird	1	>1%
		Unidentified	1	>1%
	Shell	Oyster	5	>1%
		Turtle	19	1%
	Tooth	Cow	3	>1%
Fence	Iron	Barbed wire	1	>1%
		Staple	4	>1%
Floral	Charcoal		2	>1%
	Peach pit		35	2%
	Seed		1	>1%
	Stem		1	>1%
	Wood	Unidentified	3	>1%
Fuel	Clinker		8	>1%
	Coal		40	2%
Personal	Glass	Bead	1	>1%
	Porcelain	Doll head	1	>1%
	White ball clay	Tobacco pipe	5	>1%
	White metal	Harmonica reed	1	>1%
Miscellaneous/ Unidentified	Clay		2	>1%
	Cupreous alloy		3	>1%
	Ferrous alloy	Wire	2	>1%
	Ferrous alloy		91	5%
	Glass		6	>1%

Table 8-8. Historical Artifacts Recovered from Blocks B and C

Group	*Material*	*Artifact*	*Count*	*Frequency*
	Leather	Cord	1	>1%
		Strap	2	>1%
	Quartz	Cobble	4	>1%
	Quartzite	Cobble	23	1%
	Sandstone	Cobble	9	1%
Total			1,710	100%

Blocks B and C yielded 410 domestic artifacts consisting of earthenwares, porcelain, stonewares, glass fragments, iron pot fragments and a battery rod. The greatest number of these sherds were redware (28% of the domestic total), and bottle glass (16%). The earthenwares include undecorated redware; undecorated, hand painted, transfer print and blue shel- edged pearlware; undecorated and transfer print ironstone; undecorated, annular, hand painted and transfer print whiteware; undecorated creamware; Jackfield-like ceramics; and undecorated yellowware related to food consumption, serving, preparation or storage. Porcelain artifacts include undecorated and hand painted bone china; undecorated and hand painted Chinese porcelain, and undecorated, hand painted, decalcomania, and blue wash porcelain. Stoneware artifacts consist of Albany slip stoneware, American Salt Glazed stoneware and White Salt Glazed (hand painted scratch blue) stoneware. Aqua, olive, amber, blue, green, white, clear, solarized (amethyst) glass fragments represent bottle, vessel and lamp chimney glass.

Limited food preparation activities were indicated by the presence of redware hollowware and fragments of an iron pot. Food containers consist of clear and aqua glass pharmaceutical bottle fragments, olive glass wine and liquor bottle fragments, clear glass soft drink bottle fragment and aqua glass fruit jar fragments and white milk glass fruit jar liner fragments. Food service artifacts include pressed glass tableware; bone china saucer and flatware; Chinese flatware, hollowware and a teacup; porcelain teacup, saucer, and hollowware; Jackfield hollowware; ironstone saucer, flatware and hollowware; pearlware teapot, saucer, flatware and hollowware and whiteware cup, flatware and hollowware. Food storage artifacts consist of American stoneware hollowware. Household furnishings were indicated by clear lamp chimney glass fragments and a porcelain vase fragment.

The few faunal remains from Blocks B and C consist of bird bone, tooth enamel from cattle, mussel shell, and turtle shell fragments. Floral remains include 35 peach pits, a seed, a stem, and unidentified charcoal and wood fragments. Fence staples and barbed wire indicate fencing activities. Fuel activities were represented by eight pieces of clinker and forty fragments of coal. Miscellaneous artifacts include clay fragments, cupreous and ferrous alloy fragments including two fragments of wire, glass, leather cord and strap fragments, and cobbles.

Temporally diagnostic artifacts recovered from Blocks B and C consisted of barbed wire, ceramics, enamelware, glass and nails (Table 8-9). These artifacts suggest a mid-18th

century occupation (Chinese porcelain Famille Rose, Jackfield ceramics, scratch blue stoneware, white salt glazed stoneware), a late-18th to early-19th century occupation (creamware, pearlware, white salt glazed stoneware, cut and wrought nails) and a mid-19th to early-20th century occupation based on the porcelain hard paste decalcomania, Albany slip American stoneware, graniteware, fruit jar fragments, blown in mold bottle glass, machine made bottles, solarized amethyst glass, and barbed wire.

The Jones Site Bricks

The overwhelming majority of the artifacts found on site are bricks and brick fragments. Much of this assemblage, concentrated in Block A, clearly relates to brick making on site. But not all of the brick from the site was made in the clamp. The bricks from the brick-lined well (Feature 156) appeared to be machine-made, instead of hand molded like those from the brick clamp area, with smooth surfaces, crisp definite edges, deep red color, and resistant to breakage. However, many of the bricks we found were cracked and warped, one characteristic of the inefficiencies of a clamp firing of high clay content bricks, though these flaws are often found in machine-made, kiln-fired bricks as well.

No structural foundation or chimney base composed of bricks was found at the Jones Site, even though a large expanse of ground had been exposed after topsoil was removed. Yet, the bricks made in the brick clamp presumably were intended for use nearby. The most likely explanation is that the bricks became part of a chimney for a log cabin on the tenant farm, probably soon after John Jones' purchase of the Brown tract in 1768. There was a small concentration of brick fragments (35) found in shovel tests at about the same location as a concentration of other artifacts in roughly the center of Block B/C. Unfortunately, there were no subsurface features in this location, so the significance of the concentration is unclear. The chemical analysis of the bricks from the Jones Site included both the handmade bricks - presumably wasters from the firing of the brick clamp – and the machine-made bricks from Feature 156. The results, and a comparison to several soil samples from the site, are provided in Section 8.3.2.

8.1.3 Artifact Distribution Analysis

The distribution of artifacts across the landscape at the Jones Site was examined, to aid in understanding how people used the location over time. Datable ceramic artifacts were used to differentiate those typically manufactured before 1820, such as creamware and white salt glazed stoneware versus those thought to originate after 1820, including whiteware. Since pearlware was first produced circa 1780 but continued to be produced until about 1830, it overlaps both time periods and was mapped separately. The distribution map for artifacts from non-feature proveniences is provided below (Figure 8-1).

The two fence lines were added to the distribution maps, to see if the regions separated at some time period by fences showed different patterns. The fence lines could be said to divide Blocks B and C into four regions: a northwest, northeast, southeast, and southwest "yard". The southeast yard contained the earlier well (barrel well Feature 268) and the

prehistoric/historic pit feature that may have been for food preparation (Feature 159). The southwest yard included the later well (brick-lined well Feature 156).

Brick was heavily concentrated in Block A (Figure 8-2), and consistent with the interpretation of the area for making bricks, more than 25% of that brick (by weight) appears to have been misfired. Pre-1820 ceramics clustered in two areas of the site – in the brick clamp complex area (Block A) and in the southeast yard. Pearlware seemed to be most prevalent in the northwest yard and the southeast yard. Post-1820 ceramics clustered mainly in the northwest and southwest yards.

The earlier datable historic artifacts (mid- to late 18th-century such as creamware and white salt glazed stoneware) tended to be associated with the brick clamp complex in the northern portion of the site and the barrel well, in the southeastern portion of the site. This suggests that the brickmaking carried out on site happened sometime during the first period of site occupation, between 1760 and 1820, though there is no way to be more precise. Later artifacts such as whiteware (post-1820) were concentrated in the southwestern portion of the site, near the brick-lined well, suggesting association with the later period of site occupation from the mid-19th century into the 20th. The fence lines seem to form four yards, with the southeastern yard having the earlier well and the southwestern yard including the later well. There is a minor concentration of brick in the northwest yard (Figure 8-3), but this is an area that had no major sub-surface features, so the interpretation of this concentration is unclear.

The orientation and placement of the fence lines seem to follow the angles of farm fields that were in use at the time of the 1926 aerial photography (US Army Air Corps). These farm fields cross boundaries of the 18th-century land tracts (Brown, White, and Turner tracts) and therefore were probably laid out after the tracts were combined into a 315-acre farm in the 1850s by George Davis. This leads to the assumption that farmers added the fence lines during the late 19th century, or even during the 20th century.

Artifact analysis from the features with the most artifacts (the two wells, and Feature 159, a pit of unknown use in the southeastern area of the site) generally mirrors the artifact patterns from the site as a whole. Architecture-related artifacts dominate the fill from the two wells (41% from the barrel well, and over 70% of the material from the brick-lined well), while domestic material is scant (10% of the barrel well, and less than 1% of the brick-lined well). There were only a total of 33 ceramic sherds from the barrel well, and 4 sherds from the brick-lined well (Tables 8-9 and 8-10). The latest chronologically diagnostic artifacts from the barrel well are cut nails and pearlware, which would suggest the well was built and abandoned during the site's first period of occupation between 1760 and 1820. The fill from the brick-lined well include late 19th or 20th-century objects like wire nails and barbed wire. Together with the apparent machine-made nature of the bricks, this suggests this well was installed during the mid to late 19th century, and abandoned in the 20th. The very low number of domestic artifacts speaks to a daytime, agricultural use of the site, not a domestic occupation. Perhaps the wells were intended to provide water for livestock. Apart from a few pieces of brick and fragments from an iron

pot, most of the artifacts from the pit feature (Feature 159) are actually prehistoric. Whether this was a prehistoric feature later reused during the historic period is unknown.

Table 8-9: Barrel Well Artifacts (Feature 268)

Group	Material	Typology	Function	Total	%
Activities	Iron		Horseshoe	1	0.3%
Architecture	Brick			39	12.3%
	Iron	Cut	Nail	17	5.4%
		Cut/Wrt	Nail	1	0.3%
		Unrec	Nail	6	1.9%
		Wrought	Nail	1	0.3%
	Wood			5	1.6%
			Barrel	54	17.1%
			Peg	4	1.3%
			Stake	3	0.9%
Clothing	Cupreous	Shank	Button	1	0.3%
Domestic	Coarse Earthenware	Redware		9	2.8%
			Hollow ware	7	2.2%
	Iron		Pot	5	1.6%
	Glass	Blown	Case	1	0.3%
	Porcelain	Chinese	Teacup	1	0.3%
		Hard Paste		2	0.6%
	Refined Earthenware	Creamware		4	1.3%
		Pearlware		2	0.6%
			Hollow ware	1	0.3%
	Stoneware	White Salt-glazed		1	0.3%
Faunal	Bone			2	0.6%
Floral	Charcoal			1	0.3%
	Pit			7	2.2%
	Seed			1	0.3%
	Stem			1	0.3%
Fuel	Clinker			1	0.3%
Other	Clay			2	0.6%
	Quartzite			12	3.8%
	Quartz			1	0.3%
	Sandstone			6	1.9%
	Unrecognized			2	0.6%
Personal	Ballclay		Pipe	3	0.9%
Prehistoric	Jasper			3	0.9%

Table 8-9: Barrel Well Artifacts (Feature 268)

Group	Material	Typology	Function	Total	%
	Quartzite			12	3.8%
	Quartz			4	1.3%
	Sandstone			10	3.2%
Unrecognized	Cupreous			3	0.9%
	Iron			79	25.0%
	Leather		Cord	1	0.3%
				316	

Table 8-10: Brick Well Artifacts (Feature 156)

Group	Material	Typology	Function	Total	Percentage
Activities	Iron		Bucket	36	5.8%
Agriculture	Iron		Plowshare	1	0.2%
Architecture	Brick			252	40.4%
	Cupreous		Hinge	5	0.8%
	Iron		Hoop	4	0.6%
		Cut	Nail	43	6.9%
		Cut/Wrt	Nail	179	28.7%
		Wire	Nail	11	1.8%
	Iron	Wrought	Nail	12	1.9%
	Glass		Window	2	0.3%
	Wood		Plank	1	0.2%
	Wood		Well collar	1	0.2%
Domestic	Porcelain	Hard Paste	Hollow Ware	1	0.2%
	Refined Earthenware	Creamware		1	0.2%
		Pearlware	Flat ware	1	0.2%
		Whiteware		1	0.2%
Faunal	Shell			19	3.0%
Fence	Iron		Staple	2	0.3%
		Barbed	Wire	1	0.2%
Floral	Pit			28	4.5%
	Wood			2	0.3%
Fuel	Clinker			1	0.2%
	Coal			12	1.9%
Prehistoric	Chert			1	0.2%
	Quartzite			1	0.2%
Unrecognized	Iron			3	0.5%

Table 8-10: Brick Well Artifacts (Feature 156)

Group	Material	Typology	Function	Total	Percentage
	Leather		Strap	2	0.3%
				623	

Table 8-11: Pit Feature Artifacts (Feature 159)

Group	Mater	Typology	Function	Total	%
Architecture	Brick			6	9%
Domestic	Iron		Pot	7	10%
Faunal	Tooth			3	4%
Fuel	Clinker			1	1%
Other	Quartize		Cobble	9	13%
	Quartz			3	4%
	Sandstone			3	4%
Prehistoric	Jasper	Ret	Flake	1	1%
	Quartize		1 Core, 23 FCR	24	36%
	Quartz		Flake	2	3%
	Sandstone		FCR	8	12%
				67	

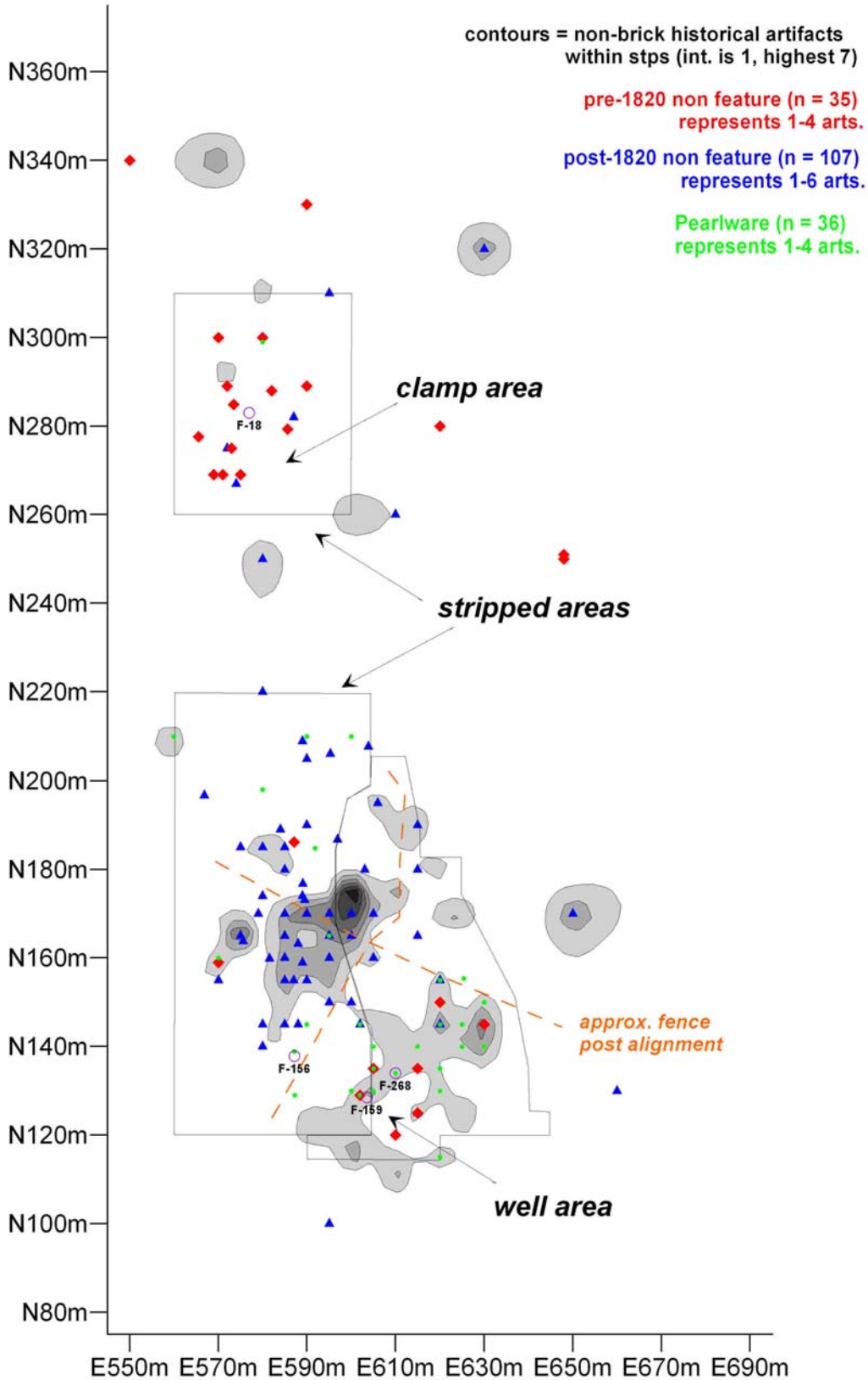

Figure 8-1. Distribution of Datable Ceramic Artifacts in both Blocks

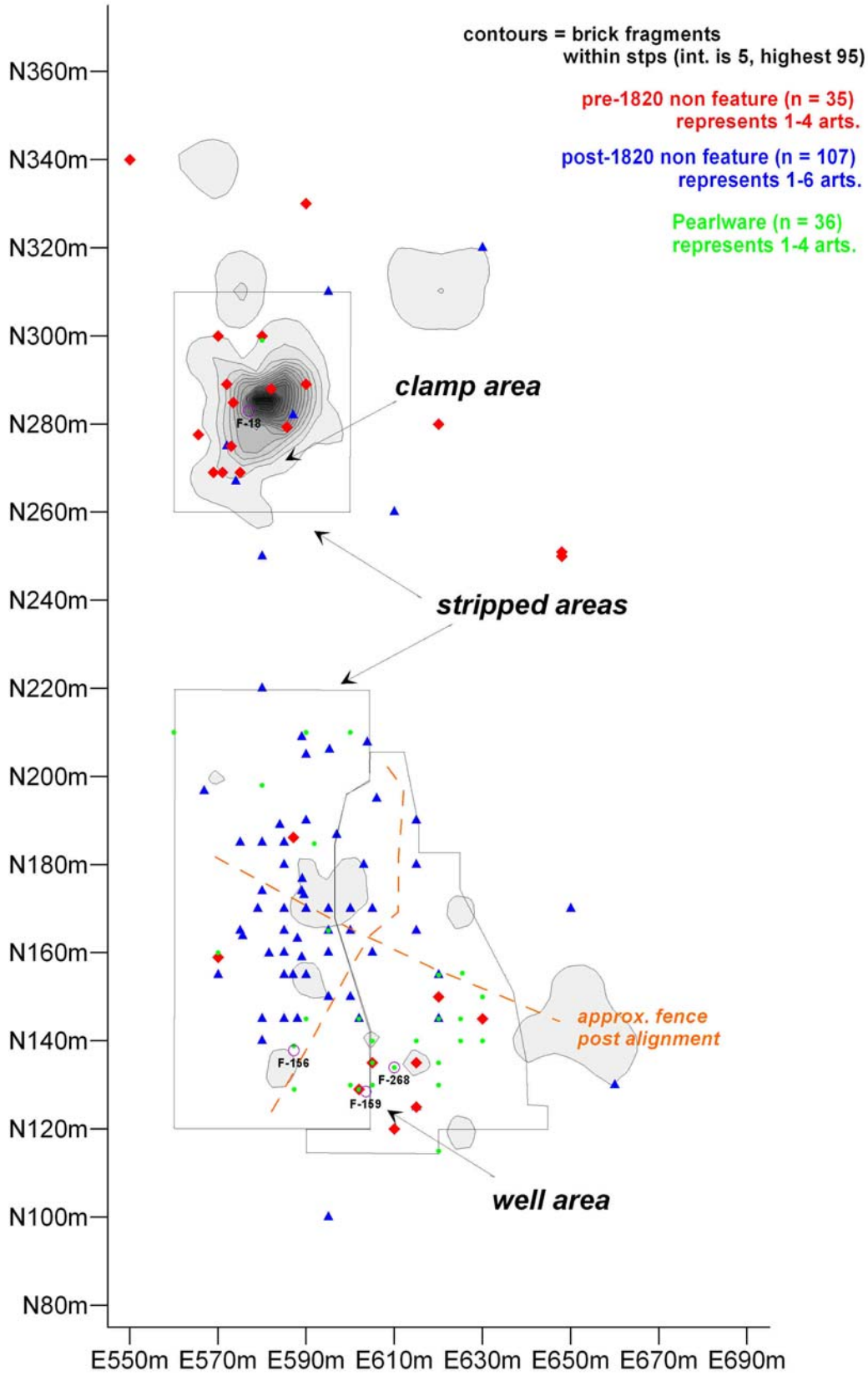

Figure 8-2: Brick Distribution at the Jones Site.

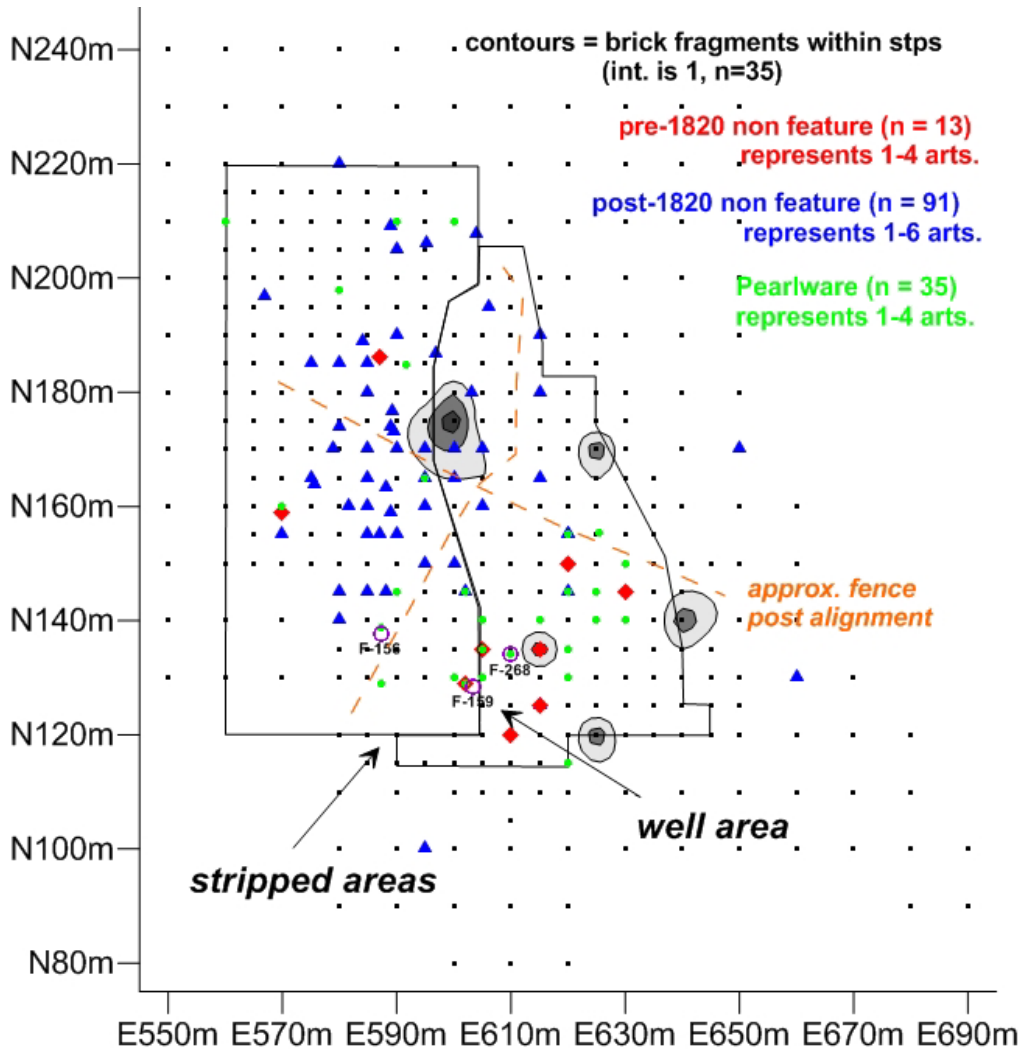

Figure 8-3: Brick Distribution at the Jones Site (Blocks B/C).

8.1.4 Interpretation

In general, the non-brick artifacts from the Jones site are low in number and small in size, and it is not impossible that some of the material was deposited in the 19th century along with nightsoil as a fertilizer. However, that there is some clear spatial patterning of datable objects that correlate with the site's apparent periods of occupation suggests that at least some of these artifacts were actually used on site. Surely this is true of the material from feature contexts. That is consistent with a daytime use of the site. The nails found on site are likely from the fences and probable outbuildings. Some hardware related to farm work is also present, and the few domestic and faunal remains could relate to meals served to farmhands during the day perhaps.

The relative paucity of domestic artifacts and faunal material found at the Jones Site argues against the site being an historic primary domestic site. A primary rural dwelling site – whether that of the main dwelling or a tenant dwelling - occupying the main yard of

a dwelling site should contain a denser concentration of domestic and faunal material, especially considering the large surface area investigated at the Jones Site. To illustrate this point, ceramic sherd counts from selected tenant farm sites in Delaware were tabulated (Table 8-9). The samples show that known tenant sites had far more ceramic material than the Jones site, often more than 10 times as much. The pattern of disposition is more akin to secondary refuse disposal on the fringes of a rural property. Such disposal is likely to occur in lesser-used regions of the farm, especially where woods would conceal the debris. This portion of the farm had the added factor of being near swampy ground on three sides, further marginalizing its attractiveness for primary domestic activities.

Table 8-12. Ceramic Sherd Counts from Delaware Tenant Sites

Site Name	***Date***	***Description***	***Sq Ft exc***	***ceramic***	***source***
McKean-Cochran	1750-1830	Two chronologically sequential tenant farms, includes outbuildings wells, and substantial foundations	1,625	13,000	Bedell et al. 1999
Ferguson Weber	19th-20th cent		Not stated	2,364	Coleman et al. 1983
Dawson Family Site	1740-1780	Features included a cellar	28,800	6,833	Bedell et al. 2002
Grant Tenancy	Early 19th-century			32,638	Taylor et al. 1987
Thomas Williams Site	1792-1920s			17,870	Catts and Custer 1990
Jones Site				***340***	

Table 8-13. Temporally Diagnostic Artifacts from Blocks B and C

Artifact	***Type***	***Primary Manufacture Location***	***Manufacturing Dates***	***Terminus Post Quem***	***Reference***
Barbed Wire	Allis' Buckthorn, sheet metal strip with lance points	USA	July 26, 1881	1881	Clifton 1970:316
Ceramic	Creamware, plain	England	1762-ca.1820	1762	Noel Hume 1969a: 125-128
	Ironstone, plain	England, USA	1813-present	1813	Noel Hume 1969a: 131
	Jackfield	England	ca.1745-1790	1745	Noel Hume 1969a:123
	Pearlware, plain	England	ca.1770's-1830	1770s	Price 1979:10; Noel Hume 1969a: 128-129; Seidel 1990:93
	Pearlware, hand painted	England	ca.1795-1835	1795	Noel Hume 1969a:129
	Pearlware, blue shell- edged	England	ca.1780-1830	1780	Price 1979:10-11; Noel Hume 1969a: 126-131
	Pearlware, transfer printed	England	ca. 1795-1830	1795	Miller 1980; South 1977
	Porcelain, Bone China	England	1795+	1795	South 1977/1978: 72
	Porcelain, Chinese, Famille Rose	China	1685-1800	1685	Noel Hume 1969a: 259
	Porcelain, Hard paste Decalcomania	Europe, USA	1890s-present	1890s	Stelle 2001
	Stoneware, American, Albany slip	USA	ca.1850-1900	1850	Noel Hume 1969a: 101
	Stoneware, American Gray	USA	1730-1900s	1730	Noel Hume 1969a: 101

Table 8-13. Temporally Diagnostic Artifacts from Blocks B and C

Artifact	***Type***	***Primary Manufacture Location***	***Manufacturing Dates***	***Terminus Post Quem***	***Reference***
	Stoneware, "Scratch Blue"	England	Ca.1760-1775 style	1760	Noel Hume1969a: 117-118
	Stoneware, White Salt Glazed	England	1720-1805	1720	Noel Hume 1969a: 115-117
	Whiteware, annular	England, USA	1830-1900+	1830	Price 1979:18; Noel Hume 1969a:131
	Whiteware, plain	England, USA	1820+	1820	Noel Hume 1969a:130-131
	Whiteware, transfer printed	England, USA	1820-1900+	1820	Little 1969:17
	Yellowware, plain	England, USA	1828-1930s	1828	Ketchum 1983:12
Enamelware	Graniteware	USA	1870s-1950s	1870s	Johnson 1996:89-90
Glass	Automatic bottle machine	USA, Various	1904 to present	1904	Ketz and Reimer 1990:48
	Black glass button	Europe, USA	1840's to present	1840's	Luscomb 1967 (1992 ed.):80-81, 88-89
	Blown in Mold	USA, Various	ca.1840-1920	Ca. 1840	Jones and Sullivan 1985: 39
	Fruit jar (blown in mold)	USA	1858 to 1920s	1858	Ketz and Reimer 1990: 47; Jones and Sullivan 1985: 42
	Milk glass fruit jar liner	USA	1869 +	1869	Ketz and Reimer 1990: 47
	Solarized amethyst	USA	ca. 1880-1914	1880	Munsey 1970:55
Nail	Wrought	USA, Various	pre-ca. 1790	pre-1790	Noel Hume 1969a: 253; Edwards and Wells 1993:6-16
	Cut	USA, Various	ca.1790-present	1790	Noel Hume 1969a: 253;Edwards and Wells 1993:6-16
	Wire	USA, Various	ca. 1880- present	1880	Edwards and Wells 1993:6-16

8.2 COOPERING AND BARRELS

Among the most unusual artifacts found at the Jones site were the beautifully preserved barrel staves in the well dubbed Feature 268 in Block C. Three barrels were placed one on top of the other, as was described in the previous chapter, 7.0 Archaeology. A more detailed description of the barrels follows, based on archaeological field evidence and the examination of the recovered barrel parts in the archaeological laboratory (Figure 8-4) along with a brief history of barrel-making or coopering. Characteristics of the barrel well at the Jones Site are contrasted with other wells from archaeological sites in Delaware as well. The forms developed for analysis of the barrel parts from the Jones Site are included in Appendix D along with the raw data from the analysis.

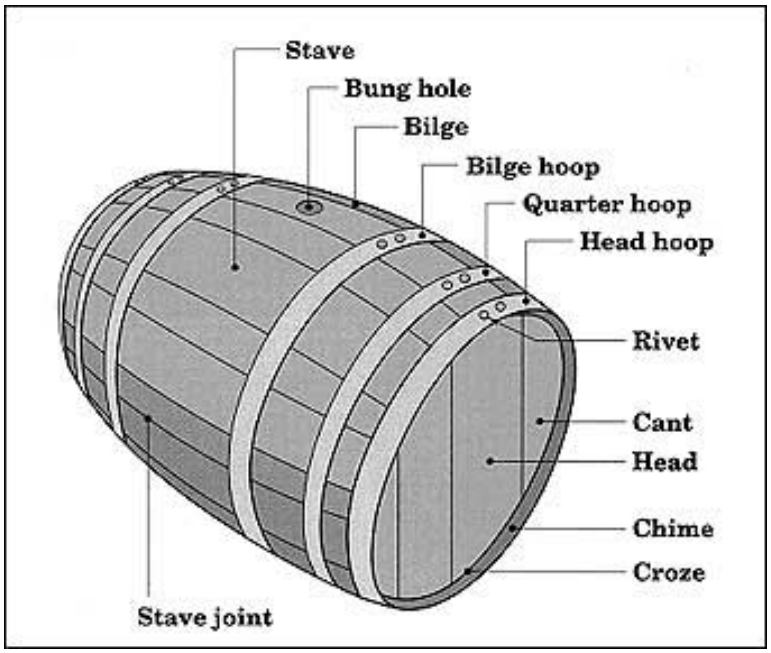

Figure 8-4. Illustration of Parts of a Barrel (Wright 2011)

8.2.1 Feature 268 Barrel Descriptions

Barrel #1 was the uppermost barrel in Feature 268; it consisted of wood staining and several cut nails. The barrel stain suggested a barrel approximately 1.2 m (4 ft.) high and 90 cm (3 ft.) in diameter. Barrel #1 was placed over the outside rim of barrel #2.

Barrel #2 consisted of wood staining representing the upper portion of the barrel and eleven fragments of wood (oak) and cut nails from the lower portion. The eleven fragments range in length from 19-to-41.8 cm (7.5-to-16.5 in.) with widths from 4.2-to-7.5 cm (1.65-to-2.95 in.) and thicknesses from 0.5-to-1.4 cm (0.2-to-0.5 in.) (Appendix D, Table D-1). Even though the wood fragments do not exhibit curvature as expected in a barrel, these fragments were placed vertically in the builder's shaft adjacent to each other. Most fragments were tapered to a point rather than beveled on the distal ends and along some edges. The proximal portions of the fragments were decayed. The barrel

was approximately 85 cm (2 ft. 9 in.) high and 75 cm (2 ft. 5 in.) in diameter. Barrel #2 was placed inside the rim of Barrel #3.

Barrel #3 was the deepest barrel recovered from Feature 268 (Appendix D, Table D-2). It was constructed of oak. Thirty staves were recovered. They exhibited varying degrees of decay at the top and thus had a wide range of lengths. The only complete stave was 102.2 cm long (3.4 ft.) (Stave #5). Although the top end of that stave was eroded, the flattened top edge still survived. The bottom portion of the Barrel #3, on the other hand, was well-preserved, due to the moist, undisturbed conditions.

The staves averaged 8.0 cm (3.1 in.) wide at the bottom (Figure 8-5). The bottom end of each stave was beveled on the interior. The tips of the ends had been planed or "topped" to provide a smooth, straight surface around the barrel. The interiors of the staves had been reduced in thickness or shaved so that the bottom 8 cm (3.1 in.) of the stave was thinner than above. This thinned area, sometimes called a "howel", was a level space in which a small groove or "croze" could be placed in order to seat a lid or the bottom of the barrel. The leveling helped to make this groove as circular as possible (Kilby 1971:30). On Barrel #3, the groove was placed 5 cm (2.0 in.) from the bottom (Figure 8-6) and it was a square channel (Figure 8-7). The groove would have been cut using an adjustable tool, also called a "croze". This tool had teeth which mark and cut the size of the channel and a blade which cuts out the wood (Kilby 1971:31-33).

Three samples of "flagging" or "flag" were recovered with the Barrel #3 staves. Flagging was a strand of fibrous material, pounded into the lid joint to further seal or water-proof the closure of the barrel. This material would swell when it came into contact with the liquid in the barrel and thus would close or seal up the joint. River rush was a preferred material for this purpose (Kilby 1971:38-39). One sample was still embedded in the channel of a stave (Stave #5).

The vertical side edges of each stave of Barrel #3 exhibited very little inward beveling toward the bottom of the staves. There appeared to be even less toward the center, but this area was frequently more decayed and harder to determine. This slight beveling would indicate that the diameter of this barrel was large. The "shot" or angle of these sides would have been dictated by the radius of the cask on the ends and in the center or "belly" or "bilge" (Kilby 1971: 23). The bigger the radius, the less the angle needed for joining.

A bunghole was located in one of the widest staves (Stave #24) (see Figure 8-3) and contained a wooden bung plug when it was recovered from Feature 268. The bung plug measured approximately 5 cm (2.0 in.) long and 3.8 cm (1.5 in.) in diameter (Figure 8-8).

Figure 8-5. Barrel Well (Feature 268), Selected Staves from Barrel #3, Exterior.

Figure 8-6. Barrel Well (Feature 268), Groove or Croze on Barrel #3 Stave.

Figure 8-7. Barrel Well (Feature 268), Profile of Square Channel of Croze on Barrel #3.

Figure 8-8. Barrel Well (Feature 268), Wooden Bung Plug from Barrel #3

Three iron nails and 36 wooden pegs were embedded in the staves of Barrel #3. The nails were either cut or hand wrought in manufacture. The pegs ranged in size from 0.5 to 0.9 cm (0.2 to 0.4 in,) and varied in placement on the staves. Ring marks were noted on the exterior of the staves of Barrel #3. These occurred at the same level on each stave and most likely represent the location of wooden barrel hoops. No manufacture's marks were noted on the staves. However, several random cut marks or scratches were observed.

Also in association with Barrel #3 were ten caskhead pieces (Appendix D, Table D-3). They all showed some extent of decay or erosion (Figure 8-9). The longest was 41.8 cm (1.4 ft.) (Caskhead #11). Three of the pieces retained one end, or "cant", that clearly displayed beveling on the top and bottom. The top bevel, or "basle", was shorter and with a steeper angle than the lower basle. These ends had also been thinned or shaved across the top surfaces before they were beveled. Nine ferrous alloy nails were lodged in the wooden pieces. Some of these were located near the ends, perhaps to help seal the heads to the sides. Most of the nails were either cut or hand wrought in manufacture. One was an early cut nail with grain flow perpendicular to the nail shank length. The head appeared to be hand-wrought but the corrosion present prevented a definitive determination (ca.1790 to 1840) (Leach 2000:38-39).

Figure 8-9. Barrel Well (Feature 268), Caskhead Fragments from Barrel #3.

Other wooden artifacts recovered in association with Barrel #3 were twenty-four fragments of split wood straps and one possible strap fragment. The split straps were flat on one side and rounded on the opposite side with the bark intact (Figure 8-10). They ranged from 1.9 to 3.1 cm (0.7 to 1.2 in.) in diameter. No nail holes were present. Strap shadows were originally evident on the barrel staves indicating the strap locations (Figure 8-11). Also, four wooden pegs were collected. They ranged in size from 3.8 to 8.2 cm (1.5 to 3.3 in.) long. They varied from 6 mm to 1.9 cm (0.2 to 0.7 in.) in diameter.

The over-all shape of Barrel #3 was a classic "barrel shape" with a narrower diameter at the ends (the barrel "chime") and outward expansion or curving of each stave midway on the barrel side at the "pitch" or "belly" of the barrel. This shape implied that the barrel may have been used for some other function prior to its placement in the well. These were not straight, cylindrical barrels designed solely to line the wall of a well (e.g., Grettler et al. 1996:55). Moreover, the presence of a large bunghole in the middle of the barrel suggested that its previous use was to contain liquids.

Figure 8-10. Barrel Well (Feature 268), Split Strap with Intact Bark from Barrel #3.

Figure 8-11. Barrel Well (Feature 268), Strap Shadows on Stave from Barrel #3.

8.2.2 Coopering History

A cooper is one who makes or repairs wooden casks and tubs (Figure 8-12). The word "cooper" is derived from the Latin "cuparius" which means makers of cupals or wooden casks in which winemakers stored their wares (Wright 2011). Wooden casks were in use in Europe hundreds of years ago, transporting goods (Wine Industry Seismic Hazard Reduction Project 2000). Coopers organized into guilds in Ireland in 1501 and in England in 1662 (Seymour 1984:89).

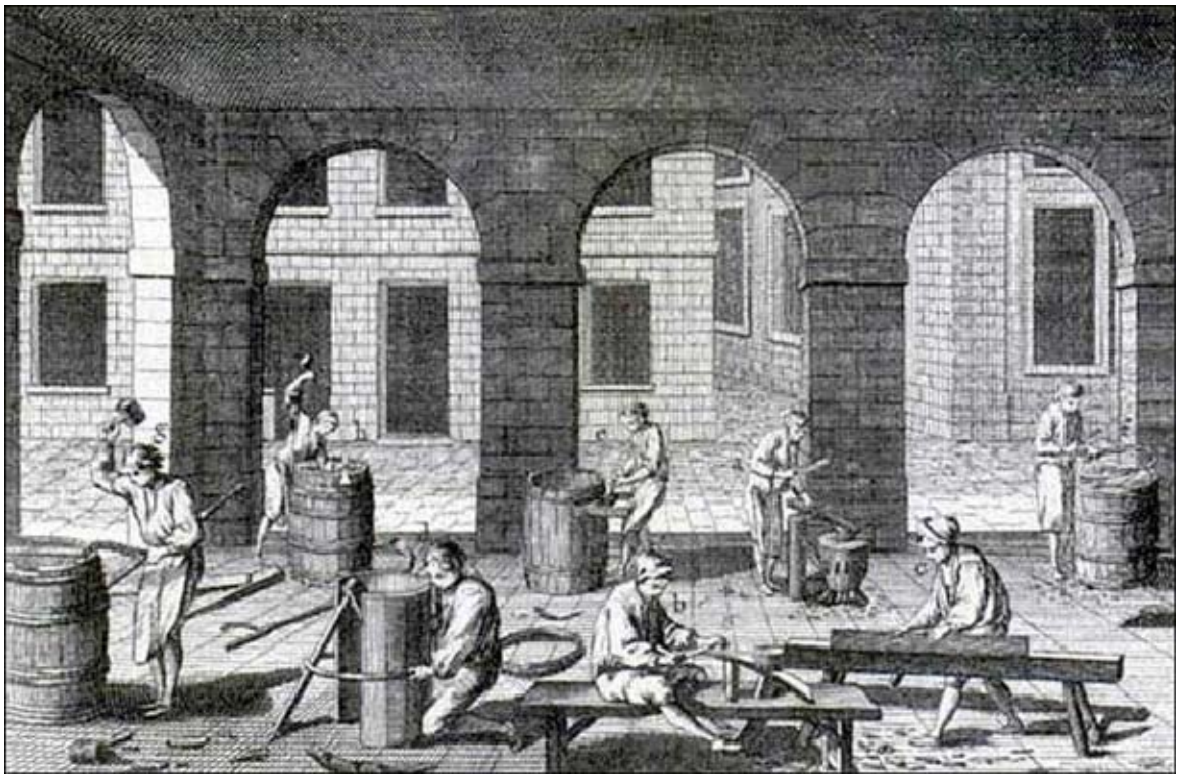

Figure 8-12. An Illustration of Coopering from Mid-18th-Century Europe (Diderot and Jean le Rond D'Alembert,1751a)

Colonial goods imported to America often arrived within barrels, especially wine, salt, and flour. John Alden, future acting governor of the Massachusetts Bay Colony, was hired to be the cooper on the Mayflower. His job was to repair damage to the water casks on board (Wright 2011). Coopers in Boston were allowed to form a guild in 1648, but only for a three-year period (Bridenbaugh 1990:6). Whale oil and salt cod were among the products exported by the New England colonies in barrels (Wright 2011). Coopers in colonial Virginia took advantage of the abundant supply of wood in the New World and created barrel staves (the wooden boards making up the sides of barrels) for export to England (Wright 2011). Large plantations often had indentured servants or slaves who were trained in coopering.

8.2.3 Coopering as a Delaware Industry

The cooper's product was essential to the gunpowder industry that was thriving in northern Delaware by the early 19th century. Records from E.I. du Pont de Nemours and Company include a letter to a customer in 1811 stating that the company will begin to manufacture the powder ordered but the delivery may be delayed because the coopers were so busy. They explained that it was very important that the barrels be well made and very dry before use so that the gunpowder would not be damaged. (du Pont 1811:120). Early on, the company purchased barrels and kegs from coopers in Boston and Philadelphia "of all sizes and qualities, and were often altogether lacking when they were most needed". The company later brought coopers to the Wilmington area and started "the manufacture of kegs on the premises" (du Pont 1920:65). E.I DuPont reported in 1827 in a letter to an editor of a Baltimore newspaper that the du Pont Mills near Wilmington employed 121 people in their factory plus 17 "Coopers for making kegs" and 2 "Tin-men for canisters" (du Pont 1920:Appendix E).

The 1820 Federal Manufacturing Census for Delaware contained 24 separate industrial categories for all three counties combined (Table 8-14).

Table 8-14. Entries in the 1820 Federal Manufacturing Census for Delaware

Industry	New Castle	Kent	Sussex	Total
Bark	1			**1**
Blacksmith		7	7	**14**
Cabinetwork		7	6	**13**
Carriages		2		**2**
Castings			1	**1**
Clothes		5		**5**
Coopers work		2		**2**
Flour	10	8	2	**20**
Gunpowder	1			**1**
Hats		2	4	**6**
Iron	1		13	**14**
Leather	4	4	16	**24**
Lumber	1	6	28	**35**
Paper	2			**2**
Saddles, bridles, & harnesses		2		**2**
Salt			1	**1**
Ships			1	**1**
Shoes & boots		7	28	**35**
Skins	2	1	3	**6**
Textiles	14		4	**18**
Tinware		1		**1**
Wagons		1		**1**
Watches		3		**3**

Industry	New Castle	Kent	Sussex	Total
Wheels		2		**2**
Total by County	**36**	**60**	**114**	**210**

From this census, it appears that coopers comprised only 1 percent of the 210 industries in Delaware in 1820. Two coopers were listed and both were based in Kent County. However, this does not seem to take into account the coopers working within another industry, like the ones hired by the du Pont gunpowder factory as mentioned previously, or working within flour mills, for example. Besides coopers, industries of clothes, tinwares, and watches were located only in Kent County in 1820, as were the carriage, wagon, wheel, saddle, bridle, and harness industries. Grist, flour, and textile mills were concentrated in New Castle County, which also contained the sole entries for gunpowder, bark (for tanning), and paper. Sussex County contained the only iron casting, salt, and shipbuilding enterprises listed for Delaware in 1820, as well as concentrations of iron forges, tan yards, sawmills, and the shoe and boot businesses. The blacksmith, cabinetwork, and hat industries were distributed evenly between Sussex and Kent counties. Only flour, leather, skins, and lumber industries were found operating in all three counties of Delaware.

The manufacture of wooden staves to be made into barrels was a separate industry from coopering. The previous table of industries in 1820 Delaware does not mention staves, although it's possible that some lumber producers may have also shaped and sized wood into staves.

The firm of Raymond and Cummins in Smyrna bought and shipped staves, to Wilmington, New York, Providence, and Boston by the 1840s. They also shipped grain, lumber, and quercitron, bark from the American black oak, used in the tanning process (Hancock 1988:256). Although Jacob Raymond and later Daniel Cummins (his son-in-law and heir) owned the Jones Site from the 1820s to the 1850s, it is not likely that their dealings in barrel parts had any relationship to the barrels used in the barrel well (Feature 268). The artifacts from the well excavations suggest a much earlier date for the well, and the raw materials were being exported by the firm, not finished barrels.

An 1851-1852 mercantile directory for Delaware listed a number of manufacturers and machinists in New Castle County (Thomson Company 1852). No coopers were noted within this listing, or within the entries for Kent County or Sussex County. Flour mills, cotton mills, and bark mills comprised 31 of the 62 listings (50 percent) in New Castle County. Others in the county manufactured woolens, saddles and harnesses, agricultural implements, gunpowder, rope, coaches, cabinet ware, stretched leather bands, and carpet. Founders, machinists, roller mills, and a spice and chocolate mill were the remaining entries.

A Mr. Ray operated a stave mill in the Brandywine Village area of Wilmington, Delaware in the mid-19th century (Industrialbrandywine.org 2011). It was located in lower Brandywine Village near Lea's Mills. Mr. Ray came to Wilmington from New

York and built the brick mill building in the 1850s. The mill manufactured wood strips or staves to make barrels. The product was sold to local coopers along the Brandywine River. Prior to this time, it is thought that barrel staves were not being made in Wilmington (Zebley 1940:186).

A location in New Castle County on the north side of Blackbird Creek is named Stave Landing by 1868 (Beers 1868). Situated in Appoquinimink Hundred, about 1.5 miles upstream from the mouth of the creek on the Delaware River, the landing's name implies that staves were being shipped out by boat from this location. Coopering has become largely a mechanized process associated with the wine industry but was practiced as a traditional craft in cooper's shops, mainly in cities, into the twentieth century.

Types of Coopering

Standard coopery, making casks to hold liquids, is "tight coopering." The tight cooper made casks designed to keep dry goods in and moisture out for a longer storage period. Gunpowder and flour casks are examples of a tight cooper's work. Tight coopers were the most skilled of the trade. Oak was generally the preferred wood for tight coopering (Wright 2011).

"White coopery" is the making of water-tight wooden vessels, bound with iron or brass, other than casks for beer, wine, or other liquor (Seymour 1984:94). Wooden buckets, butter churns, tubs, and ale drinking vessels were products of white coopery (Figure 8-13). White coopers also made military drums and small fireplace bellows (Wright 2011).

"Slack coopering" is the making of casks that do not have to hold liquid (Seymour 1984:94). Dry goods like cereals, nails, tobacco, and fruits could be stored in this type of vessel. Lighter-weight wood could be used, like oak, chestnut, and yellow pine. The staves could be bound with willow or hazel hoops, twisted and nailed. Construction could be less exact than was required for liquid-holding casks.

Barrel Parts and Barrel Construction

The unique shape of a cask or barrel affords several advantages. A heavy barrel can be maneuvered with little effort by rolling it horizontally. A barrel also can be titled onto one of its rims and rotated or "trundled" (Seymour 1984:87).

"Barrels" are officially casks that hold 36 gallons (Seymour 1984:86). Larger casks are the hogshead (54 gallons), puncheon (72 gallons), and butt (108 gallons). The kilderkiln (18 gallons), firkin (9 gallons), and pin (4.5 gallons) hold less than a barrel. The body of a cask is made of wooden slats called "staves" exactingly shaped to fit together and create a bulge along the middle of the cask (Figure 8-4). "Slight" casks have staves under 1.5 in. thick, and "stout" casks have thicker staves (Seymour 1984:92).

Figure 8-13. An Illustration of the White Coopering Process from Mid-18th-Century Europe (Diderot and Jean le Rond D'Alembert,1751b)

Metal hoops typically circle the cask to hold the staves together, although wooden hoops were part of traditional coopering as well. The smallest hoop, at the cask ends, is called the "head hoop" or "chime hoop." The next hoop in size is a "quarter hoop", while the largest hoop, closest to the central bulge of a cask, is the "bilge hoop" or "bulge hoop" (Seymour 1984:86; Wright 2011).

The innermost wood and the outermost sapwood of a tree are not used for staves. Rectangular blocks of wood slightly longer than needed for the cask are the starting material. Each stave is "hollowed out on the concave side, rounded somewhat on the convex side, tapered at each end and, finally, its two long edges are cut on a chamfer" (Seymour 1984:87). Using traditional methods, each stave is clamped into a steel device called a "horse" or a "mare" and then hollowed out with a "hollowing knife," a draw-knife with a convex blade (Seymour 1984:91). The stave is then turned over and the other side is shaped with a concave knife to create the outer face. Next, the ends of the stave are tapered on a chopping block with a "side-ax," an ax with a large head, a short handle, and only one sharp edge. This shaping is called "listing" the stave. The listed stave is then run along a slanted plane roughly five ft. long called a "jointer," to bevel its long edges.

To form a cask, temporary hoops of ash or iron are used. The finished or "dressed" staves are stood up with an end hoop called a "raising-up hoop" circling the top of the staves (Seymour 1995:91). The circle of staves is tightened by pushing the iron hoop down by hand. This "raising-up stage" is done when a second hoop is driven down over the staves with a hammer and driver (Seymour 1995:92).

In the next stage, the "firing stage," the staves are dampened with water and then stood over a burning "cresset" containing wood shavings until they are soft enough to bend (Seymour 1995:92). Thicker staves may have to soak in boiling water or in a steam chest to prepare them for bending. Then, a thick truss hoop is hammered down the barrel,

followed by a smaller one, until the original hoop falls away. The cooper then flips the barrel and hammers one side of the truss hoop back towards the center of the cask, until a smaller truss hoop can encircle the splayed stave ends above.

The set and cooled cask is next fitted with "heads," the round wooden ends. The head is composed of wooden boards that have been attached with dowels, and the outer edge is beveled with a "heading knife" (Seymour 1995:90-92). A groove is cut into the ends of the staves with a "croze" after the ends are squared off with a "topping plane." Before the head is fitted, the inside of the cask may be smoothed, and an access hole or "bung-hole" can be bored (Seymour 1995:93).

The permanent hoops are typically of metal, although ash was used in earlier times (Seymour 1995:88). The cooper takes a steel strip and sizes it to the cask. He then removes the strip and places it on a "bick iron" to rivet the strip ends together (Seymour 1995:92). To fit the heads, the end hoop is released to slacken the staves, and the bottom head is inserted from inside the cask. The top head is then pulled into place using a metal handle called a "heading vice" which has been screwed into the top. The permanent end hoops are put in place, and the rest of the temporary hoops are removed. The outer surface of the cask is smoothed with a "downright plane" and then with a curved, two-handled scraper called a "buzz" (Seymour 1995:93). The remaining permanent hoops are fitted with a hammer and driver, to complete the assembly.

Choice of Wood for Barrels

White oak was a choice wood for tight coopering since it was strong and durable (Colonial Williamsburg 2002). American white oak was even exported to Great Britain for barrel-making beginning in colonial times, since the wood had less knots than British Isles oak (Seymour 1995:89). White coopering often used cedar or pine (Colonial Williamsburg 2002). The intended purpose of the cask affected the material choice, since some woods impart a color, flavor, or smell to their contents. Such a process is desirable for some products, including aging of wine which typically occurs in oak casks.

Native Trees of Delaware Suitable for Barrel-making

Loblolly pine (*Pinus taeda*), known commercially as North Carolina pine, is suitable for making barrel staves. By the early twentieth century, the species was found naturally in Delaware mainly in lower Kent and Sussex counties, although occurred as far north as the Delaware-Chesapeake Canal (Taber 1995:29). The wood of bald cypress (*Taxodium distichum*) is easily worked and useful in cooperage. By the 1930s, this species was no longer abundant in Delaware but occurred naturally along some streams and in a few swamps and ponds in Sussex or southern Kent County (Taber 1995:41). Another Delaware native tree used in cooperage and preferring the same locations as bald cypress and is the Southern white cedar (*Chamaecyparis thyoides*) (Taber 1995:43). All of the above have non-porous wood.

Ring-porous wood has large pores in the spring wood but smaller and fewer pores in the summer wood of the annual growth ring (Tyber 1995:245). The wood of oaks tends to be strong and durable in contact with the soil, especially that of white oak (Quercus alba) (Taber 1995:101-103). White oak wood is suitable for tight cooperage and was very common throughout Delaware. Wood of the American elm (*Ulmus americana*) had similar qualities and distribution, until the Dutch elm disease began to reduce populations in the 1930s (Taber 1995:131). The slippery elm (*Ulmus fulva*) was useful in slack cooperage, but was only common to the northern portion of Delaware (Taber 1995:133). The ring-porous wood of the red mulberry (*Morus rubra*) was suitable for tight cooperage and was common but not abundant in the state (Taber 1995:137). Like white oak, the pores in red mulberry wood contain tyloses (pore sealing membranes or crystals). The species is especially valuable for tight cooperage since its wood does not cause discoloring or taste and odor effects common with other cooperage woods.

The porous wood of the river birch (*Betula nigra*) was useful for slack cooperage and was common in all of the state (Taber 1995:91). Basswood (Tilia americana) was frequently found in New Castle County and its soft wood was suitable for slack cooperage (Taber 1995:193). Barrel hoops were sometimes made from the porous wood of black ash (*Fraxinus nigra*), although this species was not common in New Castle County, at the southern edge of its natural range (Taber 1995:217).

The Jones Site Barrels

Some general observations on the Jones barrels can be made. First, the barrels did not contain any identifying marks or characteristics that suggested they were locally made. Second, the state of Delaware did not seem to have an active coopering industry until decades later than the late 18th-century date suggested by the archaeological evidence from the soil strata within and surrounding the barrels. Third, one of the three barrels contained a bung hole, indicating it was originally manufactured to hold liquids. This suggests that the barrels originally served some other function and then were re-used or re-cycled to line the well.

Comparisons were made with barrels recovered from five other archaeological sites in Delaware (Table 8-15). Sites included the Moore-Taylor Farmstead, Benjamin Wynn Tenancy, and Wilson-Lewis Farm (Grettler et al. 1996), the John Darrach Store (de Cunzo et al. 1992), and the Thomas Williams Site (Catts and Custer 1990).

The Moore-Taylor Farm Site (7K-C-380) was an owner-occupied farm that dated from the early-19th century to the 20th century (Grettler et al. 1996). Excavations led to the identification of 486 cultural features at the site, which included a frame dwelling, three outbuildings, five wells, two privies, 10 fence lines, and several activity areas.

The Benjamin Wynn Tenancy Site (7K-C-362) was a late-18th century farm located in rural Delaware (Grettler et al. 1996). Two hundred forty six cultural features were identified at the site, consisting of the remains of a house, a small blacksmith shop, two wells, eight fence lines, a probable privy, and various yard/activity related features.

The Wilson-Lewis Farm (7K-C-375) was a mid- to late-19th century owner-occupied farm in rural Delaware (Grettler et al. 1996). A total of 161 cultural features was identified at the site and included post holes related to the one-story frame house, a stable, two wells, four fence lines (from the occupation), and several midden/trash deposits. Three 20th century fence lines also were identified that were not oriented with the rest of the site.

The John Darrach Store Site (7K-A-101) was an 18th through mid-19th century store and tenant farm site located along the road to Duck Creek Landing (De Cunzo et al. 1992). The original store was a brick structure and was surrounded by yard areas and a possible impermanent outbuilding. An addition was added to the structure later and additional outbuildings, fence lines, gardens, animal pens, and privies were constructed in the yard areas. Darrach was the son-in-law of William White, the owner of the White tract near the Jones Site. White was probably the original builder of the store.

The Thomas Williams Site (7NC-D-130) was a prehistoric and historic site near Glasgow (Catts and Custer 1990). Over 200 historic features were uncovered, including two root cellars, a stone-lined cellar hole, a brick-lined well, privy pits, and postholes dating from the late 18th through 20th centuries. The property was occupied by a tenant farmer (1792-1846), stone mason (1846-1875), and an African-American laborer (1887-1920s).

In all, 12 barrels plus the 3 Jones Site barrels were compared (see Table 8-15). The height of complete barrels in this sample ranged from 2.4 ft. to 6.5 ft. Barrel diameter was measured from 2.0 to 4.0 ft. Stave thickness varied considerably, from a low of 0.75 in. to a high of 2.76 in. When known, stave material was oak or white oak. In general, the comparison suggests that the barrels found at the Jones site were fairly typical of barrels found in wells on 18th and 19th century sites in Delaware.

Table 8-15. Comparative Data on Historical Barrels from Selected Archaeological Sites in Delaware

Site	Feature No.	Notes	Height	Diameter	Wood	Staves			Original Function	Date	Citation
						Length	Width	Thickness			
Moore Taylor Farm	2	Inner Barrel-straight sided	6.5 ft.	2.5 ft.	Oak;3 hand hewn hoops at 1 foot intervals;	6.5 ft.	6 in.	1.5-1.75 in.	Well casing (straight sided)	1827-1874*	Grettler et al. 1996
		Outer Barrel-straight sided	5.8 ft.	3.2 ft.	Oak;	6.0 ft.	6 in.	1.5-1.75 in.	Well casing (straight sided)	1827-1874*	
	273	Upper Barrel	2.5 ft.	2.0 ft.	Oak; small crozes; wooden boards connected two barrels	25 in.	3.5 in.	0.75 in.	Flour or grain	1811-1844*	
		Lower Barrel	3.0 ft.	2.0 ft.	Oak; small crozes; wooden boards connected two barrels	25 in.	3.5 in.	0.75 in.	Flour or grain	1811-1844*	
Benjamin Wynn Tenancy	80	Barrel	2.4 ft.	2.3 ft.	V croze			1 inch		1749-1821*	Grettler et al. 1996
	94	Barrel	2.5 ft.	2.0 ft.	White oak; V croze	2.8 ft.	4.8 in.	2.76 in.		1759-1809*	
Wilson-Lewis Farm	123	Barrel		3.4 ft.						1855-1882*	Grettler et al. 1996
	127	Barrel		3 ft.						1842-1889*	
John Darrach	82	Upper		3.4 ft.						1830-	De Cunzo et

Table 8-15. Comparative Data on Historical Barrels from Selected Archaeological Sites in Delaware

Site	Feature No.	Notes	Height	Diameter	Wood	Staves			Original Function	Date	Citation
						Length	Width	Thickness			
Store		Barrel								1875	al. 1992
	82	Lower Barrel								1830-1875	
Thomas Williams Site	2	Barrel		4 ft.			1-1.25 in.		Hogshead (54 gallons); puncheon (72 gallons) ; butt (108 gallons)	1810*	Catts and Custer 1990
Jones Site	268	Upper Barrel	4 ft. (app. 1.2 m)	3 ft. (app. 90 cm)							Versar 2011 (this report)
		Middle Barrel	2 ft. 9 in. (app. 85 cm)	2 ft. 5 in. (app. 75 cm)	oak	7.5 to 16.5 in. (fragments)	1.65 to 2.95 in.	0.2 to 0.5 in.			Versar 2011 (this report)
		Lower Barrel	3 ft. 3 in. (app. 1 m)	3 ft. (app. 90 cm)	oak	3.4 ft. (only complete one)					Versar 2011 (this report)

* mean ceramic date

8.3 BRICK MAKING AT THE JONES SITE

As outlined in the Delaware Management Plan under Domestic Economy, Manufacturing and Trade, and Landscape for the periods of 1730-1770 and 1770-1830, research should focus on seeking evidence of intra-site land use, treatment, and alteration (De Cunzo and Catts 1990:121-122, 132, 149). Archaeologists can better understand technology and manufacturing processes with data on equipment, raw materials, and finished products preserved in the archaeological record, especially of on-site production sites clearly reflecting land use (De Cunzo and Catts 1990:19-20, 133).

Archaeological data and archival documentation is relatively sparse for colonial period Delaware industries. Historical topics associated with the early industrial theme focus on production facilities and manufacturing processes, local craftsmanship, and the use and alteration of the landscape by such processes (De Cunzo and Catts 1990:135). Two types of historical manufacture were present at the Jones Site: cooperage and brick making. The presence of an intact wooden barrel at the bottom of Feature 268 provides information on cooperage, or barrel manufacture. Evidence of local rural manufacturing processes was concentrated in the northern portion of the site, associated with a brick clamp complex.

8.3.1 Brick Manufacturing and Brick Clamps

Small Scale Brick Manufacturing

The Jones Site is rare in the archaeological record in that elements of the entire brick manufacturing enterprise were found relatively undisturbed below the Ap horizon with very few associated non-brick artifacts that could create background noise to the activities occurring at such a work site. The Jones Site clamp was one the most intact brick clamp complexes found to date in Delaware and the analysis of field data will contribute greatly to the understanding of this feature type.

There are many limitations about what can be learned from archaeological brick samples. Because the variation in historical brick is relatively low compared to other artifacts l, like ceramics, bricks are difficult if not impossible to date. Their function is clearly architectural, but what sort of structure a brick may have been intended for can't necessarily be discerned from the brick alone. Date of manufacture and specific structural function cannot be determined by analyzing brick sizes (Heite 1970). Hand molded bricks themselves usually cannot be dated because they contain no temporal diagnostics, such as maker's marks or specific manufacturing techniques until after the advent of brick machines. This makes analysis of a brick making site both a challenge and an opportunity: understanding the features and techniques associated with the manufacturing of hand molded bricks can enhance the knowledge of any archaeological site containing handmade bricks.

Little in-depth archaeological research has been conducted concerning small brick clamps, even though several dozen have been recorded (Henry Miller 1996:38). While

the number of archaeological reports containing small-scale brick manufacturing sites has increased since the early 1980s, relatively few accounts of detailed comparative information exists, including in Delaware. The small-scale brick clamp was usually used to provide bricks for a nearby house, structure, or building complex. In colonial times, middle class and wealthy families could afford to construct a house entirely composed of brick, while the lower to middle class families usually had wooden structures with brick or stone chimneys, ovens, and foundations.

The majority of the buildings in the Chesapeake Bay region constructed in the 17th century were predominately wooden structures with only chimneys and foundations made out of stone or brick. However, the Dutch colonists that came in 1631 to Hoere Kill built a brick house inside the palisade, indicating one of the earliest references to brickmaking in the state (Ewan 1938:9). In Dutch-ruled New Amstel (New Castle), Delaware, a brick kiln was established in 1659 by Cornelis Herperts de Jager (Ewan 1938:4).

The small brick features associated with the wooden structures would not have required a large process to manufacture a satisfactory number of bricks (Miller 1996:38). A small number of the early colonial houses were thought to be constructed utilizing yellow bricks, which could indicate imported bricks from Europe, or a local attempt to copy a Dutch or European style in Delaware (Becker 1977). Yellow brick has generally been accepted to be solely a 17th century import, and not produced directly in the United States. Some evidence in Maryland, however, suggests that some yellow bricks were still being imported as late as the early 1700s (Luckenbach 1994:14-15, 21).

The lack of brick in the majority of the early colonial structures was a direct result of manpower and financial shortages amongst the colonists. Bricks took time and money to manufacture and the majority of the colonists had neither to spare beyond subsistence. Usually the brick structures were reserved for wealthy land owners, plantation houses, and urban status symbols, but the majority of the population of the Chesapeake Bay region was anything but wealthy. To help offset costs yet retain a residence that was considered to be a status symbol, some yellow bricks were painted with a reddish paste to simulate and blend in with red bricks when the combination of old and new were used in construction (Luckenbach 1994:15).

As the 17th century drew to a close, the number of brick dwellings in the region began a gradual increase, as did the number of craftsmen required for the brick industry. Brick makers were professional artisans, but could also be just part-time or temporary workers performing a quick job, or seasonally employed. The men who made the bricks were usually professionals and very skilled at their occupation. Whether a slave or freeman, brick manufacturing required great skill and knowledge, and these men were in great demand, and they would travel to perform a job. As an 1806 Kentucky advertisement stated "*WANTED immediately a quantity of bricks made and laid, on my farm, three miles from Lexington*", labor was not always the result of an on-site worker (Hockensmith 1998:79). Advertisements for brick making were usually run in February to April to fulfill contracts for the upcoming season (Hockensmith 1998:80).

In slave holding regions, many hand molded bricks may have been produced by slave craftsmen (Wayne 1993:92; Hockensmith 1998:80). George Washington's slaves made bricks; however, he hired an outside artisan to oversee the operation (O'Neill 2001). A Kentucky advertisement from 1797 revealed that "White men, or those accustomed to working in a brick yard will be preferred" (Hockensmith 1998:74). In 1814, another Kentucky newspaper ran an advertisement for an auction for hiring out "TWO NEGRO MEN, one of which is a Brick Molder, the other a good Labourer" (Hockensmith 1998:77). A person of color was trying to be hired for brick making in the following 1816 advertisement: "To Hire, For the ensuing Brick Moulding Season, a yellow Man of unexceptionable character, as a Negro – is a first rate brickmoulder, setter and burner." (Hockensmith 1998:80). Little is known about the laborers working for the landowners on the Jones Site, whether slaves, free laborers working for the owner, or hired artisans. However, it is known that during ownership of the property by the Jones family (1768 to 1806), the owners lived elsewhere in the county on one of their numerous landholdings, and held over two dozen people in slavery. John Jones built a mansion house of brick circa 1760 on Mt. Jones, his plantation near Odessa. If any of his slaves were part of the brick manufacturing process that presumably took place on his plantation, they would have been experienced laborers. The Jones family was wealthy and could easily have afforded to hire an itinerant brick maker to oversee the production of the bricks at the Jones Site. It is plausible that the labor force at the Jones Site brick clamp consisted of some of the Jones family's slaves.

As previously stated, the dimensions of a hand molded brick prior to the late 1700s varied before legislation regulating the dimensions was enacted. A 2 x 4 inch brick was the standard after the 1770s-1780s, when many laws were enacted (personal conversation, Allan Gilbert, June 27, 2000). Average dimensions for Haverstraw molds were 4 3/8 x 8 ¼ inch and 2 3/8 inch thick, to account for shrinkage (Davis 1895:90-91). The John Jay Homestead in lower New York contained bricks measuring 8.75 x 4 x 2 in. (Feister and Sopko 1996).

By the 18th century, brick makers usually depended on a third party who went to a project location and calculated the number of bricks. This type of job approach demanded tighter controls on the uniformity of the bricks, as the bidder would have to rely on the consistency of the brick to adhere to the calculated dimensions (Garvin 1994:23). Because the bricks shrank according to their distance from the heat source, the dimensions of all bricks from a single firing can vary considerably (Garvin 1994:23). Most bricks will vary more in length than in width or thickness. Bricks in the same kiln may vary as much as half an inch in size (Metz and Russ 1991:100).

An 1851-1852 mercantile directory for Delaware listed a number of manufacturers and machinists based in New Castle County (Thomson Company 1852). No brick makers were noted within this listing, or within the entries for Kent County or Sussex County. However, twenty-three brick makers were listed in an 1859-1860 state directory, with two located in Smyrna, owned by William McAfee and Thomas Dobson (Boyd 1860:200). Several laborers would have been needed to produce hand molded bricks on

each location. The *Smyrna Times* of August 28, 1862 (Vol. 8, No. 8, page 2) advertised the following:

Brick
Constantly on hand,
A general assortment of brick at
Allen's Yard
On Methodist St. opposite Delaware St.,
Cheap for cash or exchanged for wood,
Persons wishing Brick burnt through the
Country would do well to give him a call

By the beginning of the 19th century, horse driven pugs mills were commonly used, which eliminated much of the human power needed to mix the clay or loam into the required consistency to slop into the wooden molds (unknown 1999:2). Some soft mud brick machines were manufactured in the early 1800s, but as a general rule, most machine-made bricks were not soft mud bricks since they could use stiffer clay (Diehl et al. 1996:5).

Large scale demand for bricks in urban areas soon outgrew the supply of hand molded brick yards making the time was right for the introduction of brick making machinery. Larger cities comprising mostly wooden structures were at terrible risk from massive conflagrations. When several cities experienced large-scale fires, the inhabitants of inner urban areas wanted to rebuild with brick. Insurance companies also played a key role in the rise of brick buildings (Hockensmith 1997:119).

The end of the Civil War generally marks the beginning of the mechanized brick industry (Gurcke 1987:84; Van Tassel and Bluestone 1939:7). Brick-making machines were patented in the United States as early as 1792; however, the machines did not grow in popularity until the 1870s, partly due to the lack of machines that could produce a quality product on a sufficiently large scale to make them profitable (McKee 1973:44). Over a hundred brick making machines were patented in the United Kingdom alone from 1820 to 1840, giving rise to the practice of branding brick (Hammond 1998:14). While some bricks were branded prior to the mid-19th century, most brands were added predominately after 1850 (Gilbert et al. 1993:35; Kelly and Kelly 1993:84).

Mass-produced bricks and tile were available in the Blackbird and Smyrna area at least by the end of the Civil War. By 1868, a brick and tile manufacturer was in operation on Smyrna Landing Road near Brick Store Road, only two miles to the southeast of the Jones Site (Beers 1868). Tile and bricks were advertised products of the facility, the only advertised brick and tile manufacturer listed in the atlas. It is not known, but assumed that the landing was using machines to manufacture the brick and tile. The operation was near a landing on Duck Creek named Brick Store Landing in 1868; this referred to a commercial warehouse or storehouse constructed of brick. Brick warehouses were touted as superior to wooden warehouses due to their fire resistance and were marketed to local farmers and millers as storage places for their goods waiting to be shipped by boat.

The steam shovel was invented in 1879; prior to that date, brick makers had to dig for clay by hand with shovels (Bonomo 1999). Once the brick makers began to see the advantages of the brick machines, they rapidly replaced small-scale hand molded operations all across industrialized America. Handmade bricks were relatively porous compared to pressed bricks produced in a machine operation. Machine-pressed bricks were appreciably stronger and more solid (McKee 1973:45). Furthermore, machines could also handle stiffer clay, and because water did not have to be added to the raw brick matrix to slop it into the mold, the process took less drying time (McKee 1973:45).

Hand Molded Brick Manufacturing Process

The process of producing hand-made bricks has changed little since the earliest historical periods (Van Tassel and Bluestone 1939:4). Many of the techniques used since recorded times have been the foundation of brick manufacturing for thousands of years. Brick makers in England in 1703 were charging customers 6 pence (d.) per thousand bricks for the labor of the molder, 4 d. per thousand for the "bearer off", 4 d. per thousand for "He that tempers the earth", and 6 d. per thousand for "He that digs it" (Neve 1703 in Lloyd 1925:20). Brick manufacturing basically contains six phases: 1) clay procurement, 2) weathering, 3) adding temper, 4) molding, 5) drying, and 6) firing (Weldon 1990:1).

Clay Procurement

Clay is a secondary mineral that is produced by the mechanical weathering and disintegration of certain rocks. Chemical changes occur due to interaction of water with the microscopic products of erosion. Many different rock minerals act as primary sources for clay. The plasticity of clay arises from the interaction of its minerals with water plus features of their crystal structure. Clay composition varies from one geographical location to another (Cotterill 1985:132-133).

The vegetable mould (root mat or forest duff) and top soil were removed and three to four spits deep of brick-earth would be removed. A spit was the depth of one cut of a spade in digging clay, varying from seven to eleven inches each (Searle 1911:67). Brick-earth was a term used to distinguish clays/loams that required little mechanical treatment, and was used whenever possible in smaller brick yards (Searle 1911:28). Fat clays had 0 to 20 percent sand, mild clays had 20 to 35 percent clay, and thin clays had over 35 percent clay (Weldon 1990:2). Fat clays produced the strongest bricks, but shrank, warped and cracked during firing. A brick containing too much sand would not attain a suitable hardness unless it had been fired well over 2000^0F, a temperature hard to maintain in a clamp (Weldon 1990:3).

Sandy clays (or mild clays) were preferred for hand-molded brick manufacturing in the 18th century, as opposed to plastic (or fat) clays, because they did not have to be weathered to break down the clay content and less temper had to be added to remove plasticity and control shrinkage (Feister and Sopko 1996:51). Less effort translated into fewer person hours and lower production costs. Mild clays and loam produced bricks

and other simple items because they did not require additives other than water and usually contained a large proportion of sand (Searle 1911:26-27). Clays from the upper two feet was considered the best by some sources, probably because some weathering, erosion, and percolation had occurred in the matrix (John Page site page 7; Davey 1961). The Fallsington Soil Series loam and sandy loam apparently contain the best potential for hand molded brick matrix in several places in Delaware (Heite 1998:36). The soil at the site of the brickclamp is Woodstown loam (WsA), which has similar properties to Fallsington loam (Matthews and Lavoie 1970).

Weathering

Stiff clays and loam with a higher clay content need to be weathered or softened through the fall and winter, and processed and fired in the summer months (Metz et al. 1998; Heite 1970:44; Dobson 1850). Rain and frost would aid in leaching out the destructive salts and cause it to expand and contract increasing its plasticity (Colonial Williamsburg Foundation 2001). The matrix was spread only two inches thick on the ground surface, then placed in a soak heap for 12 to 14 hours and then mixed with a hoe (Davis 1895:87-88; Van Tassel and Bluestone 1939:5). An account of brickmaking methods in late 17th-century England describes digging the soil before Christmas, and allowing it to lie until Easter to mellow so that the hard lumps "may shake to pieces" by the help of rain or frost (Houghton 1693 in Lloyd 1925:34).

Tempering

Tempering has two meanings in traditional brickmaking: the addition of sand, typically, to the raw soil, and the breaking down and mixing of the materials into a workable dough. All brickmaking matrixes usually contained temper of some kind, whether inherent or added, ranging from shell and bone to sand and gravel, but if the raw material did not contain a certain clay content, then no amount of heat or temper would allow the matrix to adhere to the temper and create a viable brick. Loams usually contain 50 % clay or less and the aggregate in sandy loams may have been enough temper to strengthen the brick with no additional additives (Vogel 2002:18).

The British description of late 17th-century brickmaking methods mentions what is done to the soil that has been weathering from roughly Christmas to Easter:

> Then we water the Earth well, and temper it with a narrow Spade about five Inches broad, that the Workman may hold out, with which we dig it down, and then temper it with our bare feet till it is in good case to make a Brick on, that is, like a piece of Dough, such as will just stick in the Mould or Frame when lifted up, and not fall off of itself. (Houghton 1693 in Lloyd 1925:34).

Molding

Traditionally, a wooden mold was constructed by fastening narrow wooden slats together to form a two or three mold frame with the pre-designated measurements. The volume of the brick mold generally produced a brick of the desired dimensions, but before legislation was passed regulating the size of bricks, there was great variety in the size and shape of the end product. To keep the matrix from adhering to the sides of the mold, the frame was either treated with water (slop molding), sand, or sometimes oil (Diehl et al. 1996:5). Hand-molded bricks may have cavities on the base where the hand thrown clay did not completely fill the mold. Some bricks had laminae in the interior to represent hand molding as an exposed surface to the sand or elements was kneaded or slung into the mold, as a brick pug or machine would press the clay together usually not creating a lens.

The surface of a brick formed by a sandy mold process was usually readily identifiable by the granular texture of the surface (Feister and Sopko 1996:51). The surface of a brick formed by slop molding, can sometimes be identified by the presence of smooth surfaces, rounded edges, and even brush strokes or striations from using a "strike" to scrape the excess matrix and water from the exposed surfaces after molding (Feister and Sopko 1996:51; Garvin 1994:21; Wingfield et al. 2000:5). Many of the hand-molded bricks from 7NC-J-204 have brushed marks on what is probably the top side of the brick during manufacturing. Brick were sometimes placed on straw on the ground to dry, but the bricks from the Jones Site do not contain straw impressions (Feister and Sopko 1996:62).

A brickmaker's table was mentioned in an account of the process from England in the late 17th century:

> …a Table standing upon four Legs, about three foot high, five foot and a half long, and three foot and a half over, and load it with as much [soil mixture] as 'twill bear at the Right Hand and about half way; at the other end are boards nail'd about nine Inches high to lay Sand in and in the middle we fasten with Nails a piece of board, which we calla Stock; this Stock is about half an Inch thick and just big enough for the Mould to slip down upon…we also have upon the table before the Mould or Frame a little Trough, that will hold three or four quarts of water which we put in, and in it a strike to run over the Mould to make the Bricks smooth; this Strike is usually made of Firr, nine inches long, an inch and a half broad, and half inch thick, we have also on a little Form just by the Sand-Bin about 30 little pieces of Board twelve inches long, six inches over, and half inch thick, which we call Pallat-Boards. When we are thus prepared with utensils, then one man strows Sand on the Table (as maids do Meal when they mould Bread) and moulds the Earth upon it.
> (Houghton 1693 in Lloyd 1925:34)

A description of brickmaking published in Europe in 1761 details the processes then in use. In this example, a double mold is used:

> The moulder plunges his arms into the heap of earth, cuts off a piece weighing from 14 to 15 lb., throws it, in the first place, into the compartment of the mould nearest him, leveling it at the same time with his hand by heaping up the material in it, the excess of which he throws into the second compartment, which was not filled at the first charge, like the other one. He levels this compartment, too, by hand, heaping up the earth and filling any empty spaces. Seizing, at the same time, with his right hand, the strike, the handle of which is conveniently placed at the edge of the wetting trough, in which it has been soaking, he passes it firmly across the mould, to remove all that exceeds the 28 or 29 'lignes' of thickness that the two bricks should be. He gives a tap with the flat of the strike, as with a trowel, on the middle of the mould to separate the two bricks one from the other and places the surplus earth by his side on the table. The Carrier at once draws the mould towards him by the ears and sliding it to the edge of the table, raises it with both hands, turning it over and adroitly placing it on its edge, so that the two bricks, which are soft, can neither fall nor get out of shape.
> (Gallon 1761 in Lloyd 1925:31)

An experienced molder could turn out 1,000 bricks in a 14- or 15-hour day by himself, according to an account of the process in the late 17th century. With the help of a man to temper the earth and a boy to carry off the bricks, a molder could produce 2,000 green bricks per day (Houghton 1693 in Lloyd 1925:19-20).

Drying

The hand-molded bricks were then laid out in long rows, as many as 58 bricks long and 40 rows wide in some commercial brickyards (Davis 1895:92). Once the bricks were formed (or cut as in using extremely stiff clay), they were dried, many times placed into a drying shed, and were hacked (stacked) about eight courses high on the edge with 1/2 inch spacing (Davis 1895:92-93). It was customary to place the drying shed immediately adjoining the brick floors, and the sheds were built cheaply as they were only temporary structures (Davis 1895:93). Thick or stiff wood planks, which would not curve, were placed across the top, and one end of the gabled roof was lower allowing for runoff to drain away from the bricks (Davis 1895:93-94). Bricks that have been exposed to the rain were called washed brick and usually have a rough appearance and are not considered to be of high esteem (Davis 1895:93). If portions of the bricks were lost to exposure, the amount was deducted from the brick maker's pay (Davis 1895:90).

A European description from 1761 of the placing of green bricks to dry is as follows:

> He [the Carrier] proceeds to carry the two bricks the length of his walk, there he holds the mould close to the ground, as if he were going to place it on its edge, but suddenly turning it over he lays it with the two bricks flat on the ground and lifts up the mould. He takes great care to execute this last movement vertically, for if it were done in the least obliquely, the

> two bricks would certainly be deformed. The Carrier then returns to the bin with his mould. He throws this into the bin, which is filled with sand, sprinkles it lightly and rubs the sand on all round with his hand.
> (Gallon 1761 in Lloyd 1925:31)

Firing

The clamp needed to be fired from two to seven days, depending on the method, using either an updraft or a downdraft kiln (Diehl 1996:11). During the brick firing process, the temperature is gradually raised by the addition of more fuel and the adjustment of the amount of covering of the flue openings. The water in the brick begins to evaporate as soon as the temperature is above 100 degrees Celcius (C) but is not all removed until the material becomes white hot, between 700 and 900 degrees C. The fire is kept at a lower temperature initially until the change in smoke color from white to black signals that most of the water in the brick has evaporated. The final stage of firing, vitrification, begins at 900 degrees C and involves two processes: a sintering together of what is left of the clay mineral particles; and a melting of the oxides of the two alkilis, potassium and sodium, and the two alkaline earths, calcium and magnesium. The molten oxides are fluxes and are spread around the sintered clay particles in a thin liquid layer. The strength of the fired brick depends partly on the sintering and partly from the cohesive action of the solidified fluxes. The color of the cooled brick depends largely on its iron content (Cotterill 1985:134).

Our analysis identified four classifications of brick based on level of firing from criteria gleaned from the Phase II data base:

- **misfired** – very low level firing, barely fired more than daub; located on the exterior and ends of a clamp the furthest away from the heat; miss-fired bricks may be re-fired.

- **low-fired** – thoroughly fired, but soft; can easily break or crumble or be scored with a fingernail; probably located under the exterior or ends and were usually the same consistency throughout; low-fired brick may also be re-fired.

- **glazed** – next to the heat, so hot the exterior becomes glazed. If the interior and posterior regions of a glazed brick, in relation from the fire, were not high fired, the brick may not have been intentionally glazed. High-fired glazed bricks would probably be intentionally glazed and could have been used for construction/decorational purposes.

- **high-fired** –usually located between the glazed and low-fired bricks in the clamp, and were the desired end results of a good firing. Because of their good quality, they will be completely removed from a clamp site.

Clamps in the Archaeological Record

Originally, the term "clamp" referred to a large stack of hay, potatoes, or bricks (Weldon 1990:35). Since the American Colonial period, the term has been widely used to indicate a structure or edifice used to heat bricks rather than denoting a volume (Searle 1911). A clamp, by definition, was a temporary, site-specific feature, which, after being dismantled, usually contained only a footprint of burned soil and some wasters (Davis 1895:284-285; Historic Preservation Section 1973:19; Firman 2000). The firing process could not easily be controlled while firing a clamp, which attained maximum heat immediately and could not be redistributed (Diehl et al. 1996:12). Clamps were generally considered low-end updraft kilns.

A review of literature concerning small-scale brick manufacturing techniques revealed a variety of criteria describing the structures used to fire bricks. The three most widely used terms were kiln, scove kiln, and clamp. While the general public might be most familiar with the term kiln to define an enclosed "oven" for making brick, professional brick manufacturing related reports also use scove kiln and clamp. Many times in the historical record, all three terms were used interchangeably (Metz and Russ 1991:97; Weldon 1990:35). The term "scove", when applied to brick manufacturing, refers to plastering the outside of a clamp to provide greater efficiency, and the clamp was then "scoved" (Jones 2001:1). The term "oven" was never observed, nor thought to be used, when referencing a small brick manufacturing location.

Different clamps may have been used for manufacturing different types of bricks. At Lower Westover Church in Virginia, one kiln was built for making the structural brick and a second clamp was used for decorative bricks (Heite 1973:48). However, the majority of researchers agree with Noel-Hume's description of the clamp at Carter's Grove:

> …really kilns built on the land surface and constructed from the same shaped clay bricks that were to be burned. Thus when firing was completed the entire structure was dismantled, leaving nothing permanent behind it on the ground but a scorched mark and the holes for the posts that had supported a temporary roof protecting the unbaked bricks from the weather.
> Noel-Hume 1974:33

Because brick clamps were predominately placed on the ground surface and not into a depression or trench, the features are easily destroyed by plowing. Some structural integrity can still exist if the base of the clamp was deeper than some plows could reach (Heite 1973:50). More permanent kilns would normally be excavated into the ground (Heite 1970:44). However, two Charles County Maryland clamps were used successively, with the second clamp assembled within the shallow clay extraction pit of the first clamp (Balicki et al. 2004:56). The earlier of the two Maryland clamps was built into the side of a rise, with the benches placed on leveled subsoil (Balicki et al. 2004: 77). In south Texas on the Rio Grande, an adobe brick kiln was subterranean, but still contained certain basic elements existing at the Jones Site (Boyd 1994). A brick kiln at the Rich Neck Plantation at Williamsburg had an underground kiln and associated borrow pits (Colonial Williamsburg Foundation 2000a:2).

Fire Channels

The most common criteria defining a brick clamp was the presence or mention of fire channels, also known as fire tunnels, flues, or archways. The historian is entirely reliant on contemporary accounts, which may not be entirely representative of all types of brick clamps and kilns. Therefore, the researcher cannot, with confidence, claim that all clamps had fire channels comparable to those described in the literature. However, there had to be enough space between the bricks to allow an adequate air flow to create oxidizing conditions. Since the entire system sometimes was developed by trial and error, early clamps may have varied significantly. However, by the mid-18th century, the value of fire channels should have been fully realized (Firman 2000).

Usually a foundation of green brick was laid on a flat ground surface with gapped courses to allow for air flow for the heat and fire. Fire channels/tunnels were constructed on the foundation/base to allow the fuel to be raked in and out of the clamp during firing (Heite 1973 and 2000a; Payne and Thomas 1993:27). Wasters or bad bricks from earlier firings were used to create the arches or fire channels, unless it was the first firing of a clamp, where green brick may have been used. The tunnels would be from a minimum of four to five bricks high to as many as 14 bricks high in larger clamps. The channel would be a little narrower in width than height and extend the entire length of the clamp (Glessner 1989). Shin logs, usually a series of bricks, iron plates, or some sort of shield, were placed at the end of the channels to open and close the air flow through the opening when the heat was too low or too high.

One source estimated the fire channels or arches as being 60 bricks long, 3 bricks thick and 24 bricks high, creating some very large fire channels (Searle 1911:72). Another clamp had arches 22 bricks high and 33 bricks wide, stacked on end and every course was turned 90 degrees, and produced somewhere in the neighborhood of 25,000 to 30,000 bricks (Hockensmith 1997:115).

The number of arches in a clamp varied greatly with the size. Anywhere from 3 to 36 fire channels have been documented in clamps in the United States. At a northern Mexico clamp, three tunnels were prepared to feed the fuel through with fifteen short narrow passages were placed on the sides to allow air to flow through the structure (Hockensmith 1997:115). The channels were usually oriented from side to side to allow the fuel to be added and removed at a given pace and level of effort. Theoretically, the channels were oriented so the prevailing winds could easily pass through the clamp, creating better heat convection. The flues of a Kentucky brick clamp were oriented from northwest to southeast, similar in orientation to many in Virginia (Wingfield et al. 1997; Metz and Russ 1991).

Fuel

The fire channels were usually filled with wood, but archival evidence indicates that charcoal and crushed coal were also used to fire clamps. The clamp could be burned

from as few as 3 to 5 days with little to no refueling, or up to as many as 15 to 20 days with many refueling episodes (Diehl et al. 1996:12). A kiln observed in Mexico was usually fired for approximately 24 hours and three days to cool, much shorter time periods than in the contemporary accounts and current research indicates (Hockensmith 1997:116). Larger clamps, such as found in England, were known to have been fired from two to three weeks and as long as ten to twelve weeks on the larger clamps (Proctor et al. 2000:189).

Wood would have been the predominant fuel source in Delaware, although coal may have been available, but probably at later dates than the probable late 18th century date range for the Jones Site clamp (Heite 1973:48). Wood ash residue can be found associated with clamps (Heite 1973:53). Coal dust was mixed into the clay as a common practice after 1828 to compensate for the loss of heat from under the clamp to the exterior bricks of the firing structure. The presence of the coal dust, when ignited, made the entire brick a "fireball" heated from within, rather than only baked from the exterior. The coal dust method was referred to as the "London" method of brick firing (Searle 1911:50-51). The process of adding "fuel" inside the brick, however, was dangerous, as the fire could easily get out of control. The coal dust had to be finely screened as even small fragments would leave cavities in the brick after firing making the brick weak and unstable. This method of brick burning was peculiar in that each brick contained the fuel needed for vitrification, with no stacking to allow the heat to spread uniformly throughout the clamp (Searle 1911:17). Only a few fragments of coal clinkers were recovered from the Jones Site near the clamp area and could have been discards from the farm machinery or general field scatter.

Clamp Size

Construction methods and sizes for brick clamps appear to have varied. Table 8-16 presents statistics from several clamps and kilns gleaned from the literature review for the Jones Site project, showing a wide variety of sizes and shapes of clamps across the United States as well as Great Britain and Mexico. Clamps were usually small in comparison to kilns, only 8 to 12 ft. high and 10 to 12 ft. long and 20 to 30 ft. wide (Glessner 1989; Weldon 1990:19). Some archival estimates indicate clamps could be up to 50 to 100 ft. in length but usually did not exceed 20 ft. in width (Glessner 1989; Heite 1973:48). Differences in size would presumably have related to the number of bricks needed for the project at hand. Variation in construction technique could have arisen from different traditions brick makers learned, differences in skill or experience, or the exigencies of local conditions.

Table 8-16: Dimensions of Brick Clamps in the Archival and Archaeological Record

Location	Width	Length	Height	Channel #	Volume	Source
Jones Sites, Delaware	13 ft	15 ft	unknown	unknown	unknown	
Lower	18 ft.	23 1/2 ft.	5 – 6 ft.	~ 8	unknown	Heite 1973

Table 8-16: Dimensions of Brick Clamps in the Archival and Archaeological Record

Location	Width	Length	Height	Channel #	Volume	Source
Westover, Virginia						
Drewry Point, Virginia	12 ft.	27 ft.	unknown	unknown	unknown	Heite 1973
Williamsburg	10 ft.	12 ft.	unknown	unknown	unknown	Weldon 1990:19
	11 1/2 ft.	12 ft.	unknown	3	unknown	Colonial Williamsburg Foundation 2000a
John Jay House, New York	12 ft.	15 ft.	10-12 ft.	2	unknown	Feister and Sopko 1996:54
Williamsburg	19 1/2 ft.	24 1/2 ft.	12 – 15 ft.	5	~50,000	Harrington 1950:23
Virginia	20 ft.	50 - 100 ft.	unknown	unknown	20,000	Glessner 1989; Heite 1973:48
Kentucky	unknown	unknown	unknown	Unknown, large arches	25,000 – 30,000	Hockensmith 1997:115
Lower Westover, Virginia	18 1/2 ft.	62 ft.	unknown	unknown	unknown	Heite 1973
Kentucky	unknown	unknown	unknown	3	unknown	Hockensmith 1997:115
Illinois	unknown	unknown	unknown	5	unknown	Griffin 1952:figure 186
Williamsburg	10 – 12 ft.	16 ft.	9 ft.	4	12,500	Weldon 1990:23
Liberty Hall, Virginia	16 ft.	22 ft.	unknown	4	unknown	Russ and McDaniel 1991
England	18 ft.	29 1/2 ft.	unknown	5	30,000 – 45,000	Proctor et al. 2000:189
Marshall	21 ft.	24 ft.	unknown	7	unknown	Smith 1986

Table 8-16: Dimensions of Brick Clamps in the Archival and Archaeological Record

Location	Width	Length	Height	Channel #	Volume	Source
County, Tennessee						
Kentucky	~ 24 ft.	~ 66 ft.	unknown	~ 16	unknown	Wingfield et al. 1997
Monticello, Virginia	~12 ft.	95 ft.	~9 to 12 ft	36	103,000	Weldon 1990:19-23
Carter's Grove, Virginia	unknown	289 ft.	unknown	unknown	unknown	Weldon 1990:19
England	unknown	unknown	unknown	unknown	150,000	Proctor et al. 2000:189
Charles County, Maryland, Clamp 1	13 ft.	10 ft.	unknown	3	unknown	Balicki et al. 2004
Charles County, Maryland, Clamp 2	16 ft.	13 ft.	Unknown	4	unknown	Balicki et al. 2004

Once the length and width of a clamp is determined, the researcher can compute a rough estimate of the number of bricks from a single firing. Green brick could only be stacked to a certain height before they began to crush under their own weight, usually around 8 to 12 ft. high. Using this knowledge, Harrington (1950:25) computed the area of the depression, minus the topsoil, to predict how many bricks could have been manufactured from the quarried area from a site in Williamsburg. As many as 20,000 bricks could have been put in a small kiln or clamp such as the one at the Jones site, spaced the width of a finger apart to allow for updraft (Colonial Williamsburg Foundation 2000b:2).

How long it would take to build and fire a clamp depended on many things, including the soil matrix, the speed of the brick makers, the weather and other site conditions. Stiff clays took more time to mine, soften, dry and fire than sandy loams. A mid-19th century account stated that a good brick maker with no machinery could produce 10,000 bricks a week (Feister and Sopko 1996:51). A good brick molder during the 1990s in northern Mexico could produce as many as 1,300 bricks in four hours. Therefore, he could single handedly produce enough bricks to complete a firing load for a small clamp or kiln in 80 to 100 hours (Hockensmith 1997:114). Green bricks needed to dry for at least a week, if

not longer (Feister and Sopko 1996:53-54). The firing of a small clamp, like the one at the Jones site, would have taken approximately 5 days, and would have needed to be tended 24 hours a day once the fire was lit, in order to keep adding fuel and maintain a constant temperature (Colonial Williamsburg Foundation 2005, 2006).

Huge clamps are mentioned in the archival record. Thomas Jefferson described a kiln/clamp on his property that contained 36 eyes (fire channels) and 103,000 bricks in a single firing, which produced 90,000 decent bricks and 13,000 unfit for use (Weldon 1990:19-23). Carter Grove Plantation may have contained a clamp that measured 289 ft. long, which could have held a staggering 300,000 bricks (Weldon 1990:19). Both of these large clamps may have actually been fired over a period of time with one section of the clamp firing while another section was cooling and another section perhaps being prepared. Otherwise, it is hard to imagine that a brick maker would have risked the labor behind so many bricks in the open air with concerns for the weather for such a long period of time before firing. Furthermore, the firing of such a huge clamp at one time would have been difficult to constantly fuel and maintain.

Searle (1911:66) states that while not always needed, a drying or storage shed was very convenient for the brick maker and the production process. Searle (1911:66) also stated that the ground between the hack area (drying shed) and the clamp should be slightly lower at the clamp end of the location to allow for a little less effort in hack barrowing the bricks from the shed to the clamp. The six posthole features for a possible drying canopy/shed area on the Jones Site were slightly higher in elevation, about 10 to 12 cm, above the elevation of the brick clamp heat signature.

Infrequently, clamps were protected from the wind to control the heat by a wooden roof, although the danger of burning the roof from that process must have been relatively high (Feister and Sopko 1996:63). Sometimes, the clamp was built within the drying canopy or shed, such as the recreated kiln/clamp at Williamsburg. No evidence of such a shelter for the clamp itself was recorded on the Jones Site. For greater stacking stability, the area under the stack was often “saucered” or scooped out to almost 30 cm to let the sides of the clamp slope inward towards the center, resulting in fewer fire cracks (Jones 2001:2). Even if constructed and operated correctly, a brick clamp was still an inefficient method of producing brick, since up to 20% of the finished bricks might be under or over-fired and unusable for construction (Jones 2001:5).

Location

Clamps were usually located close to the structure being built from the brick (Feister and Sopko 1996). Glessner (1987:2) states most owners of a historic brick house can point to the location on their property where the bricks were made for their dwelling. Many structures were built directly upon the area where the clamp was fired, such as at Chuckatuck, Virginia (personal communication with Ned Heite, July 2003). For example, the church at Chuckatuck was built directly over the clamp. However, apparently clamps could be some distance away from the intended construction site without any evidence of a related structure found at all, such as the Jones Site and two

brick clamps recently excavated by JMA in Hughesville, Charles County Maryland (Heite 1970:43;Balicki et al 2004).

Because the remains of a clamp could be easily confused with the old foundation of a building, a clamp could be labeled as a structure on historic maps, and in particularly, the remains of a clamp could be classified as a structure, especially when associated with 17th to 18th century sites (Custer 1989:339). Clamps built close to the structure and the yard area may be masked by domestic artifact scatters as "noise" masking the actual function of the brick making facility.

Many times, clamps are hard to define or locate, even though the brick artifacts found suggest the nearby location of a clamp. Custer (1989:339) originally identified a 19th century brick clamp impacting a Contact period site in northern New Castle County, Delaware (Custer and Watson 1985:99). The lack of information recorded on that site, as in many other clamp related reports, limits further comparisons. Heite (1998:36) reported reject bricks from the Nathan Williams House Site west of Delaware State College in Dover that could have been from a nearby clamp, but the clamp was never found. The Cheshire Site in Iowa was originally defined as an unknown residence not marked on local atlases until the brick was analyzed and it was found to be the probable location of a clamp or kiln, yet no heat signature was found (Finney and Snow 1991:70).

Investigations at the Brickyard Lot at the John Jay House in New York found the procurement pits and waster brick piles, but did not locate the clamp site (Feister and Sopko 1996:66). The location of the procurement or mining pits, however, can yield positive information about the brick maker's strategy for site location. Harrington (1950:21-22) excavated a late 17th century kiln next to a marsh, with a clay procurement pit measuring 130 ft x 90 ft impacting the marsh that also contained a well for water. The pit extended approximately 40 ft into the marsh and then another 80 ft from the edge of the marsh to the edge of the kiln, where several arches of the fuel channels were identified.

Digging Brick Clamps

The archaeological community has only relatively recently embraced the excavation of brick clamps as a viable research domain (Proctor et al. 2000:195). Prior to the 1990s, brick clamps were excavated primarily to identify nearby structures or to relate that the bricks in a nearby structure was locally manufactured. Currently, archaeomagnetic dating techniques are being used to provide accurate firing dates on these feature types when usually few, if any, temporal artifacts are recovered. Investigations are now delving into the firing process and the techniques used to build and operate the clamp rather than concentrating on relating the clamp to the structures or edifice built with the bricks.

Brick clamps are usually not considered an "exciting" feature within the archaeological community, similar to the feelings of many field archaeologists on conducting window pane glass studies, or shell midden analysis. The high-fired bricks and whole bricks were

usually completely removed from the premises and used for construction. Fragments of high-fired bricks, over-glazed brick, and a heat signature are predominately all the features and artifacts present in the archaeological record on a clamp site. Clamps also may not contain many non-brick artifacts, as the activities around a clamp, if any significant distance from the yard or structure, would only have nails for molds and a few occasional domestic artifacts perhaps dropped by the artisans or the procurement pit being used as a trash dump.

An exception to this rule can be found among the researchers at Colonial Williamsburg who recreated the entire process of hand molded bricks (Weldon 1990). Not only did the research encompass the amount of sand in the material, but also the drying time, size, and preparation time, and most interestingly, the actual firing of the clamp. Weldon (1990:24-29). Eight thermocouples were placed within the recreated clamp to retrieve specific information about heat transfer throughout the firing process. The Williamsburg clamp was fired to a maximum temperature of 2000^0F, attained at the top of the feature, but the base temperatures apparently never exceeded 500^0F to 1000^0F. By closing off the fire channels on one side, the temperature on the closed off side increased dramatically after a few hours (Weldon 1990:28-29). The firing took place for 64 hours before the clamp started to cool.

Fire channels can usually, but not always, be identified in the archaeological record by alternating bands of heat altered earth in planview. However, given that the objective of the clamp was to fire the brick uniformly throughout, evidence of fire channels would be unlikely to be observed in the archaeological record if the firing had worked efficiently (Firman 2000). The highest fired portion of the fire channel will produce a bright orange zone in the subsoil, usually in a linear pattern following the extent of the channel. This zone can have a chalky, powdery texture as it has been fired so hot that it may not be cohesive. Under the bright orange zone is usually found a dark grey brown to black zone, ranging from 1/2 inch to several inches, representing a heat altered area, but not as intense as the bright orange portion directly adjacent to the fire source. The alteration of the subsoil into a darker matrix in this zone is thought to be the result of a low oxidation environment. In some instances, another heated zone will occur beyond the darker low oxidation zone, usually identified as a dark reddish zone, still indicating intense heat, but at a lower temperature range than the other two described zones.

The heat signature holds the key to understanding the clamp construction. Heite had originally speculated the Jones Site clamp could possibly be a downdraft kiln based on the clear lack of linear fire channel heat signatures (personal communication April 2000). Downdraft kilns were circular features with vertical flues to the top and bouncing the air off a domed roof forced down through the gaps in the brick and recirculated (Diehl et al. 1996:14). Downdraft kilns were more efficient than updraft kilns because the air can evenly reach more of the bricks in a given firing (Diehl et al. 1996:14). A 45 ft wide, circular downdraft kiln was excavated in Tucson, Arizona, and contained a ring of brick with channels for the air drafts (Diehl et al. 1996:55-57). Even though the heat signature from the Jones Site clamp was rounded, no circular structural or feature evidence exists that suggests it was a downdraft kiln.

A brick clamp in Kentucky had a bright orange heat signature extending several inches into the ground surface with a u-shaped profile present only directly under the fire channel (Wingfield et al. 1997). The Kentucky brick clamp had a thin, dark brown to black, low oxidation zone under the bright orange heat signature of the fire channels. The low oxidation zone also extended under the bottom course of the archway walls between the fire channels, indicating that intense heat had penetrated through the bricks of the fire wall into the subsoil below. In planview, the Kentucky clamp did not readily reveal the existence of fire channels solely based on the presence of linear heat signatures. The southeast portion of the Kentucky clamp had a baked-clay floor that transcended across the fire channels and the base of the archways (Figure 8-14). In other words, heat had penetrated beyond the depth of the base of the archways, rather than the archways acting completely as an insulator that would only allow the heat to penetrate the subsoil directly under the fire channels.

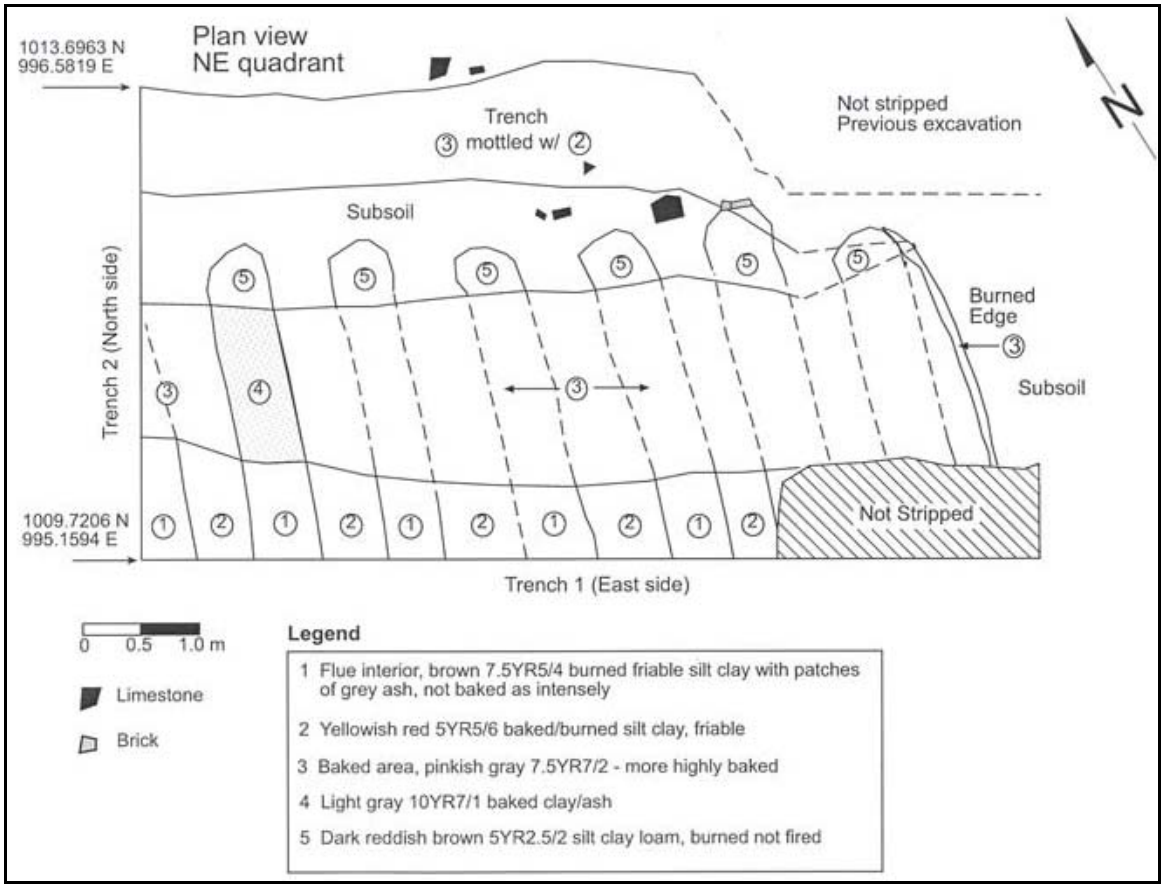

Figure 8-14: The Baked Clay Floor (Zone 3) at the Kentucky Brick Clamp (Wingfield et al. 1997).

A baked-clay clamp floor was also observed at both the Zimmerle clamp in Tennessee and the Liberty Hall clamp in Virginia (Wingfield et al. 1997). The baked-clay floor extended across the base of the feature regardless of the presence of the archways and

fire channels indicating the bottom of the arch walls conducted enough heat to fire the area beneath them. Similarly, the bright orange heat signature in the fire channels of two Charles County, Maryland clamps extended deeper into the subsoil that the area under the fire channel walls, but there was only a subtle difference (Balicki et al. 2004:95). Under the bright orange zone was, again, a baked floor area, similar to the Zimmerle and Liberty Hall features described above, and an approximately 6-inch thick reddish zone extended beyond the limits of the dark grey brown low oxidation zone under the bright orange zone on the Charles County clamps (Figure 8-15). In profile, the heat signature of the three heat zones was deeper directly under the fire channels. The bright orange zone, however, was not present directly under the archways. The low oxidation zone and the outer reddish zone were present between the archway walls in equal thickness to the area under the fire channels.

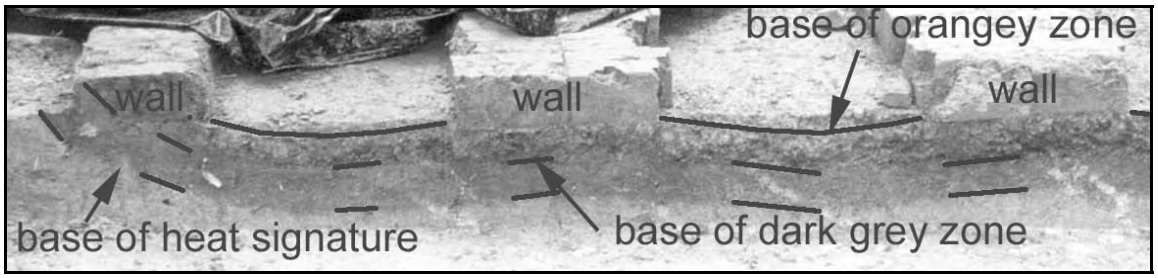

Figure 8-15: Profile of one of the Charles County, Maryland Clamps.

Research into brick clamps also focuses on the brick artifacts associated with this feature type. Research has indicated that multiple glazed surfaces on a brick could indicate a brick that was not intentionally glazed, as an intentionally glazed brick would have only been glazed on a single surface (Wingfield et al. 1997). If non-intentionally glazed bricks are present on an archaeological site, it could represent evidence of a nearby brick clamp.

Research into kiln and clamp-related archaeological reports indicated that field observations regarding clamp heat signatures have usually been surficial with limited information on profiles. Additional detailed observations of kiln and clamp heat signatures are needed to address research issues relating to questions of multiple firings, length of firing, intensity of heat, and placement of fire channels.

8.3.2 Brick Chemical Analysis

Given that the features in Area A of the Jones site appear to relate to an episode of brick making, the question arose about whether the bricks found on site were made on site with soils excavated there. To approach this question, seventeen samples of brick and soil from the Jones Site were sent to England for chemical analysis by Dr. Nick Walsh at the University of London (Table 8-17). Dr. Walsh utilized inductively-coupled plasma emission spectroscopy (ICP) for the analysis (see Chapter 5.0 Methodology). Eight samples of brick were chosen from four locations. Nine soil samples originated in three locations. Information on the amount of 21 different chemical elements and 9 oxygen

compounds (oxides) was obtained (Table 8-18). The raw data from this analysis is provided in tabular form in Appendix E.

Table 8-17. Location of Origin and Type of Sample Sent for Chemical Analysis

Sample No	Material Type	Bag No	Location
1	brick	506	Feature 268 barrel well (N134 E610, barrel #3, Str. I)
2	soil	5831 (1 of 3)	Under Feature 4 (N269 E574, Str. II, Lv. 1)
3	soil	5831 (2 of 3)	Under Feature 4 (N269 E574, Str. II, Lv. 1)
4	soil	5831 (3 of 3)	Under Feature 4 (Unit N269 E574, Str. II, Lv. 1)
5	brick	254-13	Feature 156 brick-lined well (N137.86 E587.22, Str. I, Lv. 1, north half)
6	brick	257-20	Feature 156 brick-lined well (N137.86 E587.22, Str. III)
7	brick	338-2	Feature 125 mold by brick clamp (N284.19 E572.69, Str. I, Lv. 1, north half)
8	brick	339-3	Feature 125 mold by brick clamp (N284.19 E572.69, Str. I, Lv. 1, south half)
9	brick	331-6	Feature 4 mixing pit (N274 E571, Str. I, Lv. 1)
10	soil	5835 (1 of 3)	Gleyed Soil (N123 E580, Str. I, Lv. 1)
11	soil	5835 (2 of 3)	Gleyed Soil (N123 E580, Str. I, Lv. 1)
12	soil	5835 (3 of 3)	Gleyed Soil (N123 E580, Str. I, Lv. 1)
13	soil	5833 (1 of 3)	Near posts by brick clamp (N287 E569, Str. I, Lv. 1)
14	soil	5833 (2 of 3)	Near posts by brick clamp (N287 E569, Str. I, Lv. 1)
15	soil	5833 (3 of 3)	Near posts by brick clamp (N287 E569, Str. I, Lv. 1)
16	brick	506	Feature 268 barrel well (N134 E610, barrel #3, Str. I)
17	brick	331-8	Feature 4 mixing pit (N274 E571, Str. I, Lv. 1)

Table 8-18. Elements and Oxides included in the Brick Chemistry Analysis

Element or Oxide	Chemical Designation
Aluminum Oxide	Al_2O_3
Barium	Ba
Calcium Oxide	CaO
Cerium	Ce
Chromium	Cr
Cobalt	Co
Copper	Cu
Dysprosium	Dy

Table 8-18. Elements and Oxides included in the Brick Chemistry Analysis

Element or Oxide	Chemical Designation
Europium	Eu
Iron Oxide	Fe_2O_3
Lanthanum	La
Lead	Pb
Lithium	Li
Magnesium Oxide	MgO
Manganese Oxide	MnO
Neodymium	Nd
Nickel	Ni
Phosphorus Oxide	P_2O_5
Potassium Oxide	K_2O
Rubidium	Rb
Samarium	Sm
Scandium	Sc
Sodium Oxide	Na_2O
Strontium	Sr
Titanium Oxide	TiO_2
Vanadium	V
Ytterbium	Yb
Yttrium	Y
Zinc	Zn
Zirconium	Zr

Chemical oxides found in clay bricks usually include: silica (SiO_2), alumina (Al_2O_3), iron (Fe_2O_3) or ferrous oxide (Fe_3O_4), potassium oxide (K_2O), titanium oxide (TiO_2), sodium oxide (Na_2O), calcium oxide (CaO), and magnesium oxide (MgO). Silica and alumina are the most common constituents of clay bricks, frequently accounting for approximately 50% of the constituents for SiO_2 and 15-20% for Al_2O_3. Common chemical elements in clay bricks include: barium (Ba), zirconium (Zr), strontium (Sr), rubidium (Rb), and manganese (Mn) (Dan and Přikryl 2010).

We chose hierarchical cluster analysis as the best statistical tool to find out how chemically similar or different the samples were from each other. Cluster analysis is a means of detecting natural groupings in multivariate data. Once can then display the results as a tree diagram that shows how similar or dissimilar the cases are from each other. Because the data were recorded in different units (% for the oxides, ppm for the elements) and because the scale of the results were so different (ranging from 400 to 864 ppm for Ba and from 0.03 to 0.07% for MnO), it was important to standardize the data first. This was done by calculating the standard deviation on each of the chemical variables. Following this standardization of the data, we performed the cluster analysis using the Pearson correlation measure using the single linkage method. The Pearson measure is less susceptible to differences in scale than some other methods (Wilkinson 1990). The results are shown in Figure 8-16.

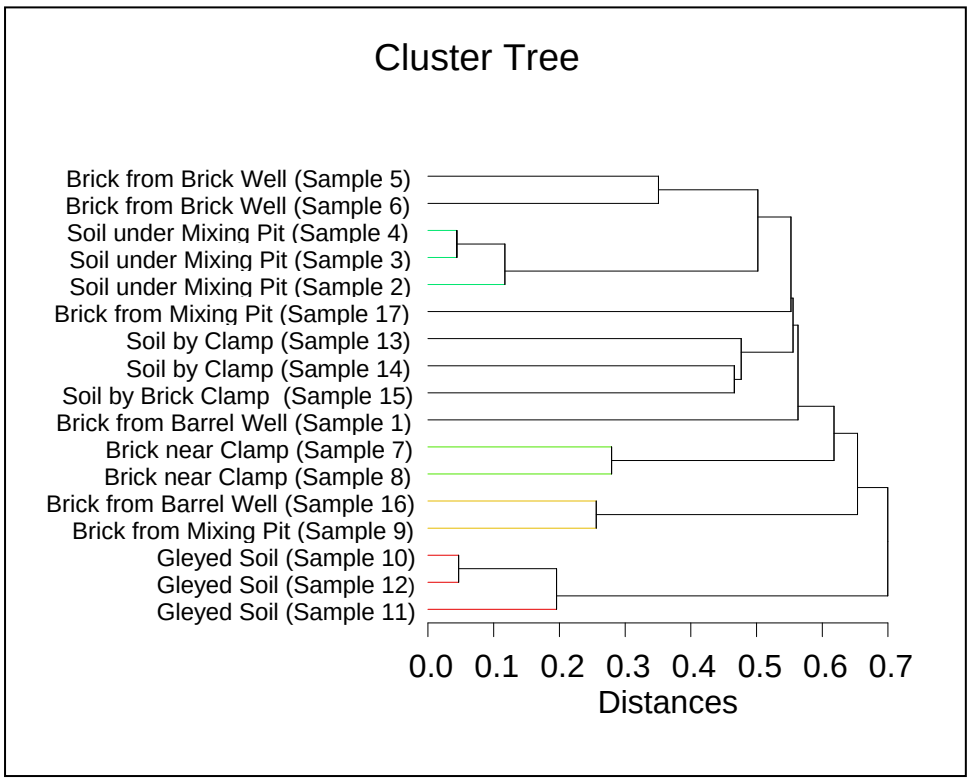

Figure 8-16: Cluster analysis of brick chemistry results

Figure 8-16 shows that the most closely related samples are 4 with 3 (mixing pit soil samples) and 10 with 12 (gleyed soil samples) for example. The samples least like any of the others are not surprisingly the gleyed soil samples (10, 11, and 12). The graph also shows that the soil samples under the possible mixing pit feature group together closely, as do some of the brick samples. Beyond that, the results are rather inconclusive on the whole. The sample of bricks from the brick-lined well appear to have been machine made, which means that they were made later than the bricks from the brick clamp, and almost certainly from clays off site. Yet they are chemically as close a match to the site soils as the brick samples taken from the barrel well or from the vicinity of the brick clamp. For that reason, we can't use these results to say for certain whether or not clays from the site were used to make the bricks or not, apart from the gleyed soils from the wetland area, which clearly were not used.

This really shouldn't be surprising however, given that we don't know specifically how clay for bricks made on the site was processed. Once collected, the clay would have been processed presumably to remove some impurities. Other material, such as sand, could have been added to improve the clay's characteristics. Either of those activities would alter the chemical composition of the resulting bricks. The fact that the brick samples from the site appear to be chemically heterogeneous may be an indication of variability in clays used or inconsistencies in processing. A larger sample of bricks would be needed to confirm this, but it might provide an interesting archaeological means of analyzing consistency in clay processing methods used in hand-made bricks.

Several interpretations can be made from this chemical analysis of brick and soil samples:

- The brick and clay samples collected are heterogeneous.
- The brick samples collected from the site are no more or less likely to have been made with clays on site than later machine-made bricks presumably made off site.
- None of the brick samples were a close match in chemical composition to the gleyed, wetland soils analyzed.

8.4 WELLS

8.4.1 Well Construction

Wells are common features of the rural landscape in Delaware, and a number have been found and excavated during archaeological projects. Data on wells from selected rural archaeological sites in Delaware and Virginia has been provided in tabular form (Table 8-19) and will be summarized below. The comparison below will focus on apparent construction technique rather than their artifact contents. Rural wells tend to differ from those in an urban setting in that urban privies and wells often contain more refuse and artifacts than their rural counterparts (Holland 1990). Proximity to the house is one factor, but on the farm, trash disposal was completely dependent on the farmer, as he could dump the trash anywhere on the property.

The Moore-Taylor Farm Site in northern Kent County, just a few miles southeast of Smyrna near Leipsic, contained two barrel wells (Grettler et al. 1996:48-71). Feature 273, an early to mid-19th-century well, had two large barrels stacked upon each other, with the upper one resting outside the upper lip of the lower barrel. Flat planks were used as shims to form a collar around the exterior two barrels at their juncture. It was not stated if the planks had been attached to the barrels or were loosely placed within the narrow builder's pit. Some of the staves were marked with Roman numerals and the wooden hoops were attached to the staves with both cut nails and wooden pegs.

A nearby well at the Moore-Taylor Farm Site, Feature 274, also dated to the first half of the 19th century and had a 5 foot wide unlined shaft with 5ft deep straight sides that tapered down to 2ft diameter. The base was lined with two to three ft. of vertical wood planks that were toe-nailed together (Grettler et al. 1996:52-53).

The well diggers for the barrel well (Feature 82) at the John Darrach Store Site near Smyrna had stacked two barrels, one on top of another, and filled the construction pit with a very dark grayish brown organic fill (De Cunzo et al. 1992:115). Two or possibly three additional barrels would have sat atop the surviving ones, if the well's entire depth was barrel-lined. Backhoe excavation was stopped at 12 in. below subsoil due to rising water issues (Figure 8-17). The sand which filled in the barrel well was apparently brought in from off-site, and was similar to that seen filling another well at the site. Soil

samples were obtained from the barrel well fill. The construction pit for the well may have been disturbed due to the decay of the barrels with mixing in of artifacts from the well fill. However, the artifacts from this disturbed context hinted at a post-1780-to-1790 deposition date due to shell-edged pearlware and cut nails (De Cunzo et al. 1992:117-120).

Figure 8-17. Barrel well at the John Darrach Store Site Feature 82 (De Cunzo et al. 1992)

Another well at the John Darrach Store Site was lined with both barrels and bricks (Feature 99, De Cunzo et al. 1992:121). The preserved barrel staves were encountered at 10.5 ft. below subsoil and were still present at a depth of 14 ft. Beneath this point, the rising water table prevented further backhoe excavation. Below a depth of 7 ft., a brick lining had been laid inside of the stacked barrels. The dry-laid bricks were stretchers laid end-to-end in a single width stack. The column was very unstable, and the builders left a space of a few inches between each brick, staggering the courses to span the gaps. The interior diameter of the well shaft, within the brick lining, was 3 ft. Brick rubble with mortar attached within the well's fill, matching some noted in the store's cellar, suggested that the well remained open until the mid-1860s when the store was demolished. Soil samples for chemical analysis were taken from the well shaft fill.

Loose sands and loam have always provided problems for well construction (Swindell 1860:31). Swindell (1860:32-36) explained that, many times, iron cylinders were needed to line the well shaft and then bricks were lined on the inside, a process sometimes referred to as "steining". The earth would be excavated from inside the shaft as the cylinder sank. The cylinder approach was similar to what apparently occurred in Feature 156, the brick-lined well at the Jones Site. In the case of Feature 156, a wooden slat-lined caisson with two wooden collars at the base to stand on was placed in the shaft probably at a depth when the water table was encountered around 80-100 cm below the former ground surface.

The bricks at the Jones brick-lined well were dry laid in an alternately breaking joint coursework, or rather, a non-radiating pattern. The bricks were placed perpendicular to the center of the well. According to Swindell (1860:34), that patterning was stronger than a radiating pattern. Many times the gaps behind the brick would be filled with chinking or concrete, but the gaps behind the bricks of Feature 156 were empty and bare. It is possible that wood may have been used, and had since rotted away. The nature of the ground and practicability of excavation usually determined the depth of the well (Swindell 1860:34).

The Jones brick-lined well is very similar to a well from the Thomas Williams Site, near Glasgow, New Castle County (Catts and Custer 1990:118-124). Dry-coursed brick was laid on two hand-planed wooden rings, nailed to eight barrel staves, forming a 4 foot hole. A higher percentage of nails from this well were wire nails, but the report does not relate if the nails holding the wooden ring in place were machine cut or wire nails, which would tighten the date of construction. As was Feature 157, the upper two ft. of the Thomas Williams Site well had slumped or collapsed into the center of the feature, probably where the old water table resided.

Similarly, a 3-foot wide 8 foot deep, brick lined well was excavated at the A. Temple Hill Site, in Ogletown, New Castle County (Hoseth et al. 1990:123-128). The wooden staves were encountered two ft. above the water table, and determined to be white pine. These staves were nailed with cut nails to two layers of a wooden ring, no wire nails were apparently recovered from this well. The A. Temple Hill well had also been periodically cleaned out by the tenants in the early 20th century.

The similarities between the Jones brick-lined well (Feature 156) and the other two described wells from north-central New Castle County, suggest literature, basic knowledge, or professional artisans for well construction were available to the local land owners in the mid-to late 19th century.

Table 8-19. Selected Rural Wells in the Delmarva.

Site	State	Feature	Type	Depth	Diameter	Builder's Trench	Brick	Wood/Barrel	Date	Citation
Moore Taylor Farm	DE	2	2 barrel	9.5 ft.		Yes		Vertical wood plank cribbing	1827-1874*	Grettler et al. 1996
		90	Brick lined	11.5 ft.	3.5 ft.	Yes	Dry laid, machine made brick	Vertical wood plank cribbing in lower level	1862-1909*	
		273	2-Barrel	8.5 ft.		Yes			1811-1844*	
		274	Unlined	9.6 ft.	5.1 ft.	No		bottom 2 ft. lined with 12 vertical oak plank cribbing	1814-1860*	
		285	unlined	11.5 ft.	5.3 ft.	No			1842-1909*	
Benjamin Wynn Tenancy	DE	80	1 barrel	6.7 ft.		Yes		Four post vertical cribbing	1749-1821*	Grettler et al. 1996
		94	1 barrel	11.1 ft.	2 x 2 foot square	Yes		Four post vertical cribbing	1759-1809*	
Wilson-Lewis Farm	DE	123	1 barrel	3.0 ft. (excavated)	5 ft.	Yes		Barrel on one half of well	1855-1882*	Grettler et al. 1996
		127	1 barrel	3.0 ft. (excavated)	5.2 ft.	Yes			1842-1889*	
John Darrach Store	DE	2/51	Brick lined	14 ft.	3.3 ft.	No	Fine gray clay mortar; handmade irregular poorly fired brick; header style configuration	Brick robber's excavation	1814.40 (robber) 1840.56 (well)	De Cunzo et al. 1992
		82	2 Barrel	12 ft.	5 ft.	Yes			1830-	

Table 8-19. Selected Rural Wells in the Delmarva.

Site	State	Feature	Type	Depth	Diameter	Builder's Trench	Brick	Wood/Barrel	Date	Citation
									1875	
		99	Brick and Barrel lined	14 ft.	5 ft.		Dry laid; Stretcher style configuration	Stacked barrels outside of brick lining at bottom	1826.27	
Richard Whitehart Plantation	DE	C495	Unlined	12.8 ft.	8-8.4 ft.	No			End ca. 1701	Grettler et al. 1995
John Powell Plantation	DE	H39	Wood lined	21 ft.	10 ft.	yes		Two sets of cribbing; upper cribbing was four timbers forming a 2 foot square shaft; bottom cribbing was also four timbers; both mortise and tenon with cross pieces	1720.2*	Grettler et al. 1995
William Strickland Plantation	DE	93	Brick lined	>20 ft.	12x 14 ft.	yes			1730*	Catts et al. 1995
		108	Unlined	>20 ft.	12 ft.	yes			1734*	
Thomas Williams Site	DE	2	Brick and barrel lined	13.82 ft.	12 ft.	no	Dry laid brick; some evidence of mortar	Barrel outside brick lining at bottom; square wooden pump stock at bottom	1810*	Catts and Custer 1990
A. Temple Site	DE	28	Brick and	8 ft.	4 ft. at top;		Some mortar present in photo;	White pine wood basal ring	1849 ?	Hoseth et al. 1990

Table 8-19. Selected Rural Wells in the Delmarva.

Site	State	Feature	Type	Depth	Diameter	Builder's Trench	Brick	Wood/Barrel	Date	Citation
			barrel/ wood lined		3 ft. at bottom		stretcher configuration	at base of well; barrel outside brick at bottom		
Heiser Tenancy Site	DE	8	Brick lined	>20 ft.	3.5 ft.		Dry laid; machine made bricks; stretcher configuration		1850-1968	Catts et al. 1989
Whitten Road Site	DE	17	Wood lined	>14 ft.	7.5 ft.	Yes		Rectangular wood box lining (outer cribbing- 4 ft. square); inner horizontal cribbing with four posts; wooden pump stock made of sweetgum	1790.8*	Shaffer et al. 1988
Buchanan-Savin Farmstead	DE	171		.5 ft.	5 ft.				1860	Scholl et al. 1994
Buckson Site	DE		Brick Lined	15 ft.	3 ft.		Dry laid brick; mortar associated with top four courses; stretcher configuration		1859-1989	Bupp et al. 2003
Harrop Plantation	VA		Brick Lined	38.5 ft.	4 ft.		Unmortared rectangular brick chinked with brick fragments; wedge shaped brick (compass brick);		1640-1700	Kelso 1984

Table 8-19. Selected Rural Wells in the Delmarva.

Site	State	Feature	Type	Depth	Diameter	Builder's Trench	Brick	Wood/Barrel	Date	Citation
							robbed			
Pettus Plantation	VA		Brick lined	44 ft.		yes	Wedge shaped brick	Wooden curb ring	1640-1700	Kelso 1984
Bray's Littletown Plantation	VA		Brick lined	55 ft.	7 ft.		Brick lined vault 18 ft. down	Wooden curb ring	1700-1781	Kelso 1984
Utopia	VA		Brick lined	67 ft.	5 ft.				1640-1700	Kelso 1984
Burwell's Landing	VA		Brick and barrel Lined	34 ft.			Rectangular bricks to 17 ft.; wedge shaped bricks to 32 ft.;	Wood barrel below 32 ft.; circular wood ring at bottom	1728-1790	Kelso 1984
Burwell's Kingsmill Plantation	VA	Kitchen well	Brick lined	48 ft. 5 in.	5 ft. 4 in.	yes	Rectangular shell mortared brick and brickbats in top 10 ft.; wedge shaped bricks below; robbed		1728-1790	Kelso 1984
		Garden well	Brick lined							
Jones	DE	156	Brick and wood lined	9 ft. 10 in.	5 ft.	yes	Dry laid brick; machine made bricks; stretcher configuration			Versar 2011 (this report)
		268	3 Barrel	9 ft. 10 in.	3 ft.	yes				Versar 2011 (this report)

* mean ceramic date

8.4.2 Jones Site Wells and the Landscape

Catts et al. (1995:104-105) found two wells on a mid-eighteenth century farmstead, and determined that the wells, trash pits, and fence lines, were usually within 40 ft. of the main house or outbuildings (Catts and Bachman 1987:45-47; Catts et al. 1989:227, 241-244). Of course, the reverse isn't necessarily true: there may, or may not, be a house within 40 ft. of a well. Unlike most of the comparable wells uncovered in archaeological excavations in Delaware, the barrel well (Feature 268) and the brick-lined well (Feature 156) at the Jones Site do not appear to be situated within the vicinity of a domestic residence.

Both of the Jones Site wells were found in the southern portion of the site, near the junction of two soil types: the Sassafras sandy loam (SaB2) on the north and the Fallsington loam (Fs) to the south. The Fallsington loam typically has a high water table, and the marshland immediately to the south of the site is within this soil type. The presence of the wetlands nearby would have alerted the well-diggers that they would be successful in reaching the water table fairly easily in this location.

The barrel well at the Jones Site appears to date from the late 18th century and may be related to the brick clamp operations nearby. As an example of this sort of arrangement, an informal well shaft with no lining was uncovered in archaeological investigations at Jamestown, Virginia, located immediately outside the boundary of a clay borrow pit. The circular well shaft was almost 5 ft. deep and was at the edge of a marsh. This borrow pit was adjacent to a brick clamp, thought to have been utilized for firing bricks for buildings at Jamestown in the 17th century (Harrington 1950:25). The estimated 850 cubic yards of earth removed from this borrow pit would have produced enough clay to fire approximately 500,000 bricks Water was typically added to prepare the dried, pulverized clay for the brick molding process, and this well was hypothesized to be associated with this tempering process.

After George Davis consolidated the small farm by 1860 into one tripled in size (over 300 acres) with two tenant houses, the brick-lined well may have been a secondary well due to its distance relatively far from either tenant house. The brick-lined well may be associated with the fence lines that may have enclosed livestock pastures or paddocks. This well may have provided drinking water for the animals' water troughs within its fenced boundary, and/or for farm workers who would have been inconveniently far from the main farm complex. Additional examples of such wells appear to be rare in Delaware archaeological reports, but this could be due to several biases. The main residential or main tenant houses on properties tend to be the focus of archaeological studies. Perhaps if these outlier wells are encountered without accompanying features, they tend to be disregarded as sites or are not investigated beyond the survey and identification stage.

8.5 RURAL LANDSCAPES AND LAND UTILIZATION

8.5.1 Soil Chemistry and Ephemeral Occupations

The artifact assemblage and features we found at the Jones site together suggest that this was the working area of a farm, and not an area the tenants or farm workers used for habitation. In settings like this, soil analysis can provide some clews about the specific kinds of farm work that may have happened here.

The analysis of soil chemistry for evidence of trace elements and fluctuations in properties, such as pH, has become an increasingly utilized tool to help define and identify activity areas at archaeological sites. Over time, human behaviors alter the physical environment in various ways and to differing degrees, for example land clearing, wood burning, and crop cultivation. Often these physical changes are visually identifiable for extended periods, or discernible through examination of re-growth vegetation and altered landscapes. However, at other times past human interaction with the environment may be masked by natural changes to the landscape, or human reuse for different purposes, whereby study of the soil chemistry may be the only tool available for identifying past human activities. The practice of soil chemistry analysis has become more widespread and can highlight general activities that may not be available in the artifact and/or feature data from an archaeological site.

8.5.2 Background on Soil Chemistry Analyses

A review of Delaware archaeological site reports revealed that five characteristics are most commonly tested for on historical archaeological sites: soil pH factor and the relative frequency of potassium (K), phosphorus (P), calcium (Ca), and magnesium (Mg). Several sites were consulted and summarized to provide a baseline of soil chemical attributes to compare with the results from the Jones Site and included: the Wilson-Slack Site (Custer et al. 1986); the Thomas Williams Site (Catts and Custer 1990); the A. Temple Site (Hoseth et al. 1990); the John Darrach Store Site (De Cunzo et al. 1992); the Buchanan-Savin Farmstead (Scholl et al. 1994); the William Strickland Plantation Site (Catts et al. 1995); the Moore-Taylor, Benjamin Wynn, and Wilson-Lewis Farmsteads (Grettler et al. 1996); the Richard Whitehart and John Powell Plantations (Grettler et al. 1995); the Bloomsbury Site (Heite abd Blume 1998). These five soil characteristics may provide insight into a range of activities occurring on many historical sites.

The Wilson-Slack site was a 19th-century farmstead and blacksmith complex located in northern Delaware (Custer et al. 1986). It contained three extant structures and informant interviews and documentary research identified several activity areas. Soil chemistry analysis was undertaken to observe the correlation between known activity areas and specific soil chemical signatures. The results of the analysis were mixed: calcium and magnesium showed similar tendencies with each other, but did not correlate to the known activity areas or structures; potassium and phosphorous were not correlated with animal penning areas as expected, but did correlate with the blacksmithing area; and the soil pH factor exhibited fluctuations associated with organic-rich midden deposits. The results,

although somewhat unexpected, provided a starting point by comparing the known activity areas with the resultant soil chemical signatures.

The Thomas Williams Site (7NC-D-130) was a prehistoric and historic site near Glasgow (Catts and Custer 1990). Over 200 historic features were uncovered, including two root cellars, a stone-lined cellar hole, a brick-lined well, privy pits, and postholes dating from the late 18th through 20th centuries. The property was occupied by a tenant farmer (1792-1846), stone mason (1846-1875), and an African-American laborer (1887-1920s). Soils information combined with artifact data was used for intra-site and inter-site comparisons.

Soil chemistry analyses were undertaken at the A. Temple Site (7NC-D-68), a mid-19th to mid-20th century tenant farmstead (Hoseth et al. 1990). A total of 86 features was identified at the site and included a stone house foundation, a brick-lined well, six outbuildings, fence lines, and two possible privies. The soil chemical analyses were used in conjunction with artifact and feature patterning to interpret yard usage of the site occupants through time. High phosphate concentrations were located in several areas of the site and interpreted as both animal penning and/or organic refuse disposal areas. Calcium peaks were identified near structures and interpreted as reflecting the building materials in the soil. Magnesium peaks mostly coincided with the calcium results, although there was a general "smear" of magnesium across the site, interpreted as being a reflection of the use of dolomitic limestone during the 20th century (Hoseth et al. 1990: 150). Potassium concentrations at the site were less useful, and coincided with the locations of buildings, or in the plow zone with modern disturbances. Soil pH levels also displayed variability and were attributed to differing fertilization methods over time, but were not helpful in identifying additional activity areas.

The John Darrach Store Site (7K-A-101) was an 18th through mid-19th century store and tenant farm site located along the road to Duck Creek Landing (De Cunzo et al. 1992). The original store was a brick structure and was surrounded by yard areas and a possible impermanent outbuilding. An addition was added to the structure later and additional outbuildings, fence lines, gardens, animal pens, and privies were constructed in the yard areas. In the late 1860s, the property was altered again, as many of the outbuildings and yard areas were plowed under so the area could be used for agriculture. Soil chemical analysis was conducted on only the subsoil, as the plow zone was mechanically removed prior to sampling. Soil pH showed variability across the site, but contained the highest (i.e. most alkaline) readings underneath the store's cellar floor, which was attributed to the lime content of the mortar. High phosphate concentrations were noted at the southwest corner of the store and in the east yard and coupled with the artifact and feature patterning suggested intensive use, perhaps as a garden, animal pen, or disposal area for household refuse. Potassium levels were erratic, but seemed to confirm the location of the chimney along the west wall of the structure and a secondary dump of fireplace ash near the road at the yard edge. Calcium and magnesium showed parallel results and were highest in the location of the store, due to the lime content of the mortar and building materials. Another concentration was noted in association with a trash pit

feature, which contained higher levels of calcium than an identified shell midden deposit at the site, which was somewhat unexpected.

The Buchanan-Savin Farm (7NC-J-175) was owner-occupied from the 19th century through the late-20th century in a rural area of Delaware. In addition to 11 extant structures at the site, which included the farmhouse, 275 historical features were identified and included remains of eight outbuildings, two privies, five fence lines, a tile line, two French drains, and a well (Scholl et al. 1994). Soil chemical analyses at the site sought to compare and contrast the 19th and 20th century site components. The 19th-century results were characterized by high levels of background chemical densities with areas of greater concentration, which marked different activity areas. For example, high levels of phosphorous helped identify animal and human waste disposal areas and the location of farm buildings. Calcium and magnesium had similar results and were associated with areas of building debris and trash middens, while potassium concentrations were found with ash disposal and trash burning locations. Soil pH factor of the site did not display discernable patterning. The 20th-century results, however, defined only a single activity area characterized by high concentrations of each soil characteristic tested, related to the use of highly concentrated modern fertilizers. It also suggested the consolidation of farm activities to a single area.

Located in a plowed field southeast of Smyrna was the William Strickland Plantation (7K-A-117), an owner-occupied colonial farmstead dating to the 18th century. A total of 189 features was identified and included an "earthfast dwelling," a post-in-ground structure, a smokehouse with a cellar, two outbuildings, two wells, trash pits, fence lines, and an incomplete cellar hole (Catts et al. 1995: i). The results of the soil chemical analyses showed that higher concentrations of elements were often associated with the larger features. Additional concentrations were also identified and more useful in delimiting spatial use at the site. A phosphorous and calcium concentration was located in association with a probable animal pen, while a magnesium concentration was located outside and along the fence line, suggesting refuse disposal. A phosphorous concentration was associated with the smokehouse location, while a phosphorous and magnesium concentration to the southeast of the site suggested a general refuse disposal area. Soil pH results were associated with the larger evident features and were not helpful in distinguishing additional activity areas.

The Moore-Taylor Farm Site (7K-C-380) was an owner-occupied farm that dated from the early-19th century to the 20th century (Grettler et al. 1996). Excavations led to the identification of 486 cultural features at the site, which included a frame dwelling, three outbuildings, five wells, two privies, 10 fence lines, and several activity areas. Soil chemical analyses at the site confirmed the locations identified as structures in the subsurface feature patterning. Soil pH levels were consistently more alkaline in areas associated with structures, related to the effects of building materials in the soil. Similarly, high concentrations of both calcium and magnesium were associated with the structure locations, also related to the building materials used. An additional concentration of calcium and magnesium was associated with a privy location. The distribution of phosphorous suggested that animals were restricted to two of the

outbuildings and the yard area between them, as extremely little phosphorous was found in the soils away from these locations. Phosphorous was not associated with either of the privy locations. Potassium was not helpful in delimiting activity areas and was found relatively evenly across the site, likely related to the use of modern fertilizers. However, in one case, an increased potassium level was associated with the kitchen addition.

The Benjamin Wynn Tenancy Site (7K-C-362) was a late 18th-century farm located in rural Delaware (Grettler et al. 1996). Two hundred forty six cultural features were identified at the site, consisting of the remains of a house, a small blacksmith shop, two wells, eight fence lines, a probable privy, and various yard/activity related features. The soil chemical analyses for the site indicated a high level of post-occupation contamination across the entire site, due to the use of modern fertilizers and animal penning. These results were observed in the high soil pH and concentrations of potassium, calcium, and magnesium in the soil without discernible patterning.

Soil chemical analysis was undertaken at the Wilson-Lewis Farm (7K-C-375), a mid- to late-19th-century owner-occupied farm in rural Delaware (Grettler et al. 1996). A total of 161 cultural features was identified at the site and included post holes related to the one-story frame house, a stable, two wells, four fence lines (from the occupation), and several midden/trash deposits. Three 20th-century fence lines were also identified that were not oriented with the rest of the site. Soil pH levels suggested use of agricultural fertilizer, but were not useful in identifying additional activity areas. The distribution of phosphorous indicated high levels associated with the stable and adjacent fence line, likely due to animal waste, while some secondary concentrations noted at the site could be from the casual disposal of waste. A single concentration of potassium was noted, and likely indicated the location of a small trash burning area. Calcium and magnesium showed similar concentrations, the highest of which was at the house location and related to the building materials used. Secondary calcium and magnesium concentrations were located at the east edge of the site and interpreted as post-occupational contamination from plowing and fertilizer.

The Richard Whitehart Plantation (7K-C-203C) was a late-17^{th-} to early-18th-century farm located in rural Delaware. A total of 163 cultural features was identified at the site and included evidence of an earthfast dwelling, four earthfast outbuildings, a well, sheet midden, five trash deposits, and three fence lines (Grettler et al. 1995). Soil chemical analyses identified two areas of concentrated high phosphorous levels: one along the west wall of the dwelling near the chimney, which was attributed to disposal of human waste; the second near the edge of a trash midden feature, attributed to wastes from penned animals. High densities of calcium in the soil were associated with the hearth/chimney and along other sides of the dwelling and attributed to mortar and other building materials. Magnesium concentrations were similar to calcium, although more concentrated over the hearth/chimney and also north of the trash midden. A potassium concentration was noted just outside the hearth/chimney of the dwelling and likely indicated the location of waste ash deposits. A secondary concentration was noted north of the trash midden (similar to calcium and magnesium) and may indicate post-

occupational contamination. Soil pH at the site was not useful in identifying activity areas and fluctuations were attributed to subsequent years of plowing and fertilization.

The John Powell Plantation (7K-C-203H) was another late-17^{th-} to early-18th-century farm located in rural Delaware not far from the Richard Whitehart Plantation (Grettler et al. 1995). Of the features identified, 82 features were considered cultural and related to the late-17^{th-} to early-18th-century occupations of the site. The features included the remains of a dwelling, three outbuildings, and a well attributed to the first occupation and a second dwelling, two outbuildings, one trash pit, and several fence lines attributed to a second occupation. In addition, five daub/trash pits and three fence lines were identified, but could not be specifically associated with either occupation. Two areas of high levels of soil phosphorous were identified, one near an outbuilding tentatively interpreted as a barn or stable, and the second along the sides of the dwelling. The latter concentration could indicate animals were penned in the yard or human wastes were disposed near the house. Calcium levels were higher near the dwellings, associated with building materials used for the structures. Magnesium levels were not parallel to calcium concentrations at the Powell Site, which was different than many other sites. The magnesium distributions were relatively steady, without much variation to interpret. Potassium was concentrated in four distinct areas: one area was associated with the same outbuilding where high phosphorous levels were identified, another was in the middle of the yard area, and two more were located along a fence line. These concentrations were associated with trash disposal and activity areas and confirmed the interpretation of intense use of these areas of the site. Soil pH displayed variation between the plow zone and subsoil samples, likely related to post-occupational plowing and fertilization, and were not helpful in delineating historical activity areas.

The Bloomsbury Site (7K-B-23) was a tenant house site located in rural Delaware, which was occupied from the mid-18th through the early-19th century by a number of different families (Heite and Blume 1998). Features identified at the site included three wells, a single house site that was likely rebuilt of replaced at one time, a variety of shallow basin-like pits and processing and activity areas. Soil chemistry analysis indicated that potassium was found in pockets across the site, particularly near the probable house location and several of the shallow basin-like pits, which often contained wood ash deposits. Higher phosphorous levels at the site were found at two places: one outside the site core that was attributed to possible animal penning (though no evidence for fencing was identified); the second, was at the northwest corner of the site core associated with several features and likely indicated an intense activity area. Calcium at the site was concentrated past the features and associated with high soil pH levels, and interpreted as bone and/or shell disposal. Additionally, calcium was associated with potash in the vicinity of two of the identified wells. The results for magnesium were difficult to interpret, as they showed no clearly defined concentration. Additionally, at the Bloomsbury site a variety of metals were tested for in the soil sample, including zinc, iron, and copper. Of these, only iron exhibited significant clustering, which "outlined" the core of the site and just north of the well (Heite and Blume 1998: 140). The results were interpreted as possibly indicating decayed nails and materials from the house. Soils from the series of shallow basin-like pits also was analyzed, and these features

tended to cluster together in comparison to the rest of the site for most of the different elements tested, which suggested a common function for these features.

The previous soil chemical analyses undertaken in the State of Delaware have provided a wealth of data correlating signatures with specific feature types or general activities. Each of the soil signatures tested for in these various studies has had variable success for site interpretation, as site specific parameters may affect the usefulness of a particular indicator. However, in examining a number of sites some generalizations and expectations may be formed to assess and compare with the Jones Site soil analyses.

Fluctuations in soil pH factor may indicate alterations from human activity, which results in the change of the natural relative acidity of the soil. These changes may be caused by the addition of agricultural fertilizer, soil fill, ash deposits, or from the effects of accumulated waste such as oyster shell or bone. In Delaware, soils are naturally acidic therefore pH readings greater than 6.0 would suggest alteration, usually due to the presence of agricultural fertilizer (Jamison et al. 1997:83). However, pH factor may also be affected the other way and become more acidic, due to the use of more organic fertilizers, so the results should be examined for several possibilities (Custer et al. 1986).

Potassium, phosphorus, calcium, and magnesium are called macronutrients, needed by plants in significant amounts to stay healthy (Catts et al. 1994). Potassium is considered to be an excellent indicator to locate and identify wood ash deposits indicating the presence of a hearth, secondary deposits of wood ash, or fence lines or other wood burning activities (Catts et al. 1995:97). Potassium and phosphorus have also been identified in association with a machine-shop/blacksmithing area (Custer et al. 1986). Phosphorus, and high levels of phosphate, is considered an indicator of, and derived from, animal waste. It has been found in higher concentrations within the fence lines of corrals or barnyards because animals tend to walk along these paths more consistently than across an open pasture or pen. Increased levels of calcium in the soil are a good indicator of human habitation sites. However, increased levels could be related to several different factors including bone residue, agricultural fertilization (using oyster and mussel shell, or crushed limestone), lime kilns, and mortar deposits (personal conversation with Silas Hurry on June 9, 2000; Catts et al. 1995:97). The relationship between magnesium and historical sites is still unclear, but its concentrations usually correlate with calcium concentrations, and may be especially high if dolomitic limestone fertilizer is utilized (personal conversation with Silas Hurry on June 9, 2000; Custer et al. 1986). Magnesium and potassium are generally not considered to be as stable within soils as calcium and phosphorus, and their presence is often related to microenvironmental factors (Catts et al. 1995). Therefore as trace element indicators of human activities, magnesium and potassium are less reliable.

The research conducted by UDCAR has found that the five soil characteristics can aid in the identification of general locations for chimneys and flues, structures, meat processing locations, animal pens, privies, and yard areas. These interpretations were generally made in conjunction with the data gathered from artifact distributions and/or the locations of specific feature types at the sites. Typically, soil chemistry analysis has not been

conducted to identify buildings, yards, chimneys, animal pens, and privies, when no evident feature remains were first identified.

Few archaeological investigations have submitted soil chemistry samples to test for trace elements, in addition to the five outlined. In one example, soil samples from a cannery site in Delaware were submitted to test for the five soil characteristics, and additionally for the concentration of Manganese (Mn) and zinc (Zn) (Heite 1990:126). Zinc and phosphorus concentrations were identified and located near the can-making waste region of the site. More recently, tests were performed for barium (Ba) and strontium (Sr) in the soil from a site containing brick and mortar (personal conversation with Karen Gartley, February 2001). While the exact reason for the barium and strontium test is not known, barium was used as an additive in bricks after 1900, to inhibit the white pasty external appearance of bricks after firing and its presence could be used to indicate later-period bricks (Gilbert et al. 1993:40-41). In Great Britain, soil chemistry testing programs have found other trace elements that may be useful to identify human occupation. In addition to potassium (K); rubidium (Rb), thorium (Th), cesium (Cs), and strontium (Sr) were all found to be good indicators of habitation sites on the Isle of Skye. The same testing program determined that phosphorus (P) was not a good indicator of a habitation site, but was better for locating stockyards or fields where manure was prevalent. Occupation and settlement will increase the potassium (K) and phosphorus (P) contents of soils with regular site debris and especially excrement (Entwistle et al. 2000:287).

Methodology for the soil sampling collection varied depending on site parameters, although there were commonalities in the UDCAR testing programs. Predominately, both plow zone (Ap) and/or A horizon samples were submitted with accompanying subsoil samples. However, UDCAR excluded submission of plow zone samples at the John Darrach House (De Cunzo et al. 1992). On the William Strickland Plantation, soil chemistry samples were taken from all the test units in the plow zone, and subsoil samples from the larger 10 x 10 ft unit blocks (Catts et al. 1995). Generally, though, a subsoil sample was always submitted with a corresponding plow zone sample, or as close to a corresponding sample as the site investigations would allow (Catts et al. 1995). The UDCAR soil chemistry test program suggested that subsoil from historical sites was less likely than the plow zone to be contaminated by post-occupational contamination, such as fertilizer spills or manure spreading. Additionally, it was suggested that the plow zone could retain detectable historical concentrations of calcium and phosphorus without much contamination from other elements (Catts et al. 1995:97). More recently at the Bloomsbury Site plow zone samples were not collected for analysis as the researchers found plow zone samples from other sites to provide redundant data from, or less concise data than, subsoil samples (Heite and Blume 1998).

Table 8-20. Previous Studies of Soil Chemistry at Selected Archaeological Sites in Delaware

Study	**SiteNo./Name**	**Elements Tested**						**Sampling Method**	**Presentation**	**Raw Data Table**
		Calcium (Ca)	Magnesium (Mg)	pH	Phosphates	Phosphorus (P)	Potassium (K)			
Catts and Custer 1990	7NC-D-130/ Thomas Williams Site	X	X	X	X		X	plow zone test units; each of the larger 10 x 10' subsoil units	Frequency distribution maps, plow zone vs. subsurface	No
Hoseth et al. 1990	7NC-D-68/ A. Temple Site	X	X	X	X		X	3 stages: 2-cup soil sample from plow zone soils of plow zone test units; from subsoil in SW corner of each 10 x 10' subunit; from certain features	Frequency distribution maps, plow zone vs. subsoil; soil sample location map	Yes (Appendix IV)
De Cunzo et al. 1992	7K-A-101/ John Darrach Store Site	X	X	X	X		X	from perimeter of site in plow zone (n=46); from subsoil at 10' grid intervals (n=382); from selected features (n=113)	Frequency distribution maps, subsoil only (insufficient distribution of samples from plow zone)	No
Catts et al. 1995	7K-A-117/ William Strickland Plantation	X	X	X		X	X	From each of 5 x 5' plow zone test units; from subsurface 10 x 10' units	Plan map of "soil chemical distributions" – shows "meaningful" concentrations based on pz	No

Table 8-20. Previous Studies of Soil Chemistry at Selected Archaeological Sites in Delaware

Study	SiteNo./Name	Elements Tested						Sampling Method	Presentation	Raw Data Table
									and subsoil data (doesn't define the term or give values)	
Grettler et al. 1996	7K-C-380/ Moore-Taylor Farm	X	X	X		X	X	Plow zone and subsoil; 10-ft intervals in core of site; 20-ft intervals from site periphery	Frequency distribution maps, plow zone vs. subsoil	No
Grettler et al. 1996	7K-C-362/ Benjamin Wynn Tenancy	X	X	X		X	X	Plow zone and subsoil; 10-ft intervals in core of site; 20-ft intervals from site periphery	Frequency distribution maps, plow zone vs. subsoil	No
Grettler et al. 1996	7K-C-375/ Wilson-Lewis Farm	X	X	X		X	X	Plow zone and subsoil; 10-ft intervals in core of site; 20-ft intervals from site periphery	Frequency distribution maps, plow zone vs. subsoil	No
Scholl et al. 1994	7NC-J-175/ Buchanan-Savin Farm	X	X	X		X	X	From each of 5 x 5' plow zone test units; from subsurface 10 x 10' units; from plow zone and subsurface of areas surrounding 20th C farm structures and 19th C farmhouse	Frequency distribution maps, plow zone vs. subsoil; soil sample location map	No
Grettler et al. 1995	7K-C-203C/ Richard Whitehart	X	X	X		X	X	From plow zone and subsoil in plow zone sample test	Frequency distribution maps, plow	No

Table 8-20. Previous Studies of Soil Chemistry at Selected Archaeological Sites in Delaware

Study	SiteNo./Name	Elements Tested						Sampling Method	Presentation	Raw Data Table
	Plantation							units; from plow zone and subsoil of surrounding 10x10m or 10x10' blocks	zone vs. subsoil	
Grettler et al. 1995	7K-C-203H/ John Powell Plantation	X	X	X		X	X	From plow zone and subsoil in plow zone sample test units; from plow zone and subsoil of surrounding 10x10m or 10x10' blocks	Frequency distribution maps, plow zone vs. subsoil	No
Colema n et al. 1985	Wilson-Slack Agricultural Works Complex									
MAAR Associat es, Inc. 1996	Charles Robinson Plantation									
Affleck et al. 1998	Locust Grove									
Jamison et al. 1997	C. Kimmey Tenant Farm/ 7K-C-119	X	X	X		X	X	Plow zone and subsoil: 10 foot intervals	Frequency distribution maps, plow zone vs. sub plow zone	No
Catts et al. 1994	Mermaid Blacksmith Shop and	X	X	X		X	X		Frequency distribution maps, plow	No

Table 8-20. Previous Studies of Soil Chemistry at Selected Archaeological Sites in Delaware

Study	SiteNo./Name	Elements Tested						Sampling Method	Presentation	Raw Data Table
	Stable/ 7NC-D-106B								zone only	
Shaffer et al. 1988	Whitten Road Site/ 7NC-D-100	X	X	X	X		X	Plow zone and subsoil: 10 foot intervals in site core; random sample of outlying 5 foot square units	Frequency distribution maps, plow zone vs. sub plow zone	No

Table 8-21. Soil Chemistry Contour Intervals at Selected Archaeological Sites in Delaware

Study	**SiteNo./Name**	**Provenience**	**Elements Tested**					
			Calcium (Ca)	Magnesium (Mg)	pH	Phosphates	Phosphorus (P)	Potassium (K)
Catts and Custer 1990	7NC-D-130/ Thomas Williams Site	Plow zone	200	20	X	20		10
		Sub Plow zone	200	20	0.4	20		5
Hoseth et al. 1990	7NC-D-68/ A. Temple Site	Plow zone	200	10	0.2		40	20
		Sub Plow zone	200	10	0.2		40	10
De Cunzo et al. 1992	7K-A-101/ John Darrach Store Site	Sub Plow zone	X	100	0.1	30		10
Catts et al. 1995	7K-A-117/ William Strickland Plantation	Plow zone	X	X	X		X	X
		Sub Plow zone	X	X	X		X	X
Grettler et al. 1996	7K-C-380/ Moore-Taylor Farm	Plow zone	125	20	0.1		40	40
		Sub Plow zone	125	30	0.2		X	40
Grettler et al. 1996	7K-C-362/ Benjamin Wynn Tenancy	Plow zone	200	X	0.5		X	X
		Sub Plow zone	200	X	0.3		X	X
Grettler et al. 1996	7K-C-375/ Wilson-Lewis Farm	Plow zone	44	20	0.1		4	9
		Sub Plow zone	8	6	0.1		10	X
Scholl et al. 1994	7NC-J-175/ Buchanan-Savin Farm	Plow zone	100	20	0.05		20	20
		Sub Plow zone	40	10	0.2		20	10
	Moffett Dairy Farm	Plow zone	X	X	0.05		40	X
		Sub Plow zone	100	X	0.2		X	X
Grettler et	7K-C-203C/ Richard	Plow zone	X	20	0.7		20	25

Table 8-21. Soil Chemistry Contour Intervals at Selected Archaeological Sites in Delaware

Study	SiteNo./Name	Provenience	Elements Tested					
al. 1995	Whitehart Plantation							
		Sub Plow zone	300	20	X		20	X
Grettler et al. 1995	7K-C-203H/ John Powell Plantation	Plow zone	200	60	1.0		40	X
		Sub Plow zone	200	40	0.5		5	40
Coleman et al. 1985	Wilson-Slack Agricultural Works Complex	Plow zone						
		Sub Plow zone						
MAAR Associates, Inc. 1996	Charles Robinson Plantation	Plow zone						
		Sub Plow zone						
Affleck et al. 1998	Locust Grove	Plow zone						
		Sub Plow zone						
Jamison et al. 1997	C. Kimmey Tenant Farm	Plow zone	400	28	0.7		40	50
		Sub Plow zone	800	100	1.0		100	200
Catts et al. 1994	Mermaid Blacksmith Shop and Stable/ 7NC-D-106B	Plow zone						
Shaffer et al. 1988	Whitten Road Site / 7NC-D-100	Plow zone	X	20	0.1	20		50
		Sub Plow zone	150	50	X	15		X

X=unknown contour interval

8.5.3 Soil Chemistry Analysis

An extensive analysis of soil chemistry was undertaken at the Jones Site. A sample of the raw data is included in Appendix F – Soil Chemistry Sample Results. Concentrations of potassium, phosphorus, calcium, magnesium, zinc, copper, manganese, and iron were examined, as well as the pH level of each soil sample. Additionally, slight variations were observed between the Ap-horizon (plow zone) and subsoil (sub-plow zone) soil samples submitted for the same soil characteristic, which may indicate varying levels of post-occupation disturbance. The results of the chemical analyses are displayed in relation to the observed features of the site to aid the interpretation of the results, for both the Ap-horizon and subsoil samples.

Block A contained the brick clamp complex, without much further evidence of other historical activities, aside from the construction of the terra cotta tile drain system. Evidence related to the presence of fuel raw materials used in the brick clamp, or by-products from the consumption of coal, was searched for in Block A.

The soil chemistry sampling strategy for Blocks B and C was different than for Block A and sought different data. Block B was located to identify possible structures related to the brick clamp complex, or the structurally supporting square postholes tentatively identified in the Phase II investigations of the Jones Site. Although the early Phase III investigations encountered a brick-lined well, several square post holes (identified as fence postholes), and one historical pit, there was no direct evidence for historical structures in either the feature or artifact data. Block C, which encompassed the removal of the spoil pile, also was placed to locate structural data. The soil sample analyses from Blocks B and C therefore was undertaken to identify any latent activity areas associated with a habitation.

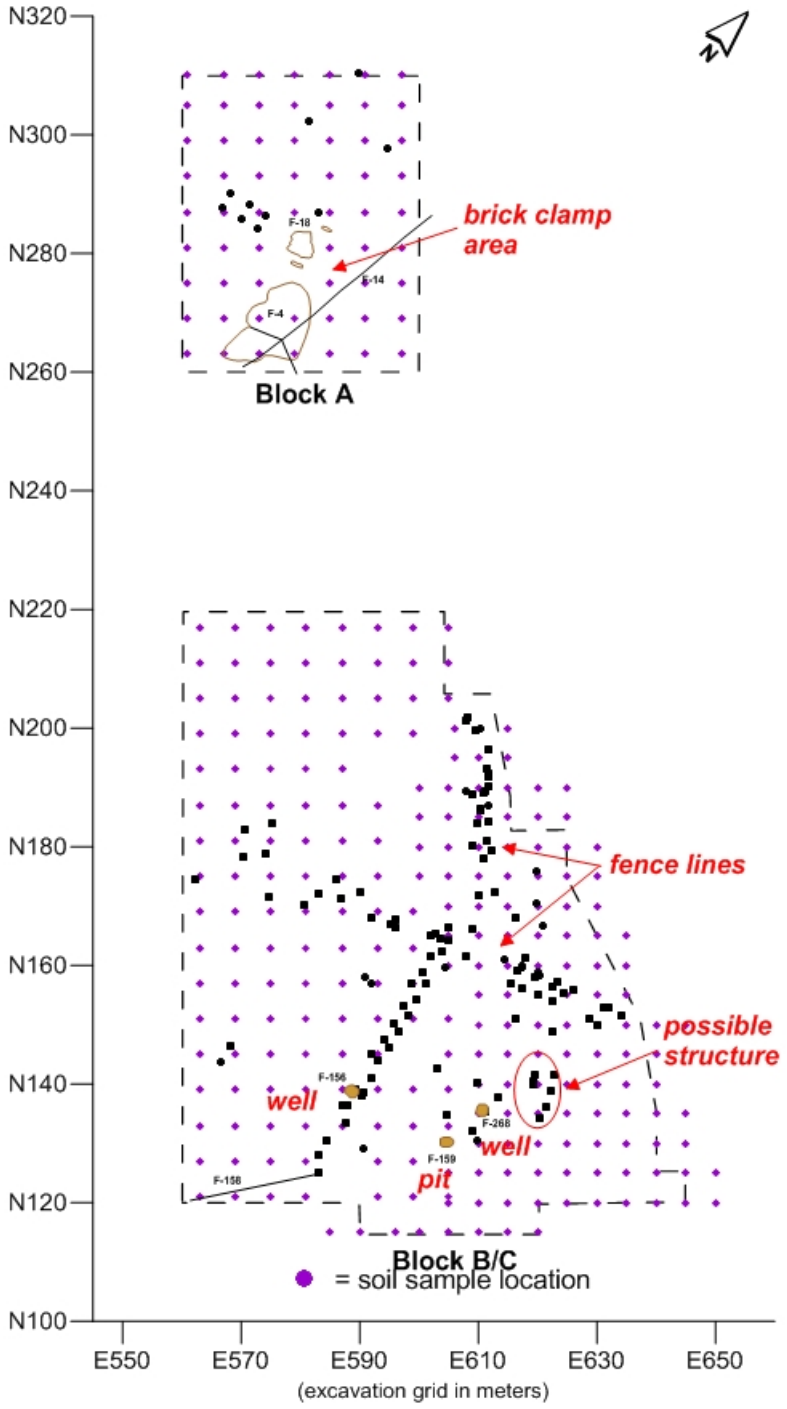

Figure 8-18. Soil Chemistry Sample Locations in Blocks A (top) and B/C (bottom).

8.5.4 Chemical Test Elements

Five elements, pH, phosphorus, magnesium, calcium, and potassium, have been the standard elements utilized to aid in identification of the presence of structures, livestock pens, fence lines, meat processing areas, privies, or heavily fertilized areas suggesting a cultivated field or garden. These activity areas have been associated with soil chemistry analysis programs from 1985 to the present in Delaware (Catts and Custer 1990; Catts et al. 1995; Custer et al. 1986; De Cunzo et al. 1992; Grettler et al. 1995; Grettler et al. 1996; Hoseth et al. 1990; Scholl et al. 1993). Specific information derived from concentrations of these elements are indicated below.

- pH - concentrations can indicate the presence of a garden, or localized crop areas, and as Delaware soils are naturally acidic, readings above 6.0 suggest agricultural fertilization (Jamison et al. 1997:83);
- Phosphorus - high levels are good indications of fecal remains, indicating animal pens and privies;
- Magnesium and Calcium - the relationship between the presence of magnesium and a historical site is still unclear, but it usually correlates directly proportionally to calcium concentrations, which can identify bone processing stations, lime kilns, and mortar deposits (Hurry 2000); and,
- Potassium - an excellent indicator to locate and identify wood ash deposits indicating the presence of a hearth, secondary deposits of wood ash, burned fence lines, or other wood burning activities (Catts et al. 1995:97).

In addition to the typical five soil chemical test elements (pH, phosphorus, magnesium, potassium, and calcium), four other elements (zinc, copper, manganese, and iron) were also tested for in both the plow zone and subsoil samples from the excavation blocks at the Jones Site. These same additional elements (sans manganese) also were tested for at the Bloomsbury Site, where only iron could be correlated to activity areas at the site (Heite and Blume 1998).

Potassium

Potassium levels, often associated with wood ash deposits or fertilizer, were slightly higher in the southern portion of the plow zone in Block A near the south end of the procurement/mixing pit (Feature 4) (Figure 8-19 left). Potassium levels from the subsoil in Block A were slightly higher to the west of the canopy/shed post alignment and the east central edge of the block, away from most feature contexts (Figure 8-19 right).
The potassium levels in Block A suggest the clamp may have been fired by wood. The higher readings located by the shed/canopy area and, more specifically to the northeast of the clamp in the plow zone, are not necessarily reflected in full in the subsoil samples, but still could represent where the wood ash was discarded after the firing and dismantling of the clamp. This could be supported by the fact that the majority of the brick from the shovel tests was found just to the northeast of the heat signature, as described in the beginning of Chapter 7.0 Archaeology.

The area in Block C, to the northeast of the fence line junction, was generally lower in potassium than the rest of the southern blocks. The subsoil in the northwest portion of Block B reflected the higher potassium content of the plow zone as well as the area around the possible post-in-ground foundation, which could be related to wood used in a structure, or from waste ash deposits associated with its use.

The close proximity of somewhat elevated potassium levels to the possible post-in-ground foundation mirror the higher levels of calcium in that same region and might suggest the presence of a structure and an area where the occupants threw wood ash out from a chimney or stove. If the barrel well relationship to the post-in-ground foundation would represent the front yard of the complex, then the presence of the potassium (wood ash) to the southeast of the Block C could represent the "backyard" of the complex. On the other hand, there are equally elevated areas of potassium to the northwest of this area, in a part of the site that does not have significant features. The potassium readings appear somewhat lower in the vicinity of the fence lines, which could mean that the areas of higher concentration reflect fertilizers the farmers used away from the fences, and not a structure at all.

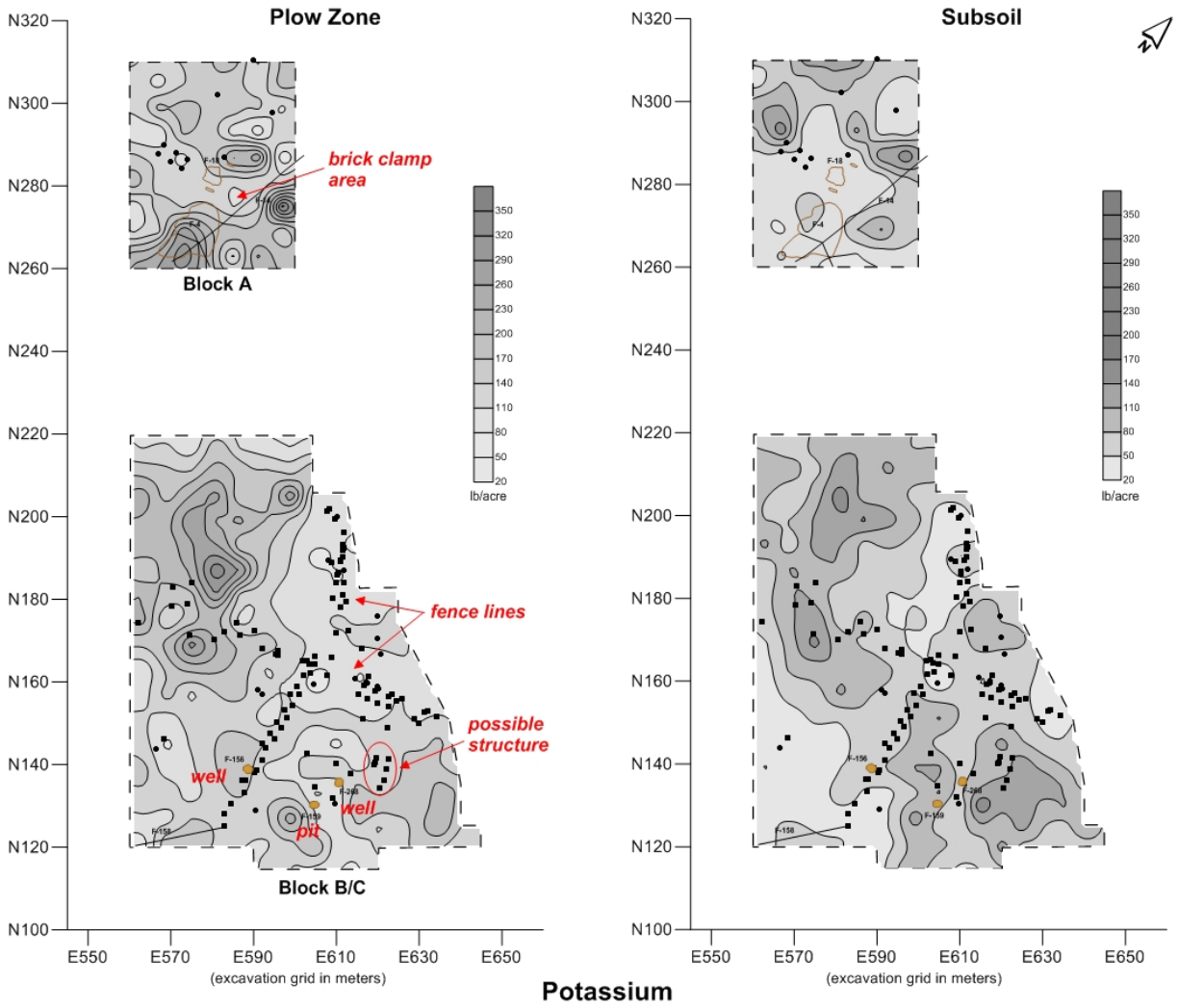

Figure 8-19. Potassium Levels within Plow Zone (left) and Subsoil (right) Contexts.

Phosphorous

Higher phosphorus levels are typically indicators of organic waste remains, such as fecal remains from privies, corrals, pastures, as well as an ingredient in fertilizer. In Block A, the phosphorous levels were relatively low in both the Ap-horizon and subsoil contexts (Figure 8-20). Even if the clamp manufacturing process included animals or beasts of burden, as suggested by the presence of possible hoof or foot prints at the base of the procurement/mixing pit (Feature 4), the short term of the process might not have left enough fecal material in the area to accumulate enough to register in the sampling process. Interestingly, the subsoil concentrations of phosphorous correlate with the subsoil concentrations of potassium: both were found to the northeast of the heat signature (Feature 18) and near the shed/canopy. As discussed in the potassium section, the area just to the northeast of the heat signature (Feature 18) was the location of the brick fragment concentration from the STPs. Therefore, this area might represent a trash and refuse disposal location, with the potassium representing woodash deposits and the phosphorous more organic waste, either from processing or fecal material. While the elevated levels of both elements outside of the shed/canopy likely represent that the area was intensely used.

A soil sample from a small cluster of stains at the Ap/subsoil boundary northeast of the heat signature was submitted as part of the soil chemistry sampling program conducted on the site. The sample contained much higher readings of phosphorus than the samples from four locations on the brick clamp-related features. The phosphorus reading for the area of the stains was 15.8 lbs/acre, whereas the brick clamp-related features had a reading of 1.9 or less. Two areas had elevated phosphorus readings in the subsoil from Block A, one to the northwest of the shed/canopy area west of the heat signature, and the other to the northeast of the heat signature where the cluster stains was located. The relationship between the stains and the brick clamp is unknown. It could represent an area where animals were tied or penned during the brick manufacturing process, though it is worth noting that the clamp was likely only fired once, and may only have ever been occupied for brick making for a period of a few months.

In Blocks B and C the phosphorous levels were generally higher than Block A, especially in the plow zone samples. The highest concentration was located at the east edge of Block B and west edge of Block C, where the north-south and east-west fence lines crossed. This concentration was more well-defined in the subsoil samples and displayed a tight concentration in the northwest quadrant of the crossed fence lines. Phosphorous concentrations adjacent to fence lines can represent either “over fence” disposal of trash, or could be related to animal penning on that side of the fence. This concentration was likely significant and spread over the greater horizontal distance in the plow zone, due to repeated plow episodes. Another phosphorous concentration was located in the vicinity of the terra cotta drain pipe, evident in both the plow zone and subsoil samples. Again, the subsoil samples produced a tighter spatial cluster, which was located southeast of the drain in an area of gleyed soils. It is not clear what specifically caused a concentration in this location, but it could represent refuse disposal or additional animal penning.

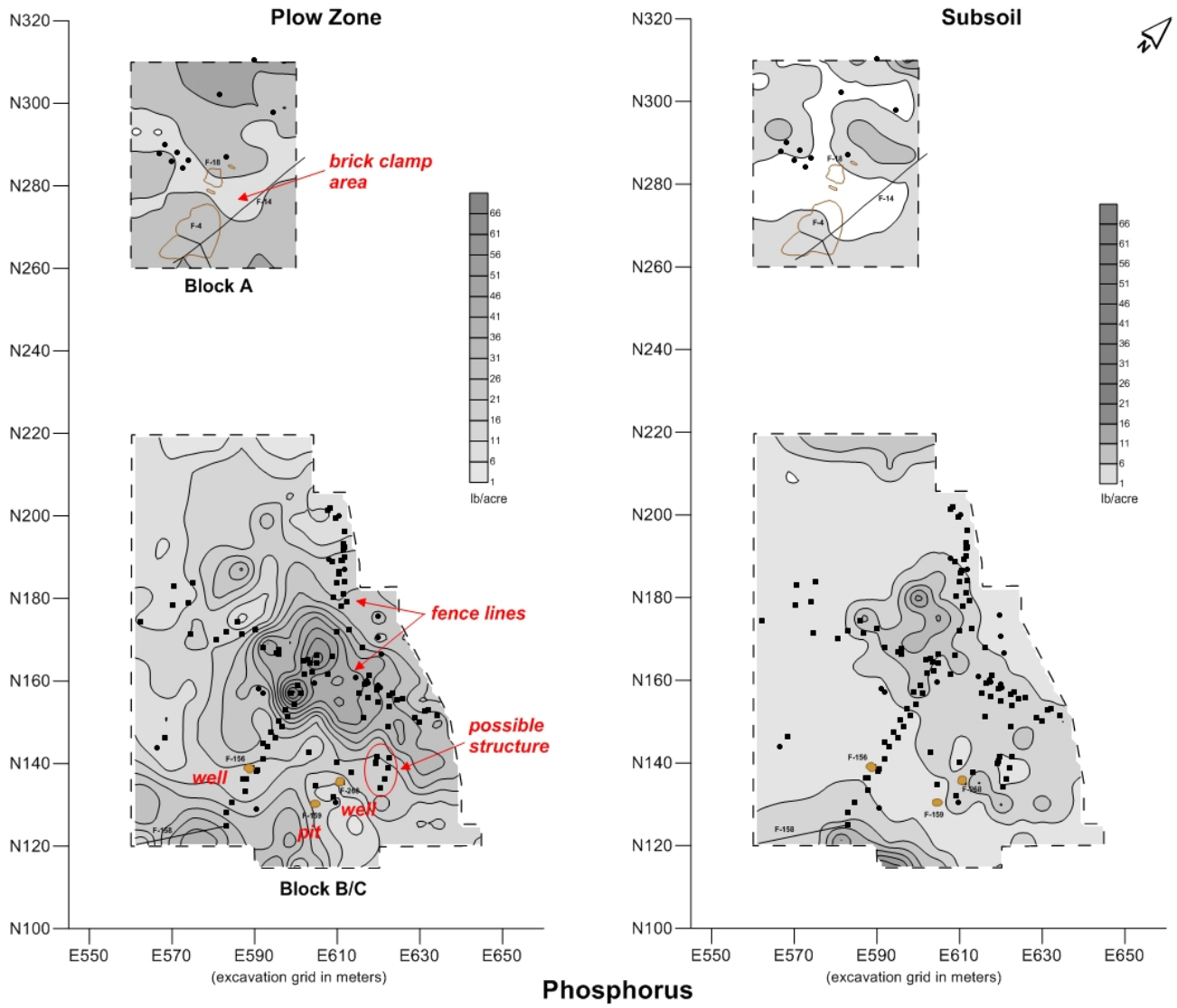

Figure 8-20. Phosphorus Levels within Plow Zone and Subsoil Contexts.

Calcium and Magnesium

Calcium levels from the plow zone in Block A peaked slightly to the west of the canopy posts and in the southern area of the procurement/mixing pit area of Feature 4 (Figure 8-22). Similar to the reviewed literature on soil chemistry studies, the magnesium levels of Block A from the Jones Site reflected the same peaks and valleys as the calcium levels. Therefore, a separate mapping of magnesium is not provided.

Calcium levels in Block A from the subsoil were generally higher around the shed/canopy post alignment just northwest of the heat signature (Feature 18), and slightly to the east of the heat signature (Figure 8-22 right).

Calcium levels from the plow zone in Blocks B and C were higher on either side of the main north/south alignment of the square post fence line. Peaks in the latter Blocks occurred in the southwest corner of Block B near the modern tree line and in the gleyed soil region and also to the southeast of the possible post-in-ground structure foundation located in the southeast corner of Block C (Figure 8-21 left).

The calcium concentrations from the subsoil in Blocks B and C were located to the northwest corner of the excavated area, away from the majority of the artifact and feature concentrations, and around and to the southeast of the possible post-in-ground structure foundation located in the southeast corner of Block C (Figure 8-21 right).

The calcium data from Blocks B and C may help shed some light on the location of a possible structure in this area. Figure 8-26 shows clearly an absence of higher calcium readings within the area along the double row fence line as well as just to the south of the historical pit (Feature 159) and the barrel well (Feature 268). The same low calcium readings were reflected in the subsoil along the same fence line area, as well as the area to the northeast of the fence line junction. High concentrations of calcium can represent possible bone processing and discard, but the low quantities of faunal remains from the site discount this possibility. The subsoil calcium readings around the possible structure and to the southeast could suggest the former presence of building materials (i.e. mortar). Since calcium is also an indicator of agricultural fertilization from crushed limestone or oyster shell, it is possible the lack of calcium along the fence lines means those areas were not heavily fertilized.

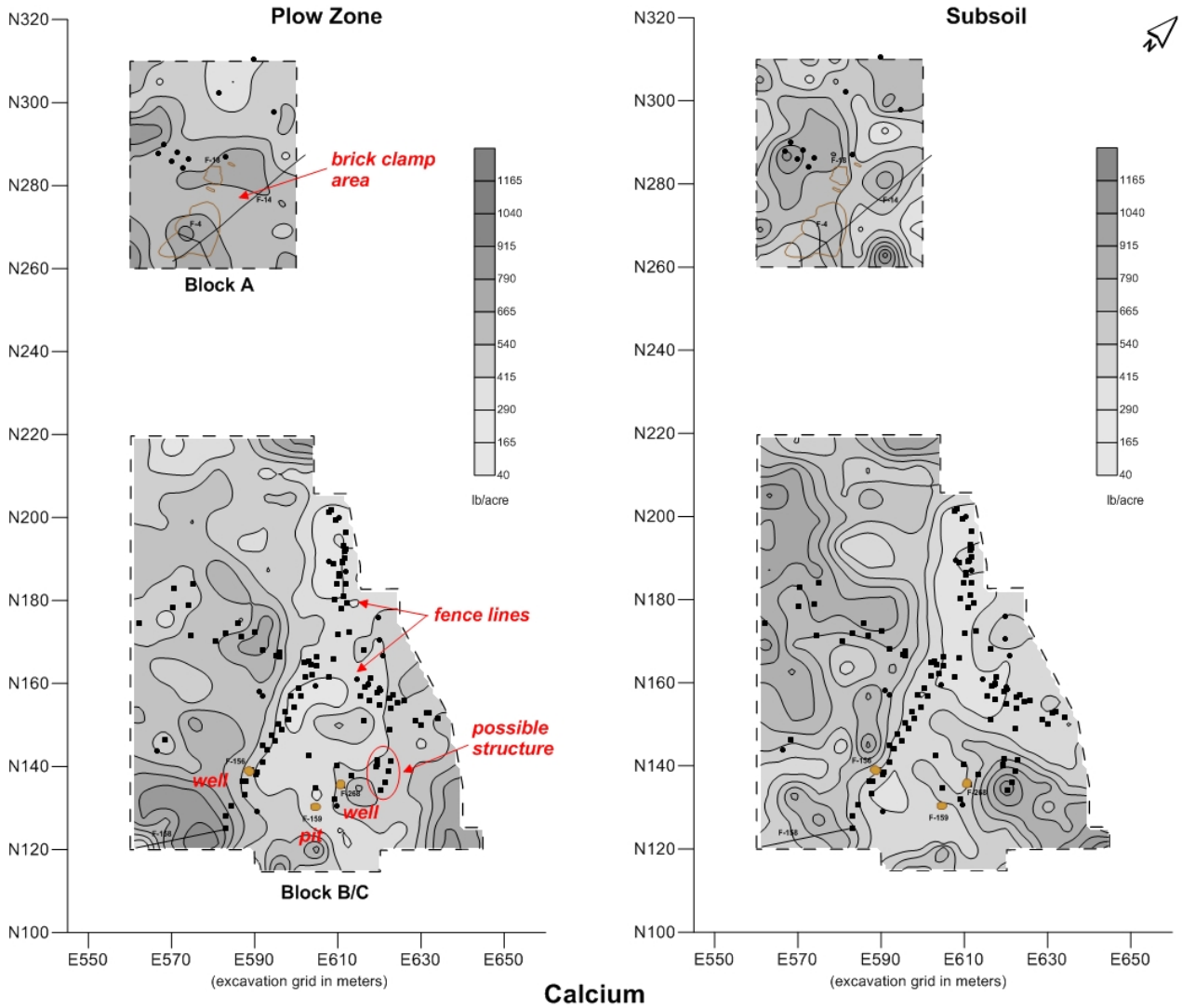

Figure 8-21. Calcium Levels within Plow Zone and Subsoil Contexts

Soil pH Factor

The pH levels across Block A do not appear to represent any significant activity areas in that excavation block (Figure 8-22). Some localized areas display less acidic readings, which could indicate influence from the areas of increased calcium concentrations, which tends to neutralize acids and raise pH levels. Or, these areas may have been fertilized with material that had only a slight effect on the pH levels. In either event, the distribution seems to be inconclusive.

In Blocks B and C the pH readings from both the plow zone and subsoil show a greater variability than Block A, which may relate to different use of these areas (see Figure 8-22). The pH levels were particularly high in both the plow zone and subsoil samples taken from under the area of the spoil pile. These results suggested the possibility of alteration of these horizons from the placement of the spoil pile dirt. However, a map of the pH readings higher than 6.0 across the site indicates Blocks B and C both contained a higher pH level than the rest of the site even away from the spoil pile. These readings could suggest a garden area or fertilized field. One area of higher pH levels that correlated with the subsoil concentrations of calcium was found in the northwest corner of Block B. However, as observed in the literature reviewed soil pH levels were helpful in demonstrating changes to the soil, but it is often difficult to attribute these changes to specific causes. In Blocks B and C, there seems to be an indication of both historical activity, observed in the northwest corner of Block B and also more modern influence, especially in the vicinity of the spoil pile. It is unclear if the spoil pile soils contained greater concentrations of calcium, or lime based fertilizers, which might cause these changes.

Since the soils that comprised the spoil pile were redeposited, their disturbed nature might facilitate the migration of elements within the soil as they resettled. This downward movement would also likely be enhanced by rainwater soaking through the less compact spoil pile soils and depositing the elements into the plow zone, and eventually the subsoils at the Jones Site. As the soils that comprised the spoil pile came from elsewhere, it is unclear if they naturally contained greater concentrations of the iron, copper, and manganese, or if these concentrations reflect activities undertaken at their original location. According to one of the bulldozer crewmen that moved the spoil pile, the matrix was removed from the Buchanan-Savin farmstead region, accounting for the mid-late 19th century artifacts it contained. However, the Buchanan-Savin project did not test for these extra four elements so no comparison of results is possible.

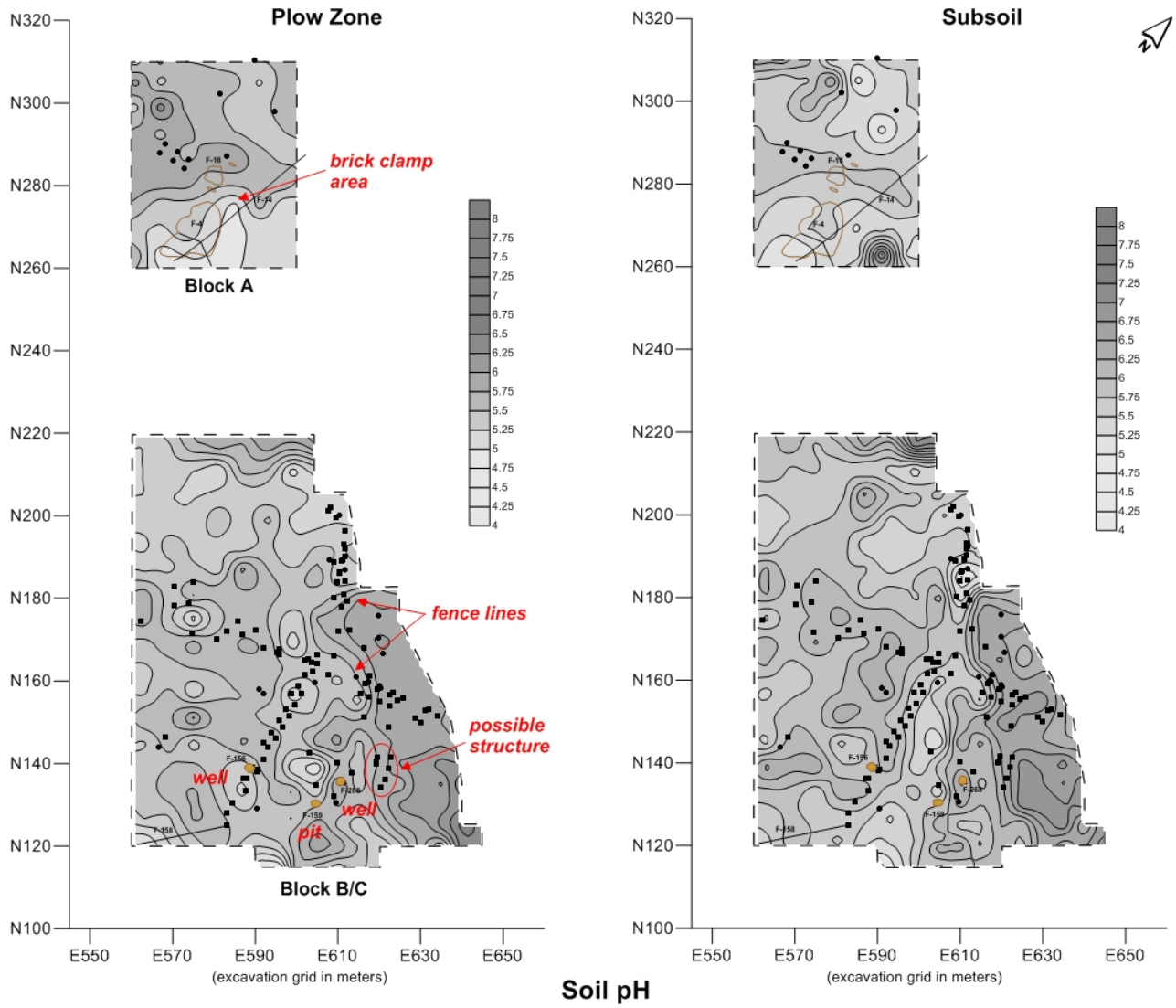

Figure 8-22. Soil pH Levels within Plow Zone and Subsoil Contexts

Additional Elements

In addition to the typical five soil chemical test elements (pH, phosphorus, magnesium, potassium, and calcium), four other elements (zinc, copper, manganese, and iron) were also tested for in both the plow zone and subsoil samples from the excavation blocks. These same additional elements (other than manganese) also were tested for at the Bloomsbury Site, where only iron could be correlated to activity areas at the site (Heite and Blume 1998). For Block A, the results of the soil chemical testing for the additional elements were less informative (Figures 8-23, 8-24, 8-25, and 8-26).

Although the majority of the Block B and C area yielded little insight into the soil chemical signatures for these elements in relation to feature function, the location of structures, or site activities, they did correlate to the location of the spoil pile. Of the additional four elements of zinc, copper, manganese, and iron, all but zinc were found in higher concentrations in the soil samples taken from directly under the spoil pile, both the plow zone and subsoil samples (see Figures 8-23, 8-24, 8-25, and 8-26). The results suggested significant leaching of elements from the spoil pile soils into the soils below.

The testing for the additional four elements may not have provided insight into specific site and/or feature function interpretations, but they did highlight the influence that introduced soils could have on soil chemistry, even within subsoil samples. This result has important implications to consider when undertaking soil chemistry analysis, especially at historical sites. The introduction of sod and other fill soils often undertaken at farmsteads, either to level surfaces, fill in wet areas, or add more organic soils to the site could postdate the occupations of "archaeological" interest, or reflect natural higher concentrations of certain elements in the introduced fill soils, either of which would skew soil chemical analyses in relation to site features and interpretations.

8.5.5 Discussion

The soil chemistry analysis provided some corroborating evidence for how people in the 18th and 19th centuries used the site, but provided little in the way of new insights. The potassium levels around the brick clamp were elevated, as would be expected with the brick makers burning wood to fire their bricks. We found elevated concentrations of phosphorus along the fence lines, as is common, suggesting that farmers or field hands tied animals to the rails at some times. But the soil chemistry did not provide definitive information about the location of a significant structure or habitation. There was a calcium concentration in the vicinity of a group of post holes that could relate to mortar from a post-in-ground structure, but neither the pattern of the posts nor the soil chemistry show a pattern that we can consider conclusive.

Few other states have implemented the number of soil testing programs that have been initiated in the State of Delaware since the mid-1980s, predominately sponsored on DelDOT projects. The Delaware SHPO supports the soil testing strategy, particularly on historical farmstead sites.

However, the majority of soil analyses have been undertaken on sites where structural information existed (either in features or historic maps) identifying the site layout. The soil chemistry was used as an additional aid to strengthen site interpretations and support what was generally known about the sites, for example fence line locations, animal pens, fireplace locations, and tentative trash disposal methods. The results in many cases did provide the additional evidence to support site interpretations and further insights into some of these historical behaviors.

Soil testing has not often been undertaken at ephemeral historical sites, such as the Jones Site, where structural evidence and site layouts are not specifically known. Certain indications in the soil chemical analyses could suggest associations with activities or conclusions based on previous investigations with known feature associations. However, site-specific parameters will influence soil chemistry results. For instance, concentrations of phosphorous have been found in association with animal pens, privies, fence lines, and foundations and without specific feature evidence, the same high concentration could be plausibly interpreted in vastly different ways. On the Jones Site, with only the brick clamp complex in Block A, and fence lines, the two well features, and possible post foundation in Blocks B and C, there is little conclusive evidence from the soil chemistry program to determine site function or layout.

Other recent soil chemical analysis has noted that the results were largely dependent on the soil matrix that was being studied, specifically the amount of silts, clays, and natural organic matter that it contained (Petraglia et al. 2002; Hayes Personal Communication 2002). Soils with greater clay content and less fine sediment tend to accumulate soil elements. Conversely, in fine sediments and looser soils, the elements will tend to diffuse more readily, thereby potentially masking archaeological patterning. Site activities that remove the upper horizons and expose B-horizon with high clay content, such as digging foundations, may also affect chemistry results (Hayes Personal Communication 2002). Therefore, particle size analysis of the samples would further aid in interpreting the obtained chemical results, but has not been considered in most previous soil chemistry testing programs.

The Jones Site also highlighted the potential significance that imported fill soil could have on soil chemistry results. At the site, the spoil pile may have had more influence on the concentrations of soil elements than was first anticipated, as many of the high concentrations noted in the study, including soil pH, iron, and potassium were found in the location of the spoil pile. These concentrations could be a result of the migration of elements from the loosely consolidated spoil pile. Comparison of soil samples from the spoil pile itself with the rest of the site was not undertaken, but may have provided interesting insight into the effects that may have been attributable to its presence and not former site activities.

Soil chemical analysis is another level of data often present on archaeological sites. As such, like data from artifacts and features, there are both benefits and limitations to the types of information it can provide for site and feature functional interpretations. Since there are many activities that can produce similar chemical concentrations, the benefits of soil chemical analyses

seem most valuable in conjunction with clear features, site layout, and artifact distributions to corroborate impressions in those data sets. It would seem more beneficial to use chemical analysis to help interpret sites that are not as clear and ephemeral to identify activity areas or latent features, but such testing exposes the limitations of soil chemical analysis. As soil chemistry analysis and patterns with feature types becomes more understood, such as through multivariate statistical analyses of co-occurrences, it will become a more effective tool for site analysis of ephemeral or unclear sites. However, there are still too many factors involved in soil chemistry, for example in particle size of the sediments, which may influence the results and are not yet clearly understood in the context of archaeological sites.

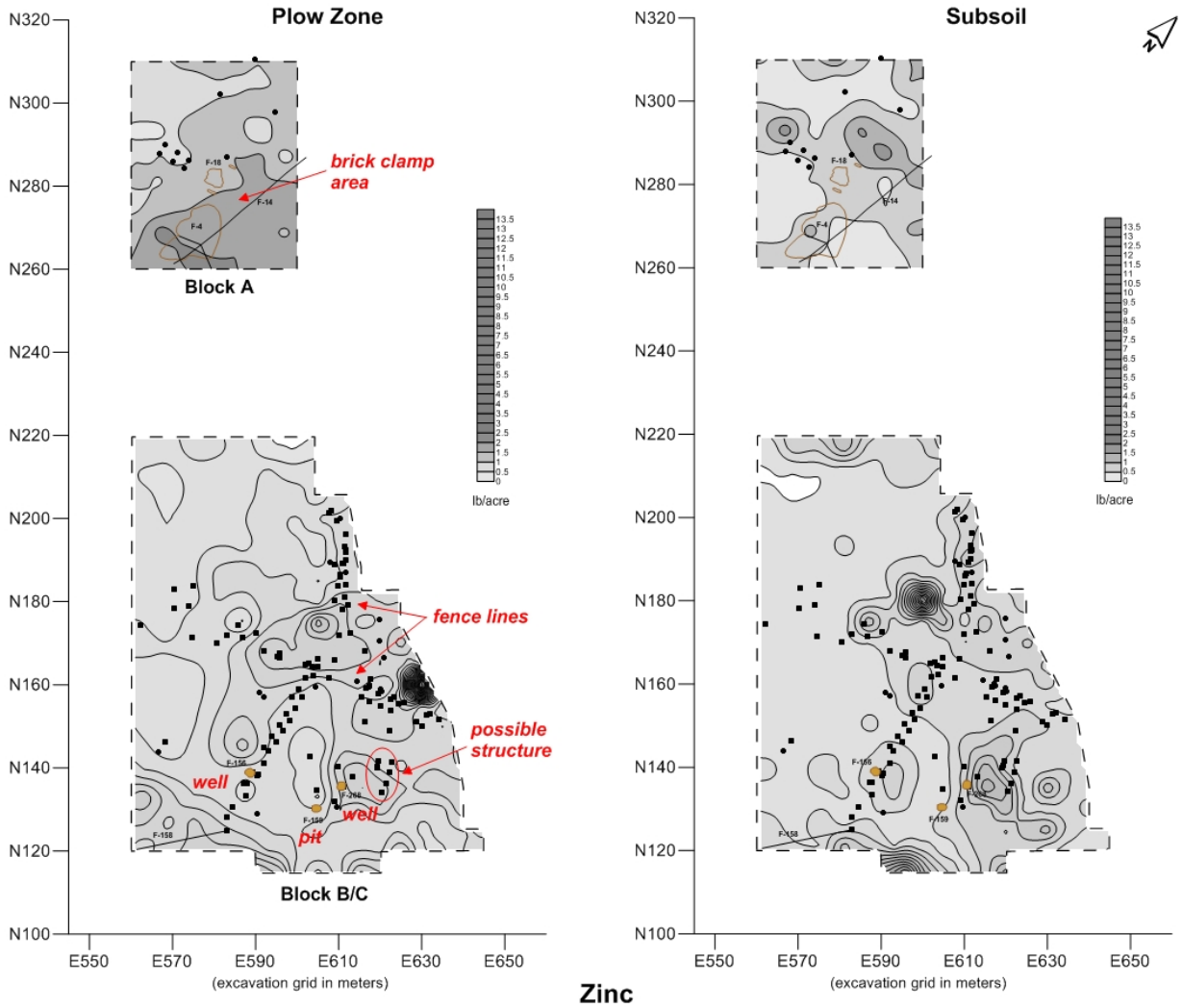

Figure 8-23. Zinc Levels within Plow Zone and Subsoil Contexts.

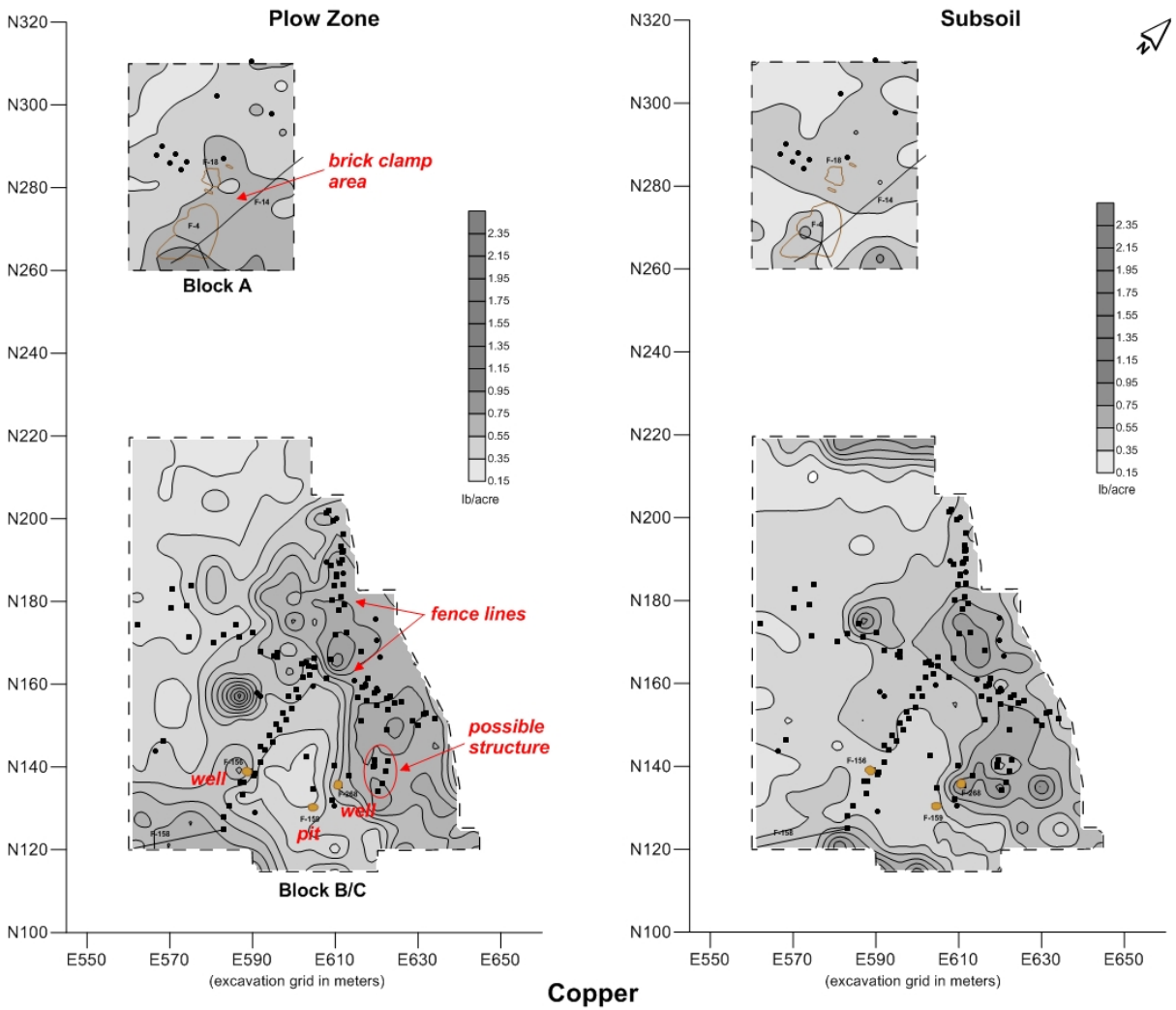

Figure 8-24. Copper Levels within Plow Zone and Subsoil Contexts.

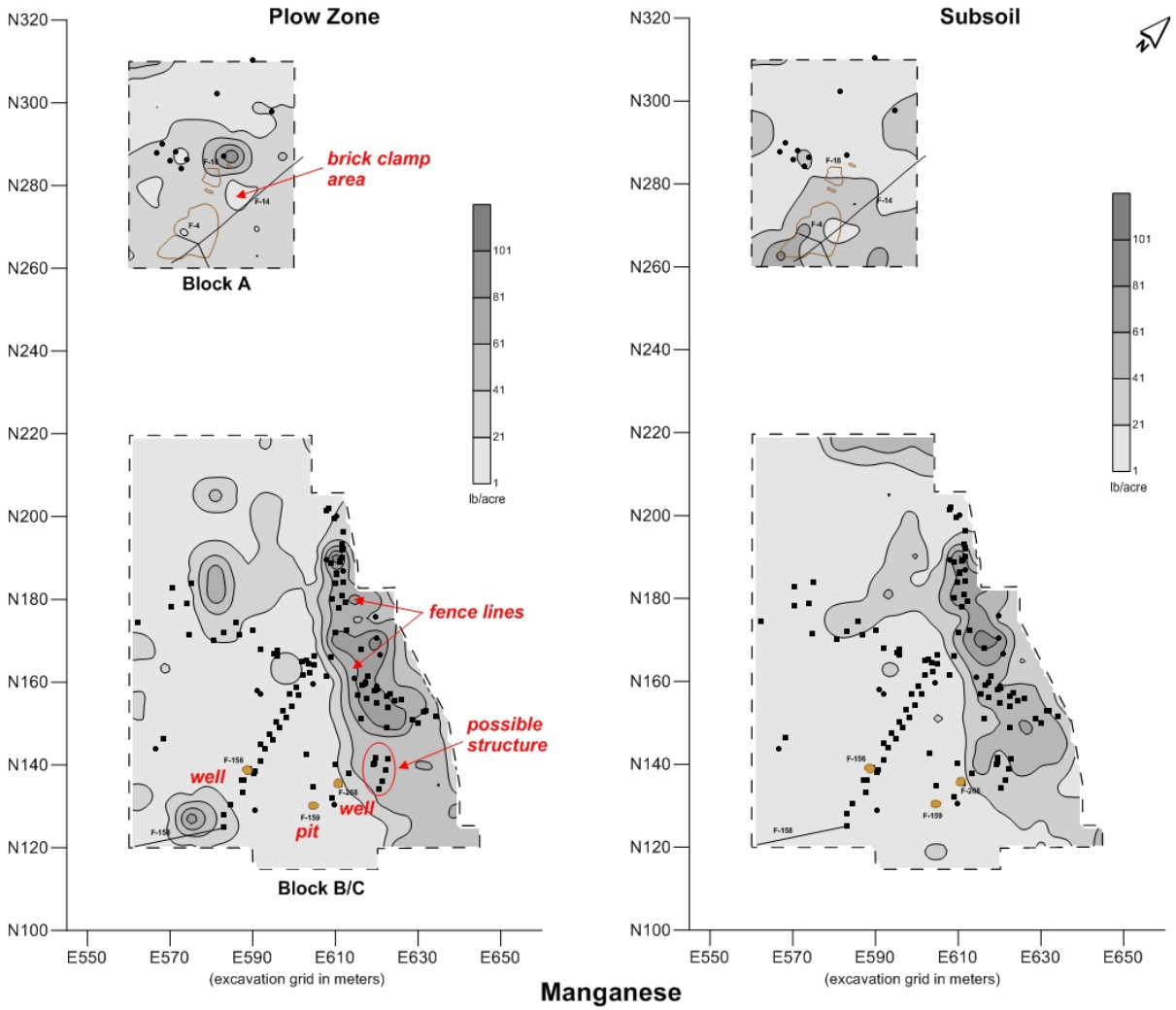

Figure 8-25. Manganese Levels within Plow Zone and Subsoil Contexts.

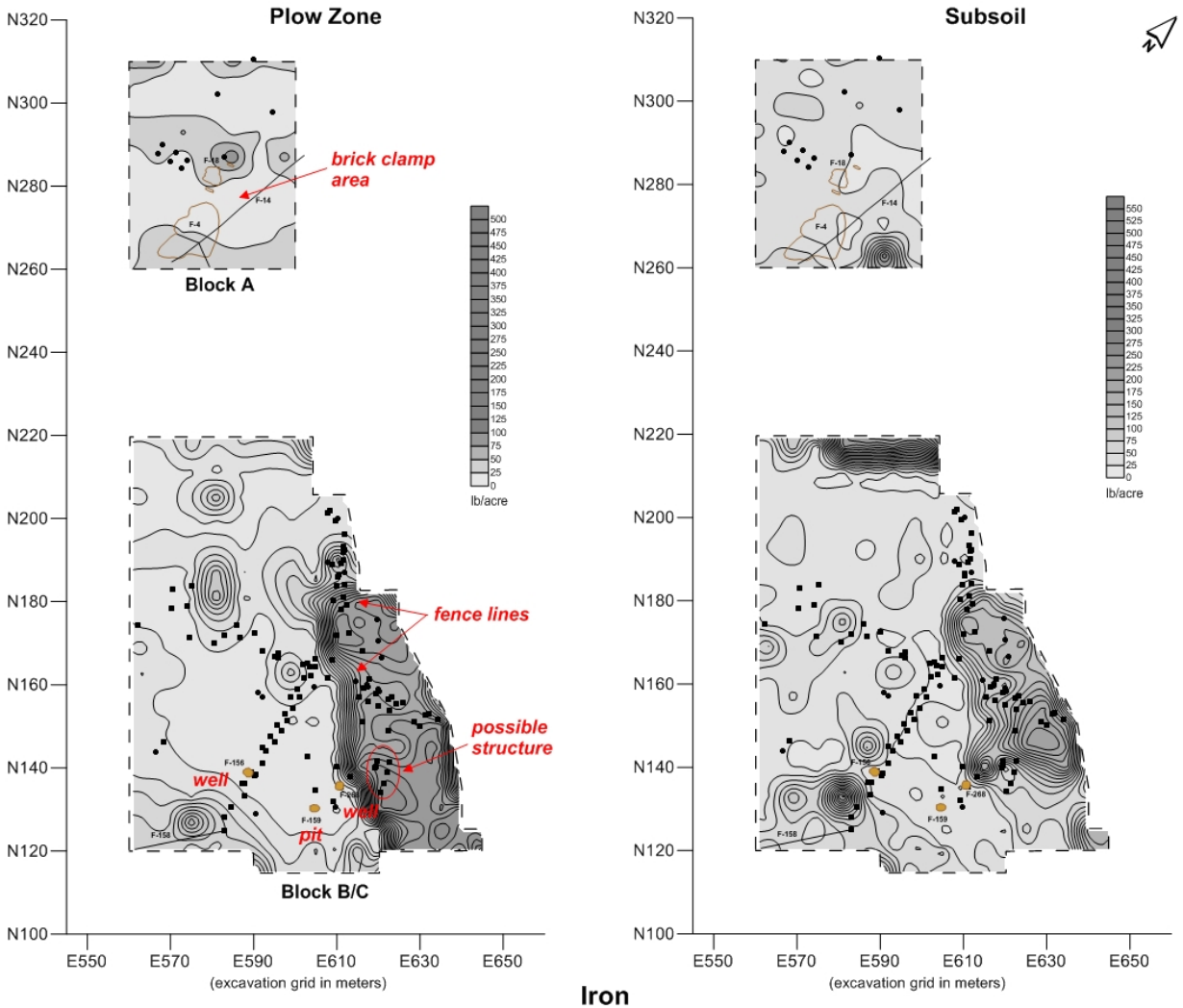

Figure 8-26. Iron Levels within Plow Zone and Subsoil Contexts.