



Michigan Technological University
Create the Future Digital Commons @ Michigan Tech

Dissertations, Master's Theses and Master's
Reports - Open

Dissertations, Master's Theses and Master's
Reports

2004

Waterpower : a geophysical and archaeological investigation of the waterpower system at the West Point Foundry, Cold Spring, New York

Kimberly A. Finch
Michigan Technological University

Follow this and additional works at: <https://digitalcommons.mtu.edu/etds>



Part of the [Archaeological Anthropology Commons](#)

Copyright 2004 Kimberly A. Finch

Recommended Citation

Finch, Kimberly A., "Waterpower : a geophysical and archaeological investigation of the waterpower system at the West Point Foundry, Cold Spring, New York", Master's Thesis, Michigan Technological University, 2004.

<https://digitalcommons.mtu.edu/etds/307>

Follow this and additional works at: <https://digitalcommons.mtu.edu/etds>



Part of the [Archaeological Anthropology Commons](#)

WATERPOWER: A GEOPHYSICAL AND ARCHAEOLOGICAL INVESTIGATION
OF THE WATERPOWER SYSTEM AT THE WEST POINT FOUNDRY, COLD
SPRING, NEW YORK.

By
Kimberly A. Finch

A THESIS
Submitted in partial fulfillment of the requirements
for the degree of
MASTER OF SCIENCE IN INDUSTRIAL ARCHAEOLOGY

MICHIGAN TECHNOLOGICAL UNIVERSITY

2004

© 2004 Finch

This thesis, "Waterpower: A Geophysical and Archaeological Investigation of the Waterpower System at the West Point Foundry, Cold Spring, New York" is hereby approved in partial fulfillment of the requirements for the Degree of MASTER of SCIENCE IN INDUSTRIAL ARCHAEOLOGY

DEPARTMENT: Social Sciences
Industrial Archaeology

Signatures:

Thesis Advisor

Dr. Susan Martin

Department Chair

Dr. Bruce Seely

Date

Acknowledgements

I would like to thank the Scenic Hudson Land Trust, Inc. for providing me with the opportunity to work on this project. Special thanks to my advisor, Dr. Susan Martin, who suffered through endless thesis drafts and provided support during the writing process. My committee, which consisted of Dr. Susan Martin, Dr. Patrick Martin, Dr. Timothy Scarlett, and Dr. Terry Reynolds provided support and input throughout the project. Thanks also go to Dr. Charles Young, who guided geophysical surveys at the foundry and assisted with data interpretation. This project would not have been successful without the incredible dedication shown by the field crew, who suffered through incessant rain, my germs, deer ticks, and incredibly powerful chili. The crew included Rachel Herzberg, David Vago, Steve Ftacilas, Mike Deegan, Pat Baird, Joe Wilson, and John Krenzel. Special thanks also go to Industrial Archaeology graduate Elizabeth Norris, who's invaluable help in the field and reminders of large chicken-like birds kept me smiling. I would like to express my gratitude to volunteers who gave their time to the project: Steve Walton, Barbara Smith, Jennifer Bollen, Leah Baird, Thomas Rushford, Jan Thacher, and Gerald Greer.

I would also like to extend thanks to my friends at Tech and in Ontario, all of whom made sure I maintained my sanity while I wrote my thesis. Thanks to Katie, who provided support through good times and bad, and made sure that our Thursday nights were still full of climbing, good food, and ER. To Alicia, my AWOL climbing partner and Thursday night partner in crime who endured endless questions about maps and Microsoft Word. Grazie to my housemates Cristina and Rachel, who put up with endless paper sprawl and didn't complain when I turned the kitchen into my office during the winter. Thanks also to the folks back in Ontario (who I forgive for pointing out that it was warmer there) for letting me drag them to MEC and stay at their houses whenever I

made it home. To my parents, for an endless supply of cookies and Tim Horton's hot chocolate. And to Andy, who provided support throughout the year and made sure that I made it out of Houghton every now and then.

Abstract

Waterpower: A Geophysical and Archaeological Investigation of the Waterpower System at the West Point Foundry, Cold Spring, New York, describes the results of ground penetrating radar surveys and archaeological excavation undertaken by Michigan Technological University (MTU) archaeologists during the summer of 2003 at the West Point Foundry, Cold Spring, New York. 2003 constituted MTU's second field season at the foundry. Fieldwork concentrated on the foundry's waterpower system, an intricate network of surface and subsurface drains, races, flumes, waterwheels, turbines, dams, and ponds that powered operations and regulated water flow throughout the site. Archaeologists utilized non-destructive geophysical technology, which expedited survey, facilitated placement of excavation units, and provided a model for future archaeogeophysical research at industrial sites. Features discovered during excavation provided valuable information pertaining to the waterpower system's construction and its functions. Data from ground penetrating radar surveys, archaeological excavation, historical photographs, documents, and maps permitted the development of a provisional chronology of the development of various components of the West Point Foundry's waterpower system. Information gathered during this project serves as an aid in site interpretation and rehabilitation.

Table of Contents

ACKNOWLEDGEMENTS	i
ABSTRACT	iii
CHAPTER 1: INTRODUCTION	1
Research Goals	1
Thesis Organization	3
CHAPTER 2: SITE DEVELOPMENT	5
Site Location	5
Physiography of the Hudson River Valley	7
Prehistoric Occupation of the Hudson Valley	8
Pre-Industrial Land use and the Development of Industrial Infrastructure ..	10
The Industrial Landscape, 1817 to 1960	12
The Post-Industrial Landscape: Excavation and Preservation	15
CHAPTER 3: ARCHAEOGEOPHYSICS	19
Geophysics and Archaeology: An Introduction	19
A History of Geophysics in Archaeology	20
Methodology	22
Resistivity	23
Ground Penetrating Radar(GPR)	26
Magnetometry	34
The West Point Foundry: Choosing a Geophysical Method	36
CHAPTER 4: GPR SURVEYS AT THE WEST POINT FOUNDRY 39	
Equipment	39
Methodology	40
GPR Project Descriptions	43
Project One	43
Project Two	45
Project Three	48
Project Four	50
Project Five	53
Project Six	55
Project Seven	58
Project Eight	61
Project Nine	65
Conclusions	69

CHAPTER 5: EXCAVATION	73
Excavation Goals and Methodology	73
Description of Excavation Units	77
The Boring Mill: Unit 4A and Feature One	77
Unit 4B	83
Unit 4C	86
Unit 4D	88
The Power House: Unit 10A	94
The Boiler House: Unit 15A	97
Battery Pond: Shovel Test Pit 1 (STP1)	100
Artifact Categorization	103
The 2003 Assemblage	107
Summary of Artifacts by Functional Category	108
Conclusion	110
CHAPTER 6: THE WEST POINT FOUNDRY WATERPOWER SYSTEM	112
Section One: An Examination of Waterpower in Four Activity Areas	114
I. The Furnace and Battery Pond	114
II. The Blacksmith Complex	127
III. The Boring Mill	131
IV. The Power House	135
Other Water-Related Features: Feature Thirteen, Fire Plugs, and Feature Twenty	139
Feature Thirteen	139
Fire Plugs	140
Feature Twenty	141
A Provisional Summary of Water Flow Throughout the West Point Foundry	143
Section Two: A Provisional Overview of the Development of the West Point Foundry Waterpower System	145
Section Three: Waterpower in the Nineteenth Century: Developing an Historical Context for the Waterpower System at the West Point Foundry	146
The Adirondack Iron and Steel Company, New York	148
The Burden Waterwheel, New York	149
The Dover Union Mill, Massachusetts	149
The Hopewell Furnace, Pennsylvania	151
The Tredegar Iron Works, Virginia	151
Conclusion	153

CHAPTER SEVEN: CONCLUSIONS	155
Recommendations for future research	159

REFERENCES

Books, Magazines, Journals, Theses, Letters, Presentations and Site Reports

Internet Resources

Historic Maps, Photographs, and Paintings

APPENDIX A: MAPS ILLUSTRATING THE SEQUENCE OF DEVELOPMENT AT THE WEST POINT FOUNDRY

APPENDIX B: 2003 ARTIFACT CATALOG

APPENDIX C: 2003 FEATURE DATABASE

List of Figures

Figure 3-1	Diagram illustrating the principles of measuring resistivity	24
Figure 3-2	Illustration of the Wenner, twin-electrode, and square resistivity arrays	26
Figure 3-3	Antenna propagation and reflection along a GPR transect	27
Figure 3-4	Soil radar arrangement	29
Figure 3-5	Resolution of a top and bottom interface at differing frequencies ...	29
Figure 3-6	Typical anomalies observed in GPR data	31
Figure 3-7	Calculating velocity based on two-way travel time	32
Figure 4-1	Photograph of the Smart Cart and Noggin ^{Plus} radar system	40
Figure 4-2	Sketch map of GPR project one	44
Figure 4-3	Sketch map of GPR project two	47
Figure 4-4	Sketch map of GPR project three	49
Figure 4-5	Sketch map of GPR project four	52
Figure 4-6	Sketch map of GPR project five	54
Figure 4-7	Sketch map of GPR project six	57
Figure 4-8	Sketch map of GPR project seven	59
Figure 4-9	Depth section illustrating a possible subsurface drain, GPR project seven, line three	60
Figure 4-10	Sketch map of GPR project eight	62
Figure 4-11	Depth section illustrating a point reflection within an area of depressed soil, GPR project eight, line zero	64
Figure 4-12	Sketch map of GPR project nine	66
Figure 4-13	Depth section illustrating chaotic anomalies, GPR project nine, line four	67
Figure 5-1	MTU excavation level form	76
Figure 5-2	Illustration of excavation units at the boring mill	78
Figure 5-3	Photograph of Feature One, tailrace inlet in boring mill	80
Figure 5-4	Planview drawing of the eastern wheelpit wall	80
Figure 5-5	Planview drawing of Feature One	82
Figure 5-6	Eastern waterwheel pit, north wall profile	82
Figure 5-7	Photograph of Feature Twelve, unit 4B	83
Figure 5-8	Planview drawing, Feature Twelve	84
Figure 5-9	Resistivity plot illustrating area of low resistivity east of the boring mill	87
Figure 5-10	Wall profiles, unit 4C	88
Figure 5-11	Wall profiles, unit 4D	89

Figure 5-12	GPR depth section, project six, line 0	90
Figure 5-13	Photograph of Feature Four, unit 4D	93
Figure 5-14	Wall profiles, unit 10A	95
Figure 5-15	Photograph of drain in unit 10A	97
Figure 5-16	GPR depth section, project five, line 0	98
Figure 5-17	Wall profiles, unit 15A	99
Figure 5-18	Photograph of flooding in unit 15A	100
Figure 5-19	GPR depth section, project seven, line 3	101
Figure 5-20	Wall profiles, STP1	102
Figure 5-21	Photograph of top of stone drain, STP1	103
Figure 5-22	Conceptual cross-section of STP1	103
Figure 5-23	Historic artifact catalog card utilized by MTU	105
Figure 6-1	1865 Painting of the foundry furnace by John Gadsby Chapman	117
Figure 6-2	Planview drawing of the furnace tailrace and surrounding area	118
Figure 6-3	Photograph of Feature Sixteen	119
Figure 6-4	Planview drawing of area south of the furnace, including stone drains	120
Figure 6-5	Planview drawing of area south of Battery Pond	122
Figure 6-6	Photograph of lower dam	123
Figure 6-7	Photograph of iron pipe, west bank of Foundry Brook	123
Figure 6-8	Photograph of iron pipe in middle dam	124
Figure 6-9	Illustration of a furnace and blast bellows	125
Figure 6-10	Illustration of a blast furnace interior	125
Figure 6-11	Catalan forge and trompe	126
Figure 6-12	Photograph of Feature Three, looking north	129
Figure 6-13	Photograph of Feature Three, looking west	129
Figure 6-14	Illustration of a tilt hammer	130
Figure 6-15	Illustration of a smith shop layout	130
Figure 6-16	Photograph of trench in unit 10A	131
Figure 6-17	Undated image of the West Point Foundry boring mill	134
Figure 6-18	Horizontal boring machinery	134
Figure 6-19	Planview drawing of boring mill	135
Figure 6-20	Photograph of presumed masonry flume support	138
Figure 6-21	Photograph of presumed masonry flume support	138
Figure 6-22	Hypothetical composite photograph showing iron flume entering power house	139
Figure 6-23	Photograph of Feature Thirteen	140
Figure 6-24	Photograph of fireplug	141

Figure 6-25	Photograph of fireplug	142
Figure 6-26	Planview drawing of Feature Twenty	142
Figure 6-27	Photograph of Feature Twenty	142
Figure 6-28	Cross-section of elevation changes in Foundry Brook, 2003	143

List of Tables

Table 3-1	Resistivity and conductivity values in soil	23
Table 3-2	Radar wave velocity of geological materials	28
Table 5-1	Mean percentages of artifacts from the West Point Foundry industrial pattern, the Carolina pattern, and the Frontier pattern	106
Table 5-2	Suggested categories for artifact classification at the West Point Foundry	107
Table 5-3	Artifact totals and percentages by excavation unit	108
Table 5-4	Artifact classes as a percentage of excavation unit totals	108
Table 5-5	Correlation between geophysical evidence, excavation units, and features	110
Table 6-1	Discharge measurements of Foundry Brook, Putnam County, Cold Spring, New York, 1954	115
Table 6-2	Provisional chronology of the development of the West Point Foundry Waterpower system	147

List of Maps

Map 2-1	The village of Cold Spring, New York, with an outline of the West Point Foundry site	6
Map 4-1	West Point Foundry Survey Map, illustrating GPR project locations	41
Map 5-1	Site map illustrating location of 2003 excavation units	74
Map 6-1	West Point Foundry dams and storage ponds along Foundry Brook	115
Map 6-2	Provisional map of the West Point Foundry waterpower system	144

Chapter 1 Introduction

During the summer of 2003, archaeologists from Michigan Technological University (MTU) returned to the West Point Foundry site in Cold Spring, New York. Archaeological research built upon recommendations made by MTU graduate student Alicia Valentino in 2002. Valentino's 2002 survey map identified several nonfunctioning components of the foundry's waterpower system, including large areas of water pooling near Battery Pond and other areas of the site. To help engineers learn about proper flow at the site, Valentino suggested utilizing the 2002 survey map, geophysical technology, and excavation.¹ Following these recommendations, the second field season entailed ground penetrating radar surveys, mapping, and archaeological excavation in several areas associated with the water system at the foundry site.

Research Goals

Two research goals guided the 2003 project: 1) to assess the applicability of GPR surveys on industrial sites, and 2) gain a clearer understanding of the location, construction details, and function of components of the foundry's waterpower system.

1. The applicability of GPR surveys on industrial sites:

Industrial sites such as the West Point Foundry pose interesting problems for archaeologists. These often large sites contain remnants of standing structures, machinery, large iron artifacts, and buried foundations. The time consuming and expensive nature of excavation rarely permits extensive subsurface investigation. Geophysical methods such as ground penetrating radar enable evaluation of large sites,

¹ Valentino, Alica. "Visualizing the Past at the West Point Foundry. Cold Spring, New York." Master's thesis, Michigan Technological University, 2003. P. 100.

and often provide archaeologists with enough data to conduct excavation without unnecessarily destroying subsurface contexts. This is especially important on sites such as the West Point Foundry, which has been designated as an archaeological park and land preserve by the Scenic Hudson Land Trust, Inc. The 2003 ground penetrating radar surveys at the West Point Foundry informed decisions concerning where to place excavation units. The West Point Foundry ground penetrating radar survey provides a model for future archaeogeophysical survey on industrial sites.

2. Understanding the West Point Foundry Waterpower System

Despite the growing popularity of steam power, the West Point Foundry site maintained a waterpower system throughout the nineteenth century. Storage ponds, dams, flumes, races, drains, waterwheels, and turbines powered machinery throughout the site. Unfortunately, most of these features are no longer evident, and historical documents do not clearly demonstrate when foundry proprietors installed various components or how they functioned.

In 2003, archaeologists generated detailed drawings and conducted excavations at several areas and features associated with the waterpower system. Subsurface stone drains, a tailrace inlet, a possible tailrace outlet, and a wheel pit constitute some of the features identified by archaeologists near the furnace, Battery Pond, the blacksmith shop, the power house, the boring mill, and the boiler house. Discovery of these features permitted a clearer understanding of how engineers constructed components of the water system. Examination of waterpower systems at other nineteenth century foundries provided an historical context in which the West Point Foundry's continued use of waterpower could be evaluated. In concert with historic maps, examination of these features permitted the development of a provisional chronology of the development of the waterpower system.

Thesis Layout

Chapter Organization

Chapter 2, *Site Development*, discusses the history of the West Point Foundry, highlighting past archaeological research conducted at the site. Past investigations focused upon industrial structures, worker housing, and foundry products, but did not include an in-depth examination of features related to the waterpower system, an integral part of operations throughout the foundry's history. For purposes of site interpretation and reconstruction, investigation of the foundry's waterpower system constituted a logical research objective during the first season of archaeological investigation. Due to the size of the site and number of areas archaeologists needed to investigate, archaeologists employed a geophysical technique.

Chapter 3, *Archaeogeophysics*, provides an introduction to archaeogeophysics, including a history of its development since the early twentieth century. This chapter evaluates resistivity, magnetometry, and ground penetrating radar, and offers an explanation as to why MTU archaeologists chose ground penetrating radar for the West Point Foundry. Chapter 4, *Ground Penetrating Radar Surveys at the West Point Foundry*, discusses the ground penetrating radar surveys conducted at the foundry in 2003. Results of these surveys informed the location of archaeological excavation, which is discussed in chapter 5, *Excavation*.

Chapter 6, *The West Point Foundry Waterpower System*, integrates historical, geophysical, and archaeological evidence into a technological and chronological analysis of features of the foundry's waterpower system. This chapter also discusses waterpower technology and systems at nineteenth century iron foundries in New York, Massachusetts, Pennsylvania, and Virginia, providing an historical context for the West Point Foundry.

Chapter 7, *Conclusions*, summarizes research conducted during the 2003 field season and revisits research questions posed in the introduction. This chapter also provides recommendations for future research.

References

References are organized into three categories:

Books, magazines, journals, theses, manuals, letters, and site reports

Internet Resources

Maps, Photographs, and Paintings

Appendices

Appendix A consists of a compilation of maps by Valentino, 2002, that illustrate the sequence of development at the West Point Foundry from 1840 through 1927.

Appendix B consists of the 2003 historic artifact catalog. The catalog lists artifacts by functional type by excavation unit and stratigraphic levels.

Appendix C consists of the 2003 feature database. This consists of photographs and references to illustrations of features recorded during fieldwork.

Chapter 2

Site Development

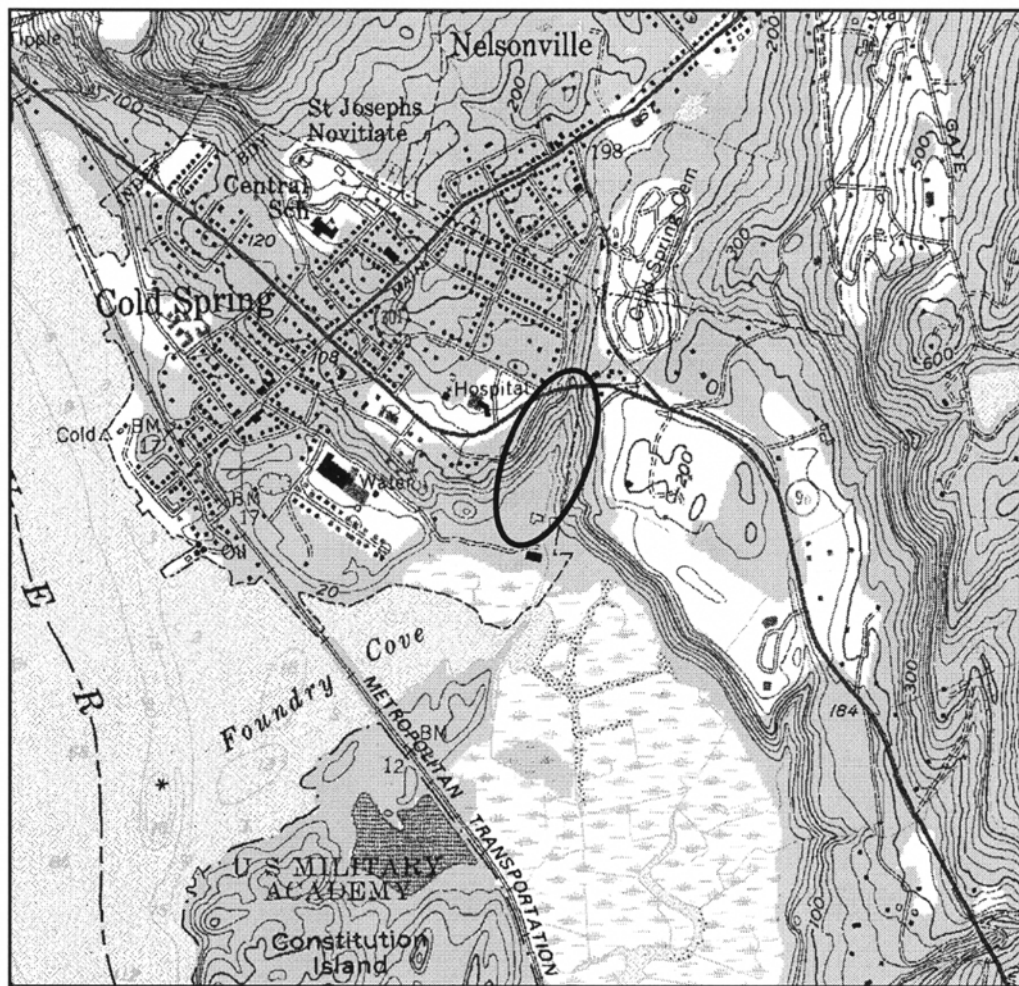
Located in the Hudson Highlands in the southeastern part of New York State, the West Point Foundry lies within an area rich in natural and cultural heritage. Long before industrial capitalists entered the region, Native American groups inhabited the valley, drawn by an abundance of resources. Thousands of years later, Europeans arrived in eastern New York State and vied for the same resources as Native Americans. As the nation recovered from the American War of Independence and the War of 1812, political and military interests looked to Cold Spring as a viable location for ordnance production; its topography, mineral and timber resources, and natural transportation corridor met industrial needs for power and materials.

For over one hundred years the West Point Foundry site supported industrial activities ranging from iron founding to metal furniture production and battery manufacturing. Although the site sits unoccupied early in the twenty-first century, building foundations and walls, dams, scatters of smelting debris and tools hint at this once bustling and nationally-important enterprise. Today, archaeologists map the valley floor, reading the industrial clues so that the nation may reclaim the history of the West Point Foundry.

Site Location

The West Point Foundry is located at 41.42N and 73.955W, next to the village of Cold Spring, New York. The 89 acre site occupies a steep valley bounded by the village of Cold Spring to the north and east, the Hudson River to the west, and Foundry Cove marsh to the south. The complex is bisected by Foundry (previously Margaret's) Brook,

The village of Cold Spring, New York, with an outline of the West Point Foundry site. Based on a map by the United States Geological Survey. Adapted by Finch, 2004.



1 Mile
Scale 1:24,000



Portion of
West Point Quadrangle
New York

1957
Photorevised 1981



Outline of approximate location
of the West Point Foundry

Map 2-1: The village of Cold Spring, New York, with an outline of the West Point Foundry

located three quarters of a mile from the village of Cold Spring (Map 2-1). Incorporated in 1846, Cold Spring lies within Putnam County, 55 miles north of New York City and approximately 100 miles south of Albany.

Physiography of the Hudson River Valley

Traversing three hundred and fifteen miles from the Adirondacks to Manhattan Island, the glacially formed Hudson River valley provided resources that supported the region's economies for the last 11,000 years. Steep and rocky ranges, separated by narrow sand-loam filled valleys, characterize the region's topography. Lower sedimentary or metamorphic series rock, such as granite, gneiss, granular quartz, talcose slate, and metamorphic limestone, predominate.¹ Well drained and permeable sandy and gravelly loam, the majority of which consist of Charlton loam, Chatfield complex and Hillis Outcrop series soils, is found on valley floors.² The Hudson valley is also rich in minerals, especially iron ore.

A temperate-deciduous forest environment supports smaller mammals, including the white-tailed deer, black bear, wild turkey, rabbits, raccoons, porcupine, and skunk.³ Fed from the upper branches of the Croton River and several small streams and tributaries, the Hudson River supports over one hundred species of fish. Just as the Hudson currently serves as an important economic artery for eastern New York State, the

¹ French, J.H. *Gazetteer of the State of New York: Embracing A Comprehensive View of the Geography, Geology, and General History of the State and A complete History and Description of Every County, City, Town, Village and Locality. With Full Tables of Statistics.* (Syracuse, New York: R. Pearsall Smith, 1860), 540 - 543.

² http://putnamvalley.com/archives/master_plan/1990/master_plan_natural.html

³ Eisenberg, Leonard A. "Physiography and Prehistory of the West Point Foundry Site" in Rutsch, Edward S., JoAnn Cotz, and Brian H. Morrell with Herbert J. Githens and Leonard A. Eisenberg. *The West Point Foundry Site Cold Spring, Putnam County, New York.* (Newton, New Jersey: Cultural Resource Management Services, 1979), 270.

area's earliest inhabitants utilized the rich resources of the Hudson River valley for subsistence and trade beginning over 11,000 years ago.

Prehistoric Occupation of the Hudson Valley

As Pleistocene ice sheets retreated, Native American populations moved into the area that is now New York State. Artifacts discovered by archaeologists throughout the state suggest Paleo-Indian through Woodland occupation, although artifacts in the Hudson Valley provide more evidence of occupation during later Archaic and Woodland periods than Paleo-Indian.⁴

Characterized by small, nomadic groups subsisting primarily on large game, Paleo-Indian populations resided along the western side of the Hudson River, possibly because of poor drainage on the eastern bank.⁵ Five Paleo-Indian sites and several individual fluted points discovered in the Hudson Valley indicate that early occupation of this area occurred between 11,000 and 9,000 years ago.^{6,7}

The Archaic period, characterized by a warmer climate, economic diversification (smaller game such as deer and rabbits, along with nuts and berries), specialized tools for hunting, food preparation and storage, organized burials, and slightly larger population groups, occurred between circa 9,000 and 3,500 years ago.⁸ Radiocarbon dates associated with chipped stone tools such as bifurcated base points, choppers, and celts indicate that Early Archaic populations inhabited the Hudson valley between 9,000 and 7,000 years ago. Middle Archaic populations occupied the area between 6,500 and 5,000 years ago,

⁴ Rutsch et al. 1979: 273

⁵ Rutsch et al. 1979: 273.

⁶ Rutsch et al. 1979: 273

⁷ Thompson, John H., ed. *Geography of New York State* (Syracuse New York: Syracuse University Press, 1966), 113.

⁸ Thompson 1966: 113.

evidenced by radiocarbon dates of cultural remnants such as shell middens.

Archaeologists also discovered large broad-bladed points and large flat-bottomed soapstone vessels indicative of Late Archaic occupation in the valley between 5,000 and 3,500 years ago.⁹

The Woodland period, characterized by the appearance of ceramic vessels and increasingly sedentary populations, occurred between 3,500 and 550 years ago.¹⁰ Evidence of Woodland populations in New York lies within the Owasco culture in the central and western parts of the state. Large, permanent villages and evidence of maize, bean, and squash cultivation from circa 950 years ago characterize this culture pattern.¹¹ Ceramic fragments recovered in the Hudson Valley suggest Woodland occupation occurred in the Cold Spring area.

Several sites located near Cold Spring early in the twentieth century, along with more recent findings at the West Point Foundry site, indicate Native American occupation also occurred on the eastern banks of the Hudson River. In 1900, Beauchamp discovered three sites close to the village of Cold Spring; one two miles south, a second consisting of a copper knife located three miles north, and finally a camp on the outskirts of the village.¹² In 1920, Parker discovered four prehistoric sites near the foundry. Three sites consisted of burials in or near Garrison, and the other consisted of a campsite on Constitution Island.¹³

Excavation by Grossman and Associates, Inc. between 1989 and 1992 resulted in the discovery of prehistoric artifacts at the West Point Foundry site. Investigation beneath historic surfaces along one of the foundry's roads enabled the definition of a

⁹ Rutsch et al. 1979: 275, 276.

¹⁰ Thompson 1966: 113.

¹¹ Rutsch et al. 1979: 277, 278

¹² Rutsch et al. 1979: 279.

¹³ Rutsch et al. 1979: 279, 280.

4000 year sequence of cultural deposits and living floors from circa 3000 BCE to the first millennium CE.¹⁴ Diagnostic artifacts recovered from these deposits included stone flakes from tool manufacture, prehistoric ceramic sherds, and projectile points.

Archaeologists also discovered an undisturbed living floor and artifacts that dated from the Middle Archaic, circa 2000 to 3000 BCE. An early pit and hearth feature, together with food processing tools, suggested that prehistoric settlements at the foundry probably consisted of permanent or semi-permanent living areas, not temporary encampments.¹⁵

Pre-Industrial Land Use and the Development of Industrial Infrastructure

European settlement along the Hudson River began in the 1620s, following Henry Hudson's voyage along the Hudson River in 1609.¹⁶ Early European settlers established small agricultural and lumbering communities along the river valley, relying on the Hudson for transportation, as roadways were poor or nonexistent until the early nineteenth century.¹⁷

The area of present day Cold Spring went through several phases of ownership both before and after its incorporation as a village in 1844. In 1677, the British Crown awarded the first land grant in this area to Adolph Philipse. During the eighteenth century, Frederick Philipse inherited one third of Adolph's land and divided it into lots for purchase.¹⁸ In 1772, this area was incorporated as the Philipse Precinct, which it remained until 1778 when incorporated as the newly established Philipstown.

¹⁴ Grossman, Joel W. *The Archaeology and Economic History of the Civil War Era Workers Housing Complex at the West Point Foundry, Cold Spring, New York*. (New York: Grossman and Associates, Inc. 1993), viii. "BCE" represents 'before common era' (also referred to as BC), and "CE" represents 'common era' (also known as AD)

¹⁵ Grossman 1993: viii.

¹⁶ Thompson 1966: 121.

¹⁷ Rutsch et al. 1979: 21.

During the American War of Independence, the military recognized that the Hudson River valley near Philipstown made a viable defense point against British troops travelling along the river. At the West Point Military Academy, the Hudson River narrowed and enabled artillery batteries to control the channel. The army also laid an iron chain across the Hudson at this point, which added to the area's defenses. Efforts proved successful, as the British did not launch an attack up river during the war.

The first half of the nineteenth century saw the development of political boundaries in the Hudson Highlands that remain today. Putnam County, which included Philipstown, was established on June 12, 1812. Soon after, settlers established small commercial buildings and residences, and by 1817 sources indicated that a waterpowered sawmill operated on Margaret's Brook. In 1844, officials drew up the charter establishing the village of Cold Spring.

As settlement increased and larger commercial and industrial enterprises were established in the eastern United States, the need for improved transportation corridors also increased. The Philipstown Turnpike Company established the first road connecting Putnam County to other parts of the state in 1815.¹⁹ In northern New York State, the Champlain Canal was completed in 1823, followed by the Erie Canal to the west in 1825. The Delaware and Hudson Canal opened access from Honesdale, Pennsylvania to the Hudson near present day Kingston in 1828. And in 1834 and 1838, the Delaware & Raritan Canal and the Morris Canal opened coal routes into New York City. Rail transport followed suit, with the opening of the Erie Railroad in 1843 and the New York-Hudson line in 1848-49.²⁰ The New York-Hudson Line, along with the construction of a large dock at Cold Spring in 1843, supported development of large-scale industrial

¹⁸ Rutsch et al. 1979: 23.

¹⁹ Rutsch et al. 1979: 24.

²⁰ Norris, Elizabeth. "An Historical and Industrial Archaeology Strategy for the West Point Foundry Site, Cold Spring, New York." Master's Thesis, Michigan Technological University, 2002: 48.

enterprises such as the burgeoning West Point Foundry.

The Industrial Landscape, 1817 to 1960

Natural resources, as well as the proximity of the Hudson River made the Cold Spring area well suited for industrial activity. The advantageous topography of the Hudson Valley, with steep hills and valleys, held great potential for the development of water powered complexes. Initially abundant mineral and timber supplies provided low start-up costs for industries. And the Hudson River provided a natural transportation corridor for shipping and receiving industrial products, supplies, and fuel.

The proximity of the West Point Military Academy also proved advantageous to the development of an iron foundry at Cold Spring. President James Madison recognized the protection afforded by the military academy as a key reason to place a foundry in Cold Spring. Evidence of military influence on the foundry's conception is reflected in early production orders; one third of the foundry's ordnance casting was for the government.²¹

The history of the West Point Foundry can be divided into six phases of ownership, beginning with its conception in 1817 and concluding with current preservation efforts initiated by the placement of the foundry site on the National Register of Historic Places (NRHP) in 1973 and the foundry's purchase by Scenic Hudson Land Trust, Inc., in 1996.

Recognizing the industrial advantages of the Hudson River Valley, the Board of Naval Commissioners assigned iron master and engineer Gouveneur Kemble the task of establishing a foundry for ordnance production in Cold Spring, New York. Captain

²¹ Rutsch et al. 1979: 19.

Philipse granted two hundred acres of land surrounding Margaret's Brook to Kemble in June of 1817.²²

Under the direction of Gouveneur Kemble, the first twenty-seven years of the foundry's existence saw rapid increases in production facilities and capabilities, personnel, and capital. The first foundry buildings at the Cold Spring site included a molding house, pattern shop, boring mill, and a pattern vault, some of which were powered by water from Margaret's Brook. At this time, the foundry employed four hundred men in the production of ordnance, water pipes, steam engines, boilers, and mill parts.²³ The 1850 *US Census of Industry* listed production values totaling \$521,000.²⁴ In addition to the aforementioned buildings, by circa 1853 structures included a smith shop, boiler shop, carpenter shop, several foundry houses and storehouses, a turning shop, and an office.

During the early years of the foundry, production also occurred at several sites outside of Cold Spring. A New York City branch finished several items produced at the foundry in Cold Spring until 1838, when it moved operations to the Cold Spring site. Foundry owners expanded facilities between 1827 and 1832, purchasing Greenwood Ironworks in Orange County and leasing or purchasing Greenwood's associated mines.²⁵ Foundry superintendent and former Army ordnance inspector Robert Parrott purchased one-third interest in Greenwood and placed his brother, Peter Parrott, in charge of operations in 1836.²⁶ Robert Parrott purchased the remaining two-thirds interest in 1838. Managers also constructed a furnace at Woodbury, New York, which operated until 1846.

²² Valentino, 2003: 30.

²³ Rutsch et al. 1979: 85.

²⁴ Rutsch et al. 1979: 87.

²⁵ Rutsch et al. 1979: 35.

²⁶ Valentino 2003: 35.

Between 1857 and 1867, West Point Foundry's production peaked under the direction of Robert Parrott. Parrott took over as foundry director upon Kemble's retirement, and subsequently began development of the Parrott Gun. The rifled cannon, which fired a rotating and therefore highly accurate projectile, was so efficient that the foundry manufactured 20-, 30-, 100-, 200-, and 300-pound sizes during the American Civil War.²⁷ Aside from the successful Parrott Gun, the foundry also produced several thousand tons of iron and brass castings, forgings, and boilers with a production value of \$420,000 listed in the 1860 *US Census of Industry*.²⁸ Government purchases for the Civil War alone totaled approximately \$4,669,946.²⁹ The 1860 census listed 342 employees, with average monthly wages of \$11,000. In addition to previously existing buildings, the 1867 Beers map shows a testing facility, new offices, a stable, a gun shop, a casting shop, and a turning shop. In 1867, Kemble's four nephews assumed control of the foundry after Parrott withdrew as director.

Partially a result of the end of the Civil War and partially a result of the rise of the steel industry, the West Point Foundry declined under the direction of Kemble's nephews between 1867 and 1897. Despite a seven year contract, the foundry's overreliance on ordnance production and lack of capital to make the transition to steel resulted in the gradual demise of iron production at the site and at the Greenwood furnace, which closed in 1885. The 1870 *US Census of Industry* lists total production values of \$387,200 for pig iron, scrap iron, coal, and mill supplies.³⁰ Average yearly wages for four hundred and fifty men employed in 1870 were \$248,000.³¹ But the 1872, 1887 and 1897 Sanborn maps are not indicative of declining production, as they illustrated several buildings and

²⁷ Valentino 2003: 37.

²⁸ Rutsch et al. 1979: 94.

²⁹ Valentino 2003: 38.

³⁰ Rutsch et al. 1979: 99.

³¹ Rutsch et al. 1979: 99

features not evident on earlier maps, including tumblers, cranes, a gun boring shop, an iron turning and planing shop, an oil house, drying ovens, a sand house, a cupola shed, and a molding shop.

The final phase of foundry activity occurred between 1897 and 1920 under the Cornells. Between 1897 and 1905, J.B. and J.M. Cornell expanded the foundry complex with a Japanning shop, a bridge shop, and a small steel facility. Along with iron and steel for buildings, castings and ordnance, the Cornells began production of sugar mills.³² An anonymous map of the West Point Foundry site circa 1900 reveals a range of structures and features not included on previous maps. Between 1905 and 1911, the Baldwin Steel Company and the Cornell Art Metal Company operated at the site. In 1912, the Cornell Construction Company took control of the site, using only the bridge shop and one other building.³³

In 1920, the Astoria Silk Works purchased the site, followed by the Deuterium Corporation in 1960. Neither of these works utilized foundry buildings, so they fell into disrepair, a change that is evident in a comparison of the 1912 Sanborn Map created at the end of the Cornell period and the 1927 Sanborn map. Occupation of the site by the Deuterium Corporation, operating as the Marathon Battery Company in the 1960s, resulted in high levels of cadmium contamination in the southern portion of the site along Foundry Brook and in the adjacent marsh, leading to subsequent environmental and, eventually, historical stabilization efforts at the site.

The Post-Industrial Landscape: Excavation and Preservation

The last decades of the twentieth century brought new life to the deteriorating West Point Foundry site. Placed on the National Register of Historic Places in 1973, the

³² Valentino 2003: 40, and Rutsch et al., 1979: 124.

³³ Valentino 2003: 40.

site has since been the focus of several archaeological investigations, an Environmental Protection Agency (EPA) cleanup, and new ownership under the Scenic Hudson Land Trust Inc., an agency committed to preserving the biophysical and historical environments of the Hudson River Valley.

Archaeological work at the foundry began in 1979, under the Cultural Resource Management Service Incorporated (CRMSI) of Newton, New Jersey. CRMSI's primary goals included sampling foundry remains by means of site survey and limited test excavation. Archaeologists documented the location and spatial relations of foundry remains and conducted an architectural survey of the 1865 office building. CRMSI also investigated the site's hydropower system to better understand the system's layout and functions. Results of this project included the creation of the 1979 historic base map, a compilation of historic map data and 1979 survey data. Archaeologists also determined that the long brick mounds located throughout the site were the remnants of brick walls.³⁴

Based on the 1979 survey, CRMSI made several recommendations related to the foundry's waterpower system. To protect surface and subsurface remains from erosion, freeze, and thaw damage caused by unregulated surface and groundwater throughout the site, CRMSI recommended reestablishing site drainage. Suggested areas of investigation included the underground tailrace that drained water from the boring mill waterwheel pit, and drain trenches near the furnace and Battery Pond, and Battery Pond itself. CRMSI also recommended plotting these features on the historic base map.

Between 1989 and 1992, Grossman and Associates, Inc. conducted federally mandated archaeological investigations at the foundry site prior to an EPA cleanup of cadmium from the 1960's Deuterium occupation. Grossman's project, which included surveys, excavation, and preservation of remains and artifacts, provided insight into the social history of the site, including worker origins and housing. Archaeological

investigation of an isolated group of Civil War era worker's housing at the foundry site resulted in the recovery of 145, 000 Civil War era artifacts.³⁵ Artifacts included high status ceramic and glassware of primarily European origin, along with technical, scientific, and weapons-related tools and instruments, which suggested that an educated and sophisticated group of workers resided at the foundry.³⁶ Archaeologists identified the possible remains of one or two non-residential administrative technical support structures, a potential line of privies above the aforementioned worker's houses, and front yards of these houses.³⁷ The three year investigation also uncovered Robert Parrot's Civil War era gun testing or proofing facilities.³⁸

In 1996, Badey and Watson Surveying and Engineering P.C. completed a survey of the West Point Foundry for the new site owners Scenic Hudson Land Trust, Inc. The resulting map outlined property lines, and coordinated natural features and property boundaries.

After acquiring the site in 1996, the Scenic Hudson Land Trust, Inc. began development of an interpretive plan for the site in conjunction with ICON Architecture³⁹. Feeling that more information was needed about the site, Scenic Hudson sought a partnership with Michigan Technological University (MTU).

Since 2001, graduate students from MTU's Industrial Archaeology program have produced two masters theses on the West Point Foundry, providing a basis for interpretive planning at the site. In 2001, Elizabeth Norris surveyed historical documents at the Putnam County Historical Society and Foundry School Museum, the Office of the Putnam County Historian, as well as archives at the West Point Military Academy, New

³⁴ Rutsch et al. 1979: 11.

³⁵ Grossman 1993: ii.

³⁶ Grossman 1993: i, vi.

³⁷ Grossman 1993: 19.

³⁸ Grossman 1993: ii.

³⁹ Valentino 2003: 45.

York City, and Washington. Her research resulted in an interactive database of available resources titled *An Historical and Industrial Archaeology Research Strategy for the West Point Foundry Site, Cold Spring, New York*.

In 2002, graduate student Alicia Valentino guided MTU students through a five-week field season that entailed mapping the archaeological remains using a Total Station, the production of a photographic record of the site, as well as historical research at the Putnam County Historical Society and Foundry School Museum and the Office of the Putnam County Historian. Research culminated in an up-to-date map of surface archaeological features and a master's thesis entitled *Visualizing the Past at the West Point Foundry, Cold Spring, New York*.

Conclusion

Historical and archaeological investigation of the West Point Foundry has provided essential information concerning the site's prehistoric, historic, and industrial land uses, as well as its layout and function. Fieldwork conducted by MTU during the summer of 2003, which built upon research and recommendations by CRMSI and MTU graduate students, concentrated on identification and investigation of the foundry's waterpower system. Ongoing investigation continues to provide a broader basis for future investigation and interpretation.

Chapter 3 Archaeogeophysics

Archaeologists frequently do not have enough time, money, or crew members to excavate large areas of a site. Nor is this always ethically acceptable. Faced with these limitations, extracting the maximum amount of data in an efficient manner requires cooperation between archaeology and sciences such as geophysics. Since the 1940s, geophysical methods such as resistivity, magnetometry, and ground penetrating radar have aided archaeological research, providing non-destructive means of locating and sometimes identifying sub-surface features.

Chapter three provides an introduction to archaeogeophysics, including a history of its development since the early twentieth century. As well, this chapter summarizes three geophysical techniques commonly used in archaeology: resistivity, ground penetrating radar, and magnetometry, with greater explanation of ground penetrating radar because of its use at the foundry. Chapter three concludes with an analysis of the applicability of geophysical techniques at the West Point Foundry.

Geophysics and Archaeology: An Introduction

Geophysics offers several forms of remote sensing, methods that permit non-invasive investigation of subsurface anomalies ranging from a few centimeters to a few hundred meters in depth. Based on the principle that all materials exhibit characteristic properties, geophysical methods measure physical contrasts due to variables such as mass-density relationships, ionic or electrical potentials, magnetic susceptibility, or elemental decay.¹ Geophysicists examine these variables by passively measuring the

¹ Heimmer, H.M.H, P.G., and Steven L. DeVore. *Near-Surface, High Resolution Geophysical Methods for Cultural Resource Management and Archaeological Investigations*, revised edition (Denver: National Park Service, 1995), 7.

effect of buried objects on the earth's electromagnetic field, or by actively putting electrical, magnetic, or acoustic signals into the ground and measuring the subsurface's response.

Archaeogeophysics refers to the application of geophysical exploration techniques, principles, and theory to archaeological contexts.² Excavation irreparably damages the contexts that archaeologists wish to study; geophysical methods present opportunities to learn about the subsurface without destroying it. Geophysical techniques also enable relatively fast data collection, saving time and money, commodities often lacking with archaeological fieldwork. Since its introduction into the field in the early twentieth century, archaeologists have relied upon geophysical prospection during field projects. More recently, geophysical techniques increasingly provide primary research data and inform cultural resource management strategies at historic sites.³

A History of Geophysics in Archaeology

As early as the seventeenth century, scientists employed geophysical methods for prospecting and analysis. Magnetic compasses used to locate iron deposits in Sweden constitute the first known use of geophysical prospecting.⁴ Later uses included the Italian scientist Folgheeraiter's use of magnetics for measuring magnetic signatures in Etruscan pottery in the nineteenth century.⁵

In the twentieth century, initial uses for geophysics included prospecting for buried objects such as pipes, tunnels, mine shafts, lithologic contacts, bedding planes,

² Kvamme, Kenneth L. "Current Practices in Archaeogeophysics: Magnetism, Resistivity, Conductivity, and Ground Penetrating Radar." In Paul Goldberg, et al. *Earth Sciences and Archaeology* (New York: Kluwer Academic/Plenum Publishers, 2001), 380.

Herz, Norman, and Ervan G. Garrison. *Geological Methods for Archaeology* (New York, New York: Oxford University Press, Inc., 1998), 147.

³ Kvamme 2001: 353, 354.

⁴ Heimmer et al. 1995: 2.

⁵ Herz and Garrison 1998: 5.

buried soil units, and depth to groundwater by geological and civil engineers.⁶ During the 1910s and 1930s, geophysical methods were increasingly applied to the search for petroleum and minerals. Equipment sensitivity and applications advanced as a result of World War Two; an electronic revolution resulted in more advanced sonar, radar, and magnetometry equipment. Since the 1960s, digital technology and computer processing have also enhanced the speed and reliability of data acquisition and processing.

Although initially used by geological and mining engineers, the potential benefits of geophysical techniques did not go unnoticed by archaeologists. These new, more precise geophysical methods held more potential than other remote sensing techniques such as aerial photography, which often did not provide enough detail for excavation. Although some authors cite Folgheeraiter's magnetics and Lieutenant General Augustus Pitt-Rivers' nineteenth century boring experiments, Richard Atkinson's resistivity surveys in the 1940s constitute the first modern use of geophysics in archaeology.⁷

Although geophysical methods were not immediately embraced by all archaeologists because of poor survey results, the second half of the twentieth century saw rapid improvements in geophysical technology and its use within archaeology. Atkinson's successful resistivity surveys, his development of transistorized equipment, and his theoretical study of electrode arrangement broke open the subfield of archaeogeophysics.⁸ Atkinson tackled problems associated with the application of geophysical laws to the small and shallow nature of archaeological deposits, helping coin the name "shallow geophysics."⁹

⁶ Conyers, Lawrence B. and Dean Goodman. *Ground Penetrating Radar: An Introduction for Archaeologists* (New York: Altamira Press, 1997), 2.

⁷ Schmidt, Armin. *Geophysical Data in Archaeology: A Guide to Good Practice* (Eynsham, Oxford: Oxbow Books, 2001), 6.

Heimmer, et al. 1995: 1.

⁸ Schmit 2001: 6.

⁹ Herz and Garrison 1998: 148.

The popularity of magnetometry on archaeological sites was reflected by increased use and new techniques in the 1950s, 1960s and 1970s. In 1958, Martin Aitkin began archaeological surveys using a proton magnetometer, which drew upon mine sweeper technology employed during World War Two. John Aldred and Frank Philpot developed methods for continuous data recording using a faster fluxgate magnetometer. Beth Ralph, Helmut Becker, and Peter Melichar introduced the alkaline vapor magnetometer in the 1970s, compensating for low sensitivity encountered with previous models.¹⁰

The 1970s also saw the first use of ground penetrating radar at archaeological sites in North America. A 1975 survey of buried walls at Chaco Canyon, New Mexico, marks one of the first archaeological applications of radar. Historical archaeologists embraced the new technique, using it to locate buried barn walls, stone walls, burials, and cellars.¹¹ A 1982-1983 survey of graves, artifacts, and house walls at a Basque whaling village in Red Bay, Labrador, pushed the limits of the technology; archaeologists gathered good data despite high moisture content and a cobbly matrix, proving the value of radar technology.¹²

Methodology

Active and passive geophysical methods consist of several techniques, each of which measures the variation of one physical parameter of the earth.¹³ Geophysicists use these techniques to examine the variables mentioned at the beginning of this chapter.

¹⁰ Schmidt 2001: 6.

¹¹ Conyers and Goodman 1997: 18.

¹² Conyers and Goodman 1997: 19.

Active Geophysical Methods

Active techniques introduce an electrical, electro-magnetic, or acoustic signal into the ground and measure the signal upon its return to the surface.¹⁴ Active methods most used in archaeology include resistivity and ground penetrating radar.

i) Resistivity

Resistivity measures the electrical resistance of the earth, and objects buried within, between two electrodes of different potentials.¹⁵ Resistance is highly dependent on the moisture content of the ground and the features within it; higher moisture content creates lower resistance, whereas dry ground creates a highly resistant environment which blocks transmission of electrical current. Different soils, sediments, and archaeological features such as brick and stone have distinct resistances to electrical conductivity; referred to as resistivity, these specific resistances enable comparison of different materials in a standardized way.¹⁶ Table 3-1 provides examples of resistivity and conductivity values in soils and sediments.

Soil	Resistivity in ohm-meters	Conductivity in mS/m
Sand, gravel	1000 - 10,000	0.1 - 1
Silty sand	200 - 1000	1 - 5
Loam	80 - 200	5 - 12.5
Silt	40 - 80	12.5 - 25
Clay	10 - 40	25 - 100
Saline soil	5 - 10	100 - 200

Table 3-1. Resistivity and conductivity values in soils. From: Bevan, Bruce W. Geophysical Exploration for Archaeology: An Introduction to Geophysical Exploration. Midwest Archaeological Center Special Report No. 1 (Lincoln, Nebraska: United States Department of the Interior, National Park Service, 1998), 8.

¹³Pasquinucci, Marinella and Frederic Tremont, eds. *The Archaeology of Mediterranean Landscapes 4: Non-Destructive Techniques Applied to Landscape Archaeology* (Oxford: Oxbow Books, 2000), 166.

¹⁴Heimmer, et al., 1995: 9.

¹⁵Herz and Garrison 1998: 11.

¹⁶Clark, Anthony. *Seeing Beneath the Soil: Prospecting Methods in Archaeology* (London: Routledge, 2001).

Minimal equipment and simple mathematical equations facilitate the use of resistivity in the field. A simple resistivity meter consists of a digital multimeter that measures voltage, current, and resistance; a battery that provides electrical current; four metal electrodes; and a wire that connects the battery to the electrodes.¹⁷ Surveyors record readings in milliAmperes (mA). More sophisticated models, which calculate resistance readings directly, consist of a self-contained battery and digital voltmeter. With any model, electrodes are inserted into the ground and current is passed through two of them; the remaining electrodes measure voltage loss resulting from lateral and vertical variation of buried materials.¹⁸ Resistance is calculated with Ohm's Law, which states that current is inversely proportional to resistance; Current (I) equals voltage (V) over resistance (R). Rearranging this formula so that $R=V/I$ provides the resistance in ohms (Ω).

Apparent resistivity can be easily calculated in homogeneous earth.

$$\Delta V = (I\rho/2\pi)(1/AM - 1/AN - 1/BM + 1/BN)^{-1}$$

Where ρ = resistivity in ohm-meters,
I = current in amps, V = volts, and
AM, AN, BM, and BN = distance from
A to M, etc.

Apparent Resistivity of unhomogeneous earth can thus be calculated:

$$\rho_a = [\Delta V/I(2\pi)](1/AM - 1/AN - 1/BM + 1/BN)^{-1}$$

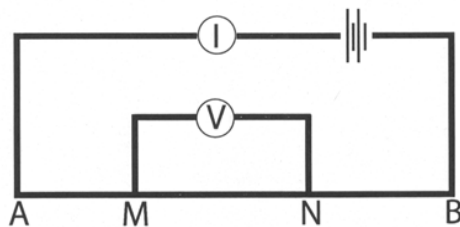


Figure 3- 1:
Diagram illustrates
principles of measuring
resistivity.
Illustration by Kim Finch.

¹⁷ Bevan 1998: 10.

¹⁸ Heimmer et al. 1995: 30.

Resistivity calculations vary according to the type of electrode configuration, or array, employed in the survey. There are three primary arrays: Wenner, pole-pole, and square. The Wenner array employs two current electrodes that set up a potential gradient in the ground, and two potential electrodes between them that sample this gradient.¹⁹ Resistivity for this array is calculated as $\rho = 2\pi a(\Delta V/I)$.

Developed specifically for archaeology, the pole-pole, or twin electrode, array is essentially the Wenner array divided by two.²⁰ One pair of electrodes serves as a permanent reference, placed in a fixed position far from the other pair. The other pair moves over the site, serving as detector electrodes. Large spacing between current and potential electrodes removes double peaking encountered with the Wenner array, facilitating interpretation. This array is most sensitive to lateral variations because it measures the second derivative of potential (V) from a simple current source.²¹ Resistivity for the pole-pole array is calculated using the formula $\rho = 2\pi a(\Delta V/I)$.

As the name implies, the square array consists of a square configuration of electrodes designed to give a sharper data response.²² The compact set-up permits interchangeability of electrode function so that readings from one point can be averaged to remove directional bias. This array is easy to work with because it is compact and does not have trailing wire. However, the pole-pole array allows deeper penetration and takes unambiguous readings without averaging.²³ The formula $\rho_a = \pi a[2(\sqrt{2})]\Delta V/I$ provides resistivity values for the square array.

¹⁹ Clarke 2001: 37.

²⁰ Clark 2001: 44.

²¹ Herz and Garrison 1998: 159.

²² Clark 2001: 47.

²³ Clark 2001: 47.

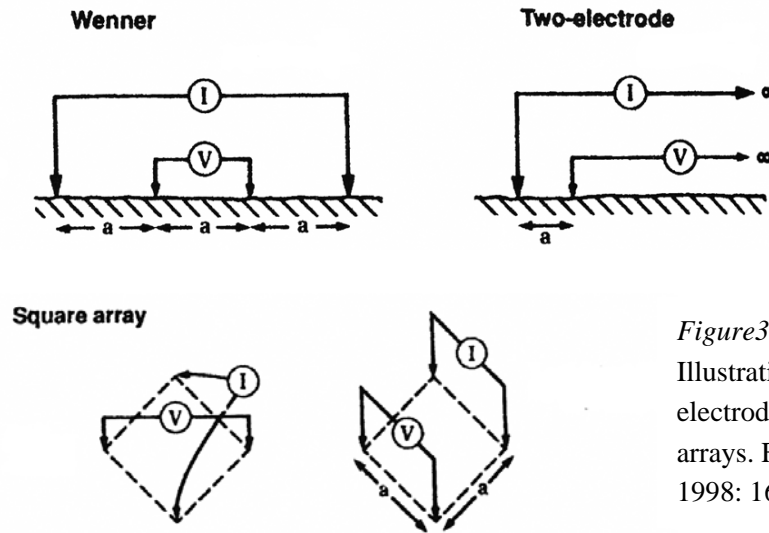


Figure3-2:
Illustration of the Wenner, twin-electrode, and square resistivity arrays. From: Herz and Garrison 1998: 162.

Resistivity surveying has many archaeological applications. Resistivity facilitates detection of constructed features such as foundations, walls, compacted soils, excavations, and occupation related humus.²⁴ Unlike other active techniques, resistivity works well in wet and clay-rich environments. Inexpensive and easily obtainable equipment make resistivity one of the most economical methods available, especially with tight field budgets. Although resistivity does not work well in dry, sandy environments, surveyors can sometimes counter contact resistance encountered in these conditions by adding moisture to the soil at electrode insertion points. Another drawback of resistivity is its limited success detecting very small objects. As with any survey, however, knowledge of surface and sub-surface conditions permit evaluation of the technique and potential problems prior to the survey.

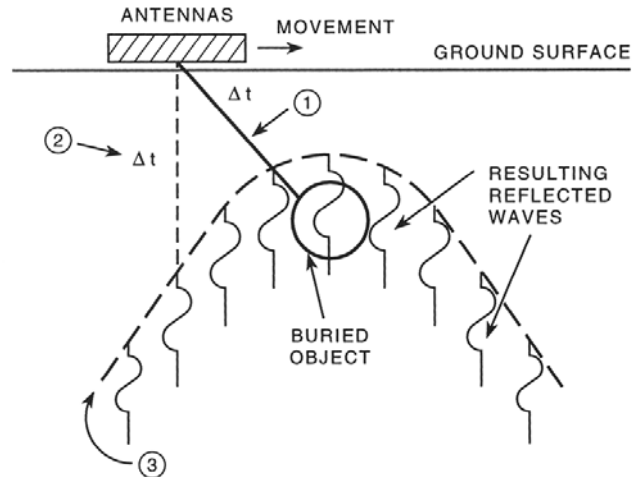
ii) Ground Penetrating Radar

Ground penetrating radar, or GPR, is an electromagnetic technique that introduces high frequency radio waves into the subsurface. Two electric properties of the subsoil determine the success of GPR surveys: i) conductivity and ii) dielectric constant, which

²⁴ Heimmer et al., 1995: 30.

characterizes the permeability of the matrix to electrical current.²⁵ Highly dielectric materials with low electrical conductivities provide the best radar-energy penetration.²⁶ Surveyors delineate the location and nature of buried objects based on comparisons of the strength and velocity of radar waves, which are distorted when there is a change in dielectric properties of materials (Figure 3-3).²⁷

Figure 3-3:
Antenna propagation and reflection along a GPR transect. From: Conyers and Goodman 1997: 30



Several other variables also affect the outcome of GPR surveys. These include soil and sediment mineralogy, clay content, ground moisture, depth of buried features, surface topography, and vegetation. While resistivity works well in highly conductive environments, GPR will not provide good data in clay rich or very moist environments because of signal attenuation.²⁸ Surface vegetation and features also pose a problem, as they may interfere with signal penetration and alter data characteristics.²⁹ Table 3-2 provides examples of different soil materials and signal propagation. Knowledge of site variables permits selection of proper equipment and antenna frequency.

²⁵ Herz and Garrison 1998: 170.

²⁶ Conyers, Lawrence B. and Dean Goodman. *Ground Penetrating Radar: An Introduction for Archaeologists* (New York: Altamira Press, 1997), 32.

²⁷ Herz and Garrison, 1998: 173.

²⁸ Attenuation: diffusion of radar waves due to high moisture content in the subsurface matrix.

²⁹ Conyers and Goodman 1997: 16, 42.

Material	Wave Velocity in nanoseconds (ns)	
Air	1 ns / foot	(0.3 ns / meter)
Dry Sand	2-2.4 ns / foot	(6.1 - 7.3 ns / meter)
Wet Sand	5.5 ns / foot	(16.6 ns / meter)
Saturated Clay	2.8 - 3.3 ns / foot	(8.5 - 10 ns / meter)

Table 3-2: Radar wave velocity of geological materials. From: Conyers and Goodman 1997: 45.

Ground penetrating radar operating systems may be bulkier than resistivity units, but they are highly portable and easily powered, providing flexibility in the field. Typical systems consist of a transmitting and receiving antenna, a wave generator, and a monitor with a graphic printer and data acquisition unit (Figure 3-4). Common operating frequencies are 80 to 1000MHz, with some radar operating as low as 15MHz or as high as 2.5GHz. Operators choose the strength of the transmitted radar wave, usually in the 100 MHz to 1000MHz range, based on the aforementioned variables; high frequency antennas have a shorter wavelength, providing good resolution but with higher signal attenuation. Lower frequency antennas have a longer signal wavelength, providing deeper penetration with a coarser resolution (Figure 3-5).³⁰

Straightforward and relatively fast data collection also facilitates use of GPR units at archaeological sites. Surveyors move the antennas along a predetermined grid, collecting data at set intervals or as a continuous set, depending on the type of unit and surveyor's preference. As the antennas move along the grid, the transmitting antenna sends radar energy into the subsurface, usually at a frequency of 25,000 or 50,000 pulses per second.³¹ An onboard data logger or external computer records two-way time travel, the velocity of the radar signal from the transmitting to the receiving antenna in nanoseconds per foot or meter.³² Survey notes, however, serve an equally important role

³⁰ Pasquinucci and Tremont 2000: 126.

³¹ Pasquinucci and Tremont 2000: 127.

³² Pasquinucci and Tremont 2000: 168.

in a GPR survey. Operators must record data such as line location, antenna frequency, direction of survey, horizontal scale, above ground features, and other variables that might affect the dataset.

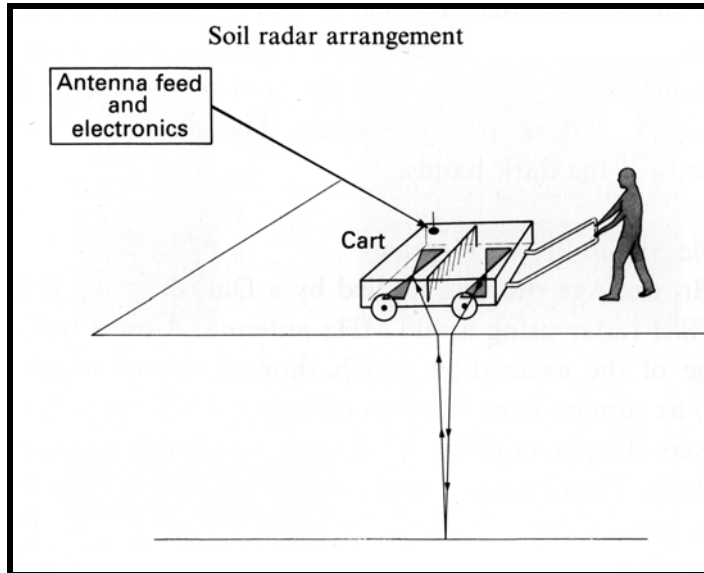


Figure 3-4:

Surveyor pushes a cart containing a transmitting and receiving antenna. Radar waves travel through the ground, reflecting back to the GPR unit when they hit a different medium.

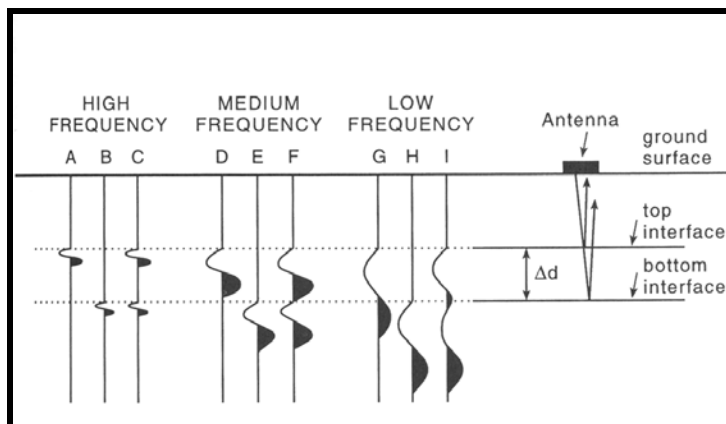


Figure 3-5:

Resolution of a top and bottom interface at differing frequencies. From: Conyers and Goodman 1997: 47.

Examination of raw data from a completed survey provides an indication of the depth and extent of buried features. Reading the amplitude, phase (positive or negative), and frequency of the reflected wave provides information about the nature of the feature.³³ Soil horizons appear as bands in GPR data. Breaks in these bands, known as anomalies, usually indicate the presence of features. For example, small objects produce

³³ Pasquinucci and Trement 2000: 168.

arcs and excavated areas produce depressions. Figure 3-6 illustrates typical anomalies observed in GPR data. The strength of the reflected signal also provides clues to the nature of the buried material. When a radar pulse encounters an electrically conductive material such as iron, it causes damped oscillations in the conductor, which produce prominent banding in the data. Lateral continuation of objects can be observed using a time-slice map, which represents a cut across the horizontal and vertical plane at a specific time.³⁴

Another important calculation is object depth. Data loggers measure GPR waveform according to two-way time travel, which must be converted to depth before data interpretation can begin.³⁵ Before converting to depth, however, operators must know the velocity of the material through which the radar energy is travelling.³⁶ Operators can measure velocity by sending radar waves along a known distance and measure the travel time, dividing by a value of two to obtain the one-way travel time. The formula $v=2d/t$ enables calculation of velocity (Figure 3-7). More sophisticated operating systems calculate the velocity interactively by matching a theoretical hyperbolic response of a small buried object to one observed in the data. New computer data manipulation and mapping programs also calculate depth.

³⁴ Herz and Garrison 1998: 173.

³⁵ Conyers and Goodman 1997: 107,108.

³⁶ Conyers and Goodman 1997: 108.

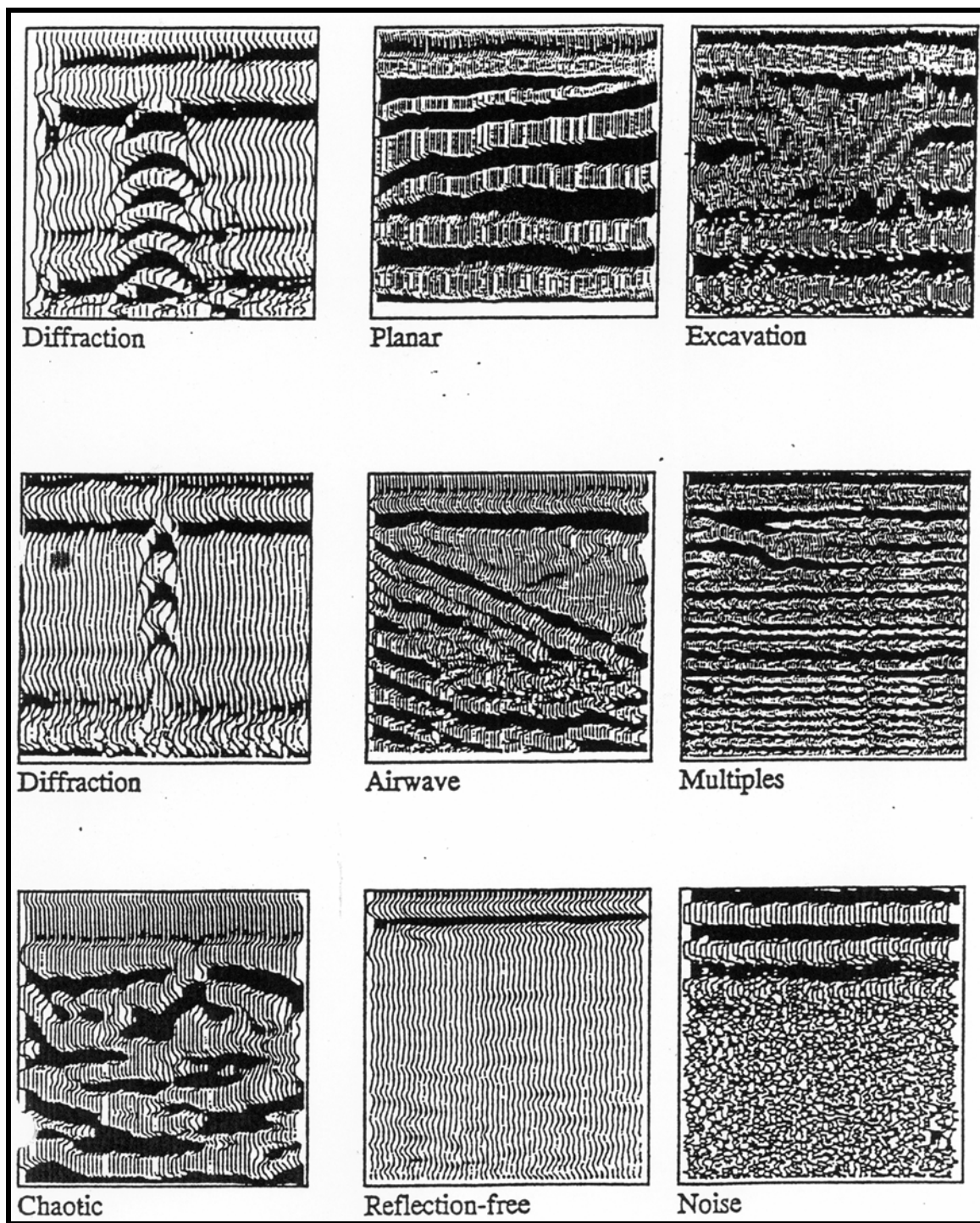


Figure 3-6: Typical anomalies observed in GPR data.. Courtesy of Quentin Graham, Michigan Technological University, 1992.

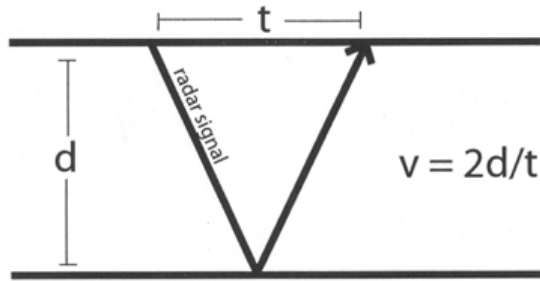


Figure 3-7:
Calculating velocity
based on two-way time
travel of radar signal.
Illustration by Kim Finch.
 v = velocity
 d = distance
 t = time

One of the most important stages of a GPR project occurs after surveyors complete fieldwork. Cleaning up background noise, as well as correcting depth and horizontal scale, occurs during data manipulation.³⁷ Because most antennas produce horizontal bands, or "ringing," which often obscure reflection data, clearing this background "noise" is an important step in interpreting the data. To do this, a program sums all of the amplitudes of reflections recorded at the same time along a profile and divides by the number of traces summed; the resulting composite digital wave, an average of all background noise, may be subtracted from the data set, leaving reflections that can represent significant archaeological features.³⁸ More sophisticated programs are even capable of removing specific frequencies. Caution is needed with all background filters, as they can remove essential data, especially with relatively horizontal stratigraphy.³⁹

One of the final considerations that interpreters face is data presentation. Wiggle traces, the simplest mode of presentation, display individual data traces and their amplitude, facilitating detection of subtle subsurface changes.⁴⁰ The traces may be displayed in color or greyscale; many authors argue that greyscale avoids making traces

³⁷ Conyers and Goodman 1997: 77.

³⁸ Conyers and Goodman 1997: 78, 80.

³⁹ Conyers and Goodman 1997: 80.

⁴⁰ Tealby, Andreas and T. Campbell. "A Report on the Evaluation of Ground Penetrating Radar in Archaeology (1990/1991)," in Andreas Vogel and Gregory N. Tsokas (eds.) *Geophysical Exploration of Archaeological Sites* (Vieweg: Bertelsmann Publishing Group International, 1993), 224, 225.

too "busy," therefore facilitating interpretation. More sophisticated data presentation includes computer modeling, which provides a three-dimensional representation of data.

Ground penetrating radar is now considered one of the most reliable methods used in archaeology, but like other geophysical techniques, knowledge of its limitations are as important as knowledge of its potential applications. GPR is particularly adept for identification of different soil interfaces, depth to bedrock, cavities and voids, rock features, ice thickness, buried stream channels, burial sites, and metallic objects.⁴¹ Continuous vertical profiling enables cost effective, non-invasive coverage of large sites without compromising detail; subsurface resolution ranges from a few centimeters to several meters, depending on signal strength and antenna frequency.⁴²

It is particularly important to understand the limitations of GPR prior to use in the field, especially since it is one of the most expensive geophysical techniques. GPR does not provide good data in highly conductive environments; clay, in particular, results in high signal attenuation. Bumpy ground surfaces also create problems, interfering with data characteristics by recording anomalies where they do not exist in the subsurface.⁴³ And even though GPR effectively records the location of metallic objects, it is important to remember that anything beneath this material will not be recorded. It is therefore crucial that operators understand the nature of the site on which the surveys will be conducted.

Knowledge of the equipment and incurred expenses are also important. Incorrect antenna frequencies may obscure or miss features. The use of unshielded antennas present problems such as coupling, the acquisition of unwanted signals from above ground objects, which can obscure subsurface anomalies.⁴⁴ The high cost of GPR units

⁴¹ Heimmer et al. 1995: 42.

⁴² Conyers and Goodman 1997: 11. Heimmer et al. 1995: 44.

⁴³ Heimmer et al. 1995: 42.

⁴⁴ Heimmer et al. 1995: 42. Tealby and Campbell 1993: 242.

often inhibits their use on archaeological sites. Units cost between \$22,000 and \$80,000. Many companies rent radar equipment, but even this costs approximately \$200 per day, plus shipping. Added expenses include hiring a professional crew for \$1,375 to \$1,650 per day, and professional data interpretation at a cost of \$350 to \$550 per day.⁴⁵

Passive Geophysical Methods:

Passive methods measure the effect of buried features on the planetary subfield; current is not introduced.⁴⁶ The most common passive technique used in archaeology is magnetometry.

i) Magnetometry

Magnetometry surveys measure the strength or amplitude of ferrous objects distorting the earth's magnetic field at a specific location.⁴⁷ This distortion, caused by a concentration of the magnetic field in iron-containing objects that in turn reduce or enhance the nearby field, often indicates the presence of archaeological objects or deposits.⁴⁸

There are several different types of magnetometers, but archaeologists need only concern themselves with sensor configuration. Single sensors measure the earth's total magnetic field, while a two-sensor configuration, a gradiometer, measures the difference in the field at the sensors. Several advantages favor use of a gradiometer over one sensor, including automatic correction of changes in the earth's magnetic field during a survey, recognition and distinction of close objects, and ability to ignore moderately distant iron

⁴⁵ Heimmer et al. 1995: 47.

⁴⁶ Herz and Garrison, 1998: 11.

⁴⁷ Bevan 1998: 19. Clark 2001: 101.

⁴⁸ Bevan 1998: 19.

objects such as nearby cars.⁴⁹ Unfortunately, a gradiometer is directionally sensitive; misalignment of the sensors provides invalid readings. Benefits of a total field magnetometer include the ability to take measurements at a greater spacing than with a gradiometer.⁵⁰

Magnetometers measure differences in the strength earth's magnetic field, which averages from about 40,000 to 60,000nT in North America.^{51 52} Archaeological features average from 1 to 100nT. Magnetics instruments are very sensitive, measuring to approximately 0.01nT.⁵³

A survey's success, however, depends primarily on the magnetic susceptibility of subsurface materials, not the size of the anomaly.⁵⁴ Orbiting electrons generate a magnetic field, causing atoms to react to magnetic fields and have magnetic susceptibility, the ability to become magnetized.⁵⁵ When materials are fired, such as clay, pottery kilns, or burned house floors, they tend to possess elevated magnetic properties due to realignment of their magnetic properties.⁵⁶ Magnetometers easily register this phenomenon, known as thermoremanent magnetism, as well as permanently magnetized objects such as iron nails.

On archaeological sites without abundant modern surface trash and historic ferrous materials, magnetometers provide good detail of subtle magnetic details in the subsurface.⁵⁷ Archaeological applications of magnetometers include locating burned

⁴⁹ Bevan 1998: 19.

⁵⁰ Bevan 1998 19.

⁵¹ Clark 2001: 64, defines the unit of magnetic flux density as the SI sub-unit nanoTesla (nT) = 10^{-9} tesla (T). This is numerically identical to the formerly used 'gamma'.

⁵² Kvamme 2001: 357.

⁵³ Bevan 1998:19.

⁵⁴ Heimmer et al. 1995: 70.

⁵⁵ Clark 2001: 90.

⁵⁶ Kvamme 2001: 357.

⁵⁷ Kvamme 2001: 357.

areas, hearths, kilns, fired bricks, displaced soil materials, and earthen structures.⁵⁸ They reliably locate magnetic discontinuities in the deeper subsoil; however, active methods such as resistivity provide more accurate readings of magnetic anomalies in the topsoil.⁵⁹ Sites with abundant surface and subsurface ferrous material, however, can prove a "nightmare" for magnetic surveys.⁶⁰

The West Point Foundry: Choosing a Geophysical Method

Industrial sites such as the West Point Foundry pose interesting problems not faced on most prehistoric or historic archaeological sites. Machinery, large metallic artifacts, as well as remnants of standing and subsurface structures that once supported the vibrations of heavy industry necessitate careful site and methodological analysis before choosing a geophysical technique. The soils and sediments at the foundry, as well as surface and subsurface artifact concentrations, rule out the use of many geophysical techniques.

The valley floor of the foundry site lies hidden underneath industrial waste and over 100 years of forest regrowth. Slag, iron conglomerate, tools, machine parts and bases, coal, glass, ceramic, brick, and stone walls cover much of the 89 acre site. Underneath the industrial residue lies sandy-loam and yet more artifacts, pushed into and out of the subsurface by numerous tree roots. Modern trash also covers several areas of the site.

The large concentration of iron objects at the foundry immediately diminishes the utility of magnetometry at the site. A sensor height of one meter necessitates removal of iron objects larger than metal cans or lids, while surveyors should remove all iron objects

⁵⁸ Kvamme 2001: 357, and Heimer et al. 1995: 8.

⁵⁹ Clark 2001: 90.

⁶⁰ Kvamme 2001: 357.

larger than a small nail when using a sensor height lower than one meter.⁶¹ As 2003 excavations at the foundry demonstrated, thousands of nails, iron scrap, and other iron artifacts in every stratigraphic layer make magnetometry the least appropriate survey method.

Site conditions are much more favorable for resistivity than magnetometry. Despite a sandy matrix that lies approximately one half meter to one meter under the ground surface, the site's position on the valley floor provides moisture values required for this type of survey. Resistivity's ability to locate large objects also supports its use at the foundry. The primary problem, however, is the time-consuming nature of this technique; it would take several people weeks to cover multiple areas over the 89 acre site, an impractical solution during a short field season.

Ground penetrating radar was the most appropriate choice for the 2003 survey because of its ability to take large quantities of data quickly and operate well under site conditions. Located within one to two meters of the ground surface, archaeological features and artifacts at the foundry fall within the range of GPR antenna frequencies. Previous successful surveys of voids and cavities including grave sites encouraged its use in detecting subsurface watercourses at the foundry. Little concern existed over the potential for excessive signal attenuation as the sandy-loam matrix drains well even in wet conditions. GPR also promised fast data collection and immediate results because of an onboard data logger and monitor.

Archaeogeophysics has opened new avenues of inquiry within archaeology; large historical resources can now be located and managed without excavation. Geophysical techniques, however, only measure different properties of the earth, including natural or man-made alterations. It is important, especially in the case of scientific research, to determine if features have archaeological meaning through excavation. Ground

⁶¹ Bevan 1998: 20.

penetrating radar surveys at the West Point Foundry enabled archaeologists to see beneath the surface and strategically plot areas from which further information could be gained.

Chapter 4 Ground Penetrating Radar Surveys at the West Point Foundry

Ground penetrating radar surveys at the West Point Foundry occurred between May 22 and 28, 2003, under the direction of MTU geophysics professor Dr. Charles Young. Archaeology students worked in teams with Dr. Young, completing nine radar projects across the foundry site. The selection of areas for the radar survey was based on historical map data, visible drains, depressions, and the presence of standing and running water. The surveys were designed to identify the presence of subsurface features related to the foundry's water system. They provided data which informed the placement of excavation units in three areas at the foundry.

This chapter describes the equipment and methodology of the GPR survey at the foundry and provides analysis and interpretation of geophysical anomalies in each survey area. Survey description includes a discussion of problems encountered during surveys and their solutions. The chapter concludes with a discussion of the successes and failures of the GPR surveys at the foundry, including recommendations for future geophysical research at the site.

Equipment

Archaeologists employed a Noggin^{Plus} radar unit and Smart Cart manufactured by Sensors & Software Inc. of Mississauga, Ontario, Canada (Figure 4-1). The Noggin^{Plus} consisted of a sixteen pound, shielded, monostatic 250MHz antenna capable of acquiring 100,000 samples per second.¹ The Noggin^{Plus} measured 25 x 16 x 9 inches. The Smart Cart consisted of a collapsible fiberglass frame with a platform on which the Noggin^{Plus}

¹ Product information provided by the manufacturer, Sensors and Software, Inc.

was mounted. The cart contained an integrated battery and digital video logger that permitted direct observation of subsurface images as the cart passed over buried features. The Smart Cart also contained a wheel odometer designed to enable quick calibration of radar wave velocity and depth of objects. Under ideal circumstances, the wheel odometer triggers the radar unit to acquire traces at equal intervals, such as five or 10 centimeters, along survey transects. Unfortunately, leaf and brick debris at the foundry interfered with this function.

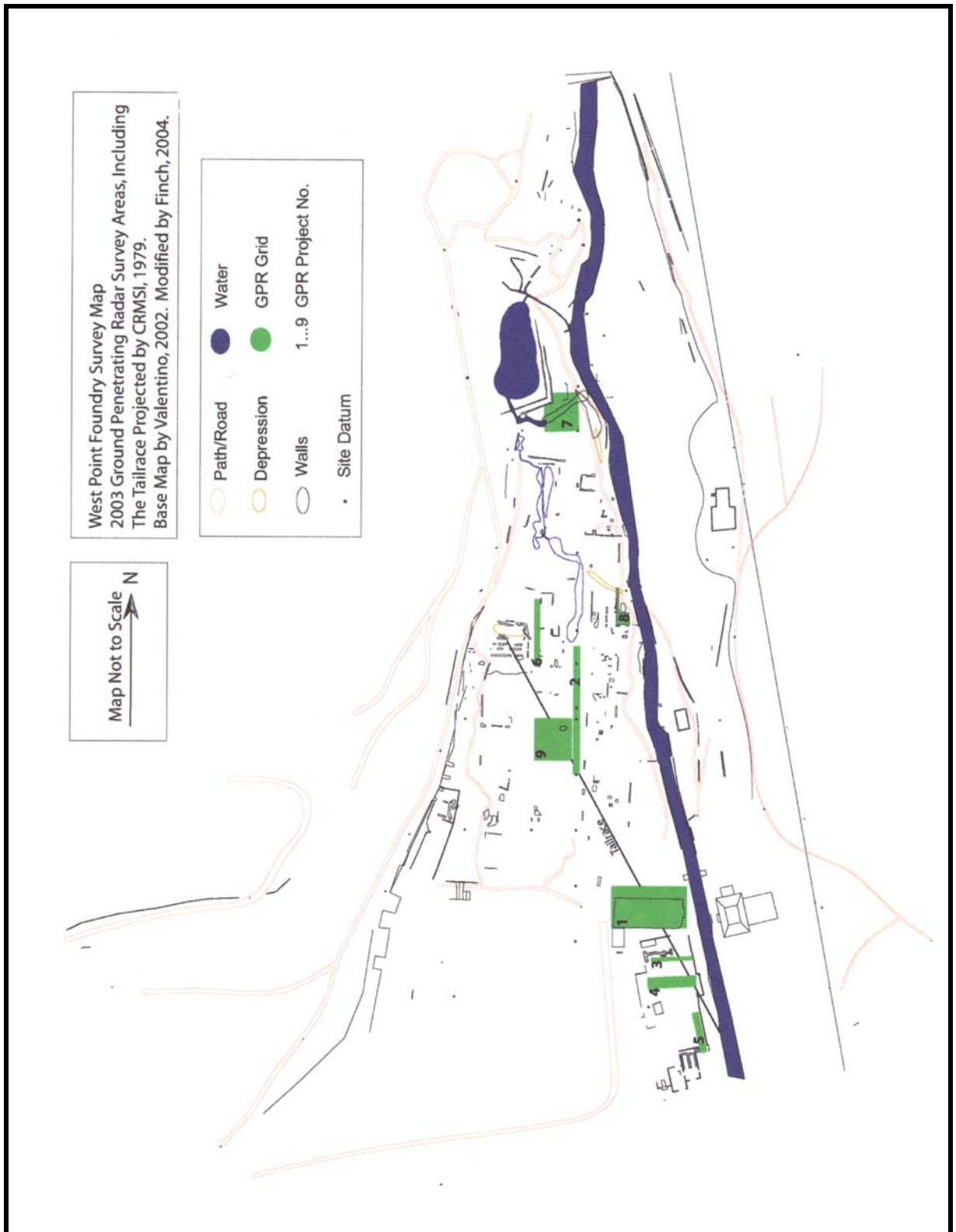


Figure 4-1:
Smart Cart and
Noggin^{Plus} by Sensors
and Software, Inc.
Photograph by Pat
Martin.

Methodology

Archaeologists chose nine radar survey, or project, areas based upon data from historic maps, as well as visible drains, depressions, and standing and running water across the site.² Map 4-1 illustrates the location of each project area. The survey began on the large cement platform west of the office building (project one), followed by a survey along the site baseline (project two), two areas south of the pattern shop (projects

² Software from Sensors and Software refers to a survey sub-area as a "project," which typically consists of several parallel radar profiles or transects.



Map 4-1: Ground penetrating radar survey areas

three and four), one area northeast of the boiler house (project five), an area east of the boring mill (project six), a large area south of Battery Pond (project seven), one area adjacent to Foundry Brook at the location of the old power house (project eight), and a large area within the old molding shop southeast of the boring mill (project nine).

Prior to each survey, student teams positioned fiberglass tapes along the x- and y-axis of each survey area and marked the origin of each transect with pin flags, enabling efficient and methodological data collection. Survey corners were situated at fixed datum points whenever possible. Student teams mapped the location of GPR grids not referenced by a site datum. As it is much more efficient to identify potential causes of anomalies while in the field, Dr. Young and the archaeology students sketched the survey grid in a designated notebook prior to each survey. Notebook sketches and notes included the location of features in the survey area that could influence results.

Teams of three students, supervised by Dr. Young, performed each survey. Student responsibilities included recording data in the GPR notebook, operating the Smart Cart, and removing obstacles from the path of the cart. Students positioned the Smart Cart over the center of the fiberglass tape and pushed the cart at a steady interval along the survey line. The Noggin^{Plus} captured data every five centimeters along survey transects. Uneven terrain, brick scatters, large roots, and logs frequently created difficult driving conditions for the Smart Cart; students compensated for impassible sections of ground by manually lifting the cart over obstacles and repositioning it on the survey line. Students also manually captured data every ten centimeters along difficult survey transects in projects two, seven, and nine as described below. Upon completion of each transect, students pushed the Smart Cart back to the x-axis and began the next survey line.

GPR Project Descriptions

Project One:

Project one consisted of 18 survey transects in a 20 by 35 meter area that covered the cement platform east of the 1865 office building. A modern boathouse and ruins of the pattern shop, as well as the foundry grounds, lay to the south and north of the platform, respectively. Survey along all transects proceeded from west to east. Radar signals penetrated to a depth of approximately one meter.

Archaeologists placed a large grid in this location for several reasons; the cement platform provided an obstacle-free area for archaeologists to become familiar with the Noggin^{Plus} and Smart Cart operation, as well as with note-taking required during surveys. Transects also bisected a line denoted on the 1979 historic base map as the path for the tailrace that extended southeast from the boring mill to Foundry Brook. Although the historic base map is not an authoritative source, archaeologists could not discount the possibility that a tailrace ran underneath the cement platform.

A large number of anomalies were detected throughout project one. Some of these anomalies may represent remnants of an underground drain, race, or pipe, but their irregular nature prevented absolute identification of the location of subsurface features. Iron objects within the cement platform and surface features such as the modern boats in the southwest corner of the grid may also have produced anomalies in the data. Discontinuous soil horizons also create irregular patterns similar to those present in this data set. Examination of anomalies plotted on a grid, however, revealed three possible features (Figure 4-2). Patterns described in every GPR project were identified based upon the nature of anomalies in the data set, including depressions, arcs, and chaotic soil horizons.

When plotted on the 2002 survey map, the tailrace identified on the 1979 historic base map crossed the cement platform between 9 and 16 meters along the platform's

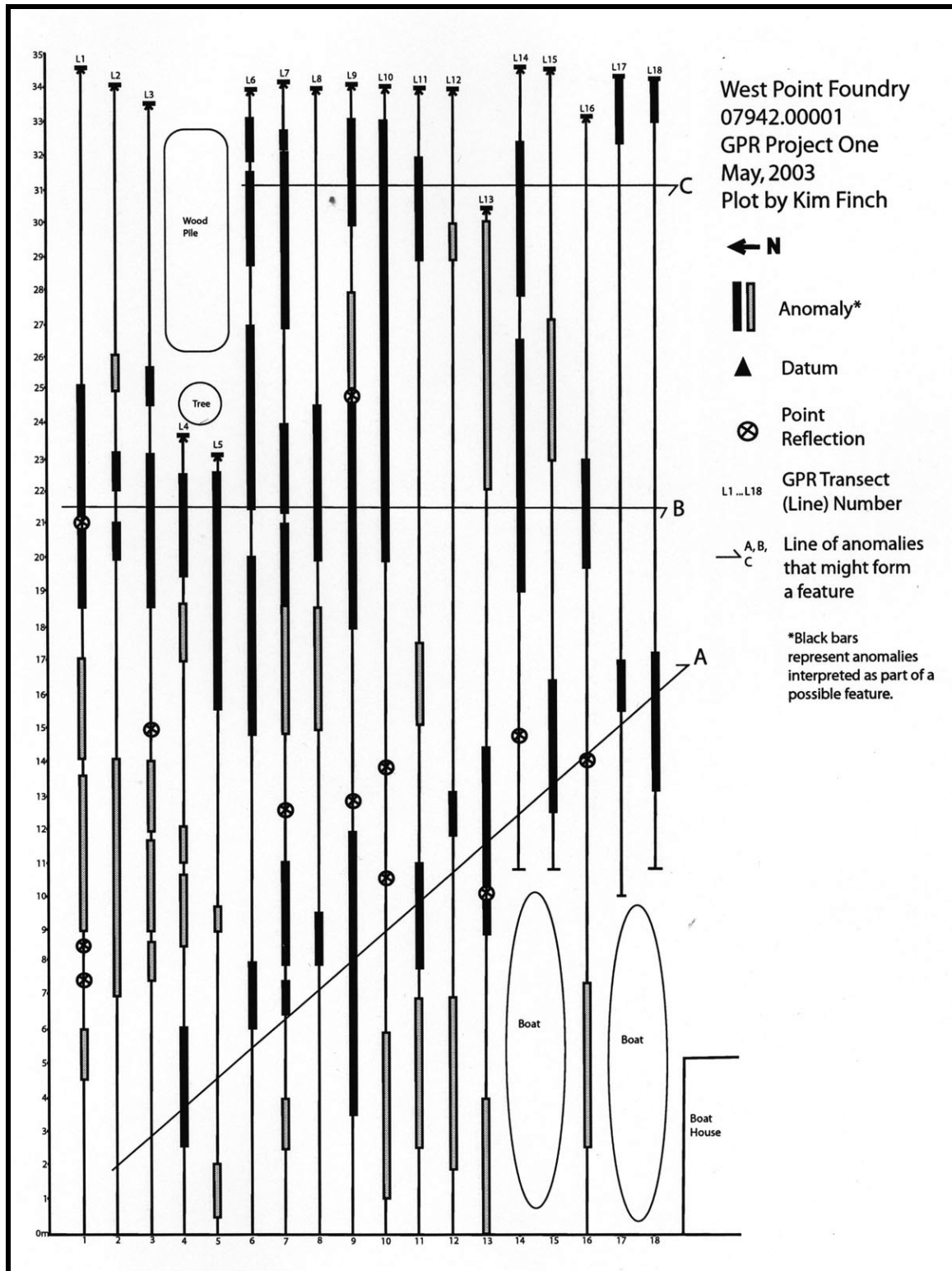


Figure 4-2: Sketch map of GPR project one

northern edge. A series of depressions that ranged from one meter to nine meters in length formed a northwest to southeast line that originated at the grid's northwestern corner (pattern 'A' on Figure 4-2). Although these do not line up exactly with the projected tailrace, they should not be disregarded without further geophysical testing or subsurface investigation.

Another series of depressions that ranged from 1 to 10 meters in length began between 18 and 25 meters along line one. This line progressed south on lines one through four, dipped to the west on lines five and six, and turned southeast from line eight. Although this pattern did not continue on lines eleven and twelve, it appeared once again on lines thirteen through sixteen (pattern 'B').

Another line of depressions appeared on lines six, seven, nine, ten, eleven, twelve, thirteen, fourteen, seventeen, and eighteen. These anomalies, which ranged between 1 and 13 meters in length, occurred along the eastern end of their respective transects. Although these may represent a subsurface feature, they most likely represent the northern edge of the cement platform (pattern 'C').

Project Two:

The survey area for project two consisted of a 57 meter by 3 meter rectangle along the old rail line that currently serves as the site datum line. According to the 1979 historic base map, the tail race that originated at the boring mill crossed the survey area between datum B and datum C. GPR transects in project two were placed to investigate data implied by the historic map. Archaeologists positioned the southern boundary of the survey at datum B. Radar signals penetrated to a depth of approximately one meter.

The survey consisted of three transects, each of which ran from south to north. Line zero ran along the established baseline. The survey crew placed line one 1 meter west of line zero, and line two 1 meter east of line zero. The Noggin^{Plus} captured data traces every 5 centimeters along lines zero and one. The Smart Cart could not move

continuously along line two due to excessive surface debris; students compensated for these obstructions by employing a step method in which they positioned the Smart Cart on the survey line every ten centimeters, capturing data at these points.

Two distinctive anomalies, along with several smaller anomalies, appeared in project two. Figure 4-3 illustrates the survey lines and location of visible anomalies.

Line zero began at datum B and proceeded north along the site datum line, terminating at 56.8 meters, or 6.8 meters north of datum D. An area of disturbed soil layers appeared between 4 and 20 meters on line zero.³ An area of disturbed soil occurred between 27 and 36 meters along the line. A log, located between 37 and 39 meters along the survey line, was most likely responsible for an anomaly that appeared between 36 and 43 meters.

Line one began 1 meter west of line zero and terminated at 57 meters. Interpretation of the radar data revealed a depression between 13 and 25 meters along line one. Areas of disturbed soil were apparent within this depression, possibly the result of uneven terrain and obstructions such as piles of bricks that the Smart Cart bumped against. A small area of disturbed soil also occurred between 27 and 32 meters.

Due to a brick scatter along the survey transect, line two began 10 meters north of datum B, 1 meter east of Line zero. Line two terminated at 57 meters. A depression appeared between 10 and 22 meters along line two. Examination of time-depth print-outs suggests that this anomaly may extend further south, placing it in line with anomalies in lines one and zero. A small depression also occurred between 31 and 35 meters along this line.

Depressions visible in lines one and two, as well as the area of disturbed soil in line zero, follow a line from west to east on lines 0, 1, and 2 (pattern 'A' on Figure 4-3). If the depression between 10 and 22 meters on line two extended further south, it might

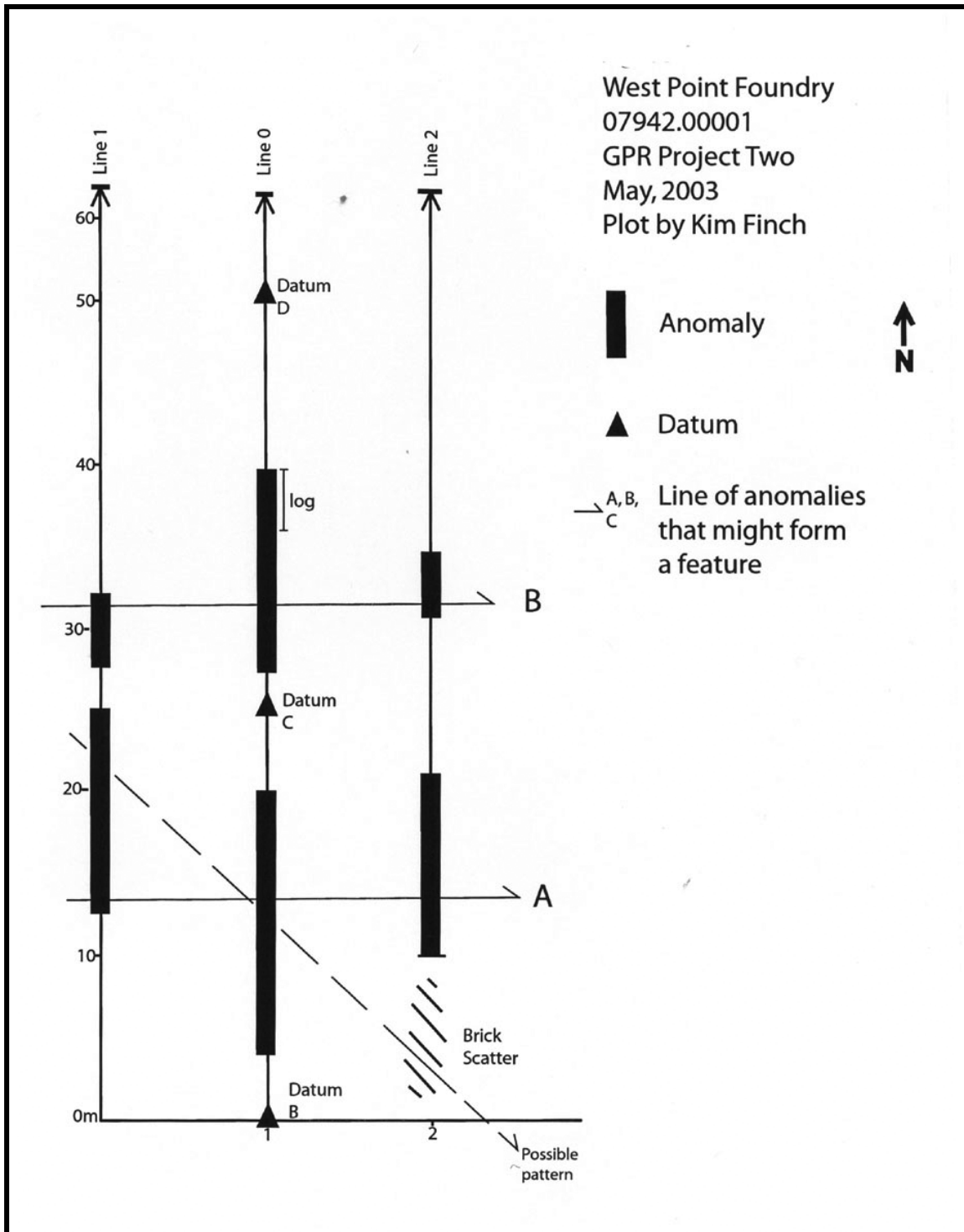


Figure 4-3: Sketch map of GPR project two

³ "Disturbed" soil layers refers to chaotic horizons in the data set. Refer to Figure 3-6.

also form a line and follow the line projected by the 1979 historic base map as the underground tailrace extending from the boring mill to Foundry Brook. Smaller anomalies located between twenty-seven and thirty-five meters on each line most likely represented features such as roots or the log in line zero (pattern 'B').

Project Three:

Project three consisted of two survey lines south of the pattern shop, bisecting the path of the tailrace identified on the 1979 historic base map. GPR transects in project three were positioned to note consistency with the historic base map. Line zero, positioned 2 meters south of temporary datum N4945, E5050, extended 17.5 meters west.⁴ Line one, positioned 3 meters south of datum N4945, E5050, extended 22 meters west. GPR signals penetrated to a depth of approximately one meter in both lines.

Although this area provided easy access for the Smart Cart, several surface and subsurface features created background noise, possibly obscuring deeper features. These features included at least two subsurface ceramic drains that ran east-west and into Foundry Brook; remnants of a cement floor from the pattern shop; and several small artifacts such as bottles, iron fragments, and ceramic fragments scattered throughout the survey area. These items most likely account for numerous point reflections apparent on time-depth sections for project three. Figure 4-4 illustrates survey line location and position of anomalies along the lines.

Line zero began at N5048, E4945 and terminated at 17.5 meters due to dense brush. Several anomalies appeared along this line, none of which were over three meters in length. Four consecutive anomalies, 2 meters, 0.5 meters, 1.5 meters, and 1 meter respectively, occurred between 1 and 6 meters along line zero. These appeared as areas of depressed soil. Other anomalies included a 1 meter long anomaly at 8 meters, a small

⁴ All temporary datum points are referenced from permanent site Datum A. The coordinates for Datum A are N5000, E5000.

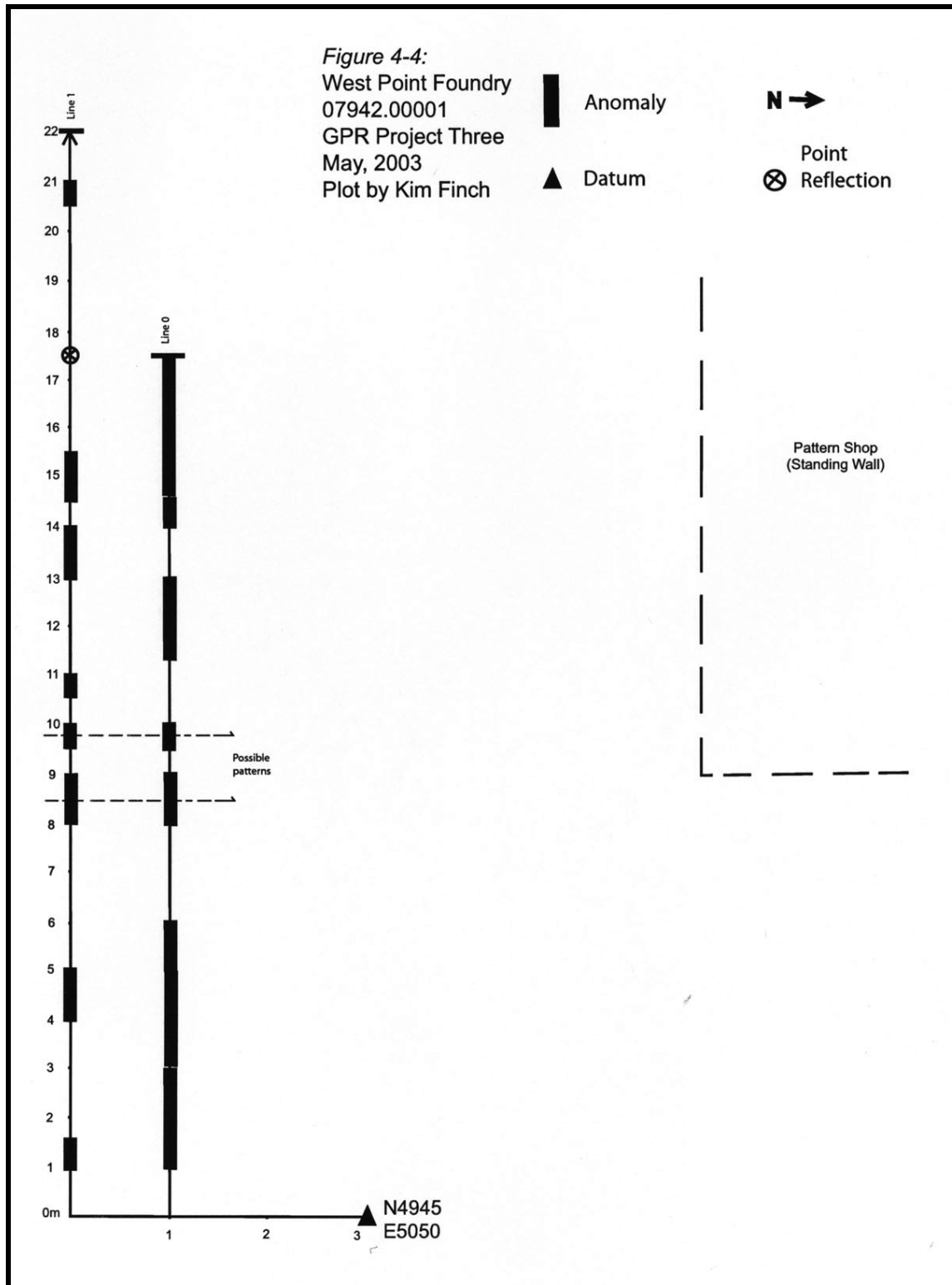


Figure 4-4: Sketch map of GPR project three

anomaly of less than one half meter at 10 meters, a 1.5 meter long depression that began at 11.5 meters, and a disturbance of less than 0.5 meters at 14.5 meters along the line. The largest anomaly of this project, an area of disturbed soil, began at 14.5 meters and ended at 17.5 meters.

Several small anomalies also occurred along line one, which began at N 5047, E4945, and terminated at 22 meters in dense brush. Four 0.5 meter long anomalies began at 1, 9.5, 10.5, and 19.5 meters along line one. Four 1 meter long anomalies began at 4, 8, 13, and 14.5 meters along this line. A large point reflection also extended into the subsurface at 17.5 meters along line one.

Due to the high frequency of small anomalies along these lines, it is difficult to ascertain whether significant features existed in this survey area. As previously mentioned, the large number of features in the area resulted in numerous point reflections capable of masking significant features located underneath. To maximize data from this area, archaeology students established further lines in the pattern shop area immediately south of project three.

Project Four

Project four consisted of four survey transects 9 meters south of line one in project three. Temporary datum point N4935, E5050 served as a reference for this survey area. This survey area also permitted relatively easy operation of the Smart Cart. However, surface roots and fallen trees added to the background noise created by surface and sub-surface features previously identified in project three. GPR transects in this area supplemented data from project three. All surveys proceeded from east to west. GPR in this survey provided approximately one meter of visibility below ground surface.

Numerous anomalies less than two meters in length were visible in the data, as well as a line of point reflections that lined-up with a similar reflection in project three; this line may represent a buried pipe. With the exception of the line of point reflections

and an anomaly between 17.5 to 20 meters on lines one through three (patterns 'A' and 'B', respectively on Figure 4-5), there does not appear to be a pattern to the anomalies. Although several had a north-south alignment, most appeared at different depths and consisted of a mixture of depressions and disturbed soils. Refer to Figure 4-5 for a sketch of the survey transects and location of anomalies.

Line one began 2 meters south of datum N4935, E5050, and terminated at 20 meters.⁵ A disturbed soil layer and adjacent area of depressed soils began at 0.5 meters and ended at 3 meters. Another depression occurred from 3.5 meters to 7 meters. Areas of disturbed soil began at 7 meters and 9.5 meters. The latter disturbance, which was four meters in length, was due to significant root activity along the survey line. A large point reflection lay between 15 and 16 meters. A 2.5 meter long area of depressed soil began at 17.5 meters along line one.

Line two began 3 meters south of datum N4935, E5050, and terminated at 20 meters. Areas of disrupted soil began at 1, 5, 5.5, 8.5, and 10 meters, and measured 2.5, 2, 1, and 2.5 meters, respectively. A 2.5 meter long area of depressed soil began at 17.5 meters. A large point reflection occurred between 15 and 16 meters.

Line three began 4 meters south of datum N4935, E5050, and terminated at 20 meters. An area of disrupted soil combined with a small depression began at 1 meter and ended at 3.5 meters. Other areas of disrupted soils occurred between 6.5 and 8 meters, and 12 and 13 meters. A depression occurred between 17.5 and 20 meters. Two small point reflections occurred at 5 and 10.5 meters. A larger point reflection occurred at 14.5 meters along line three.

Line four began 5 meters south of datum N4935, E5050, and terminated at 17.5 meters. Survey along this line began 1 meter north of the E5050 line due to rubble that

⁵ The survey initially consisted of five transects: lines 0, 1, 2, 3, and 4. However, data from line 0 was not recorded by the on-board data logger, therefore making the first line line 1.

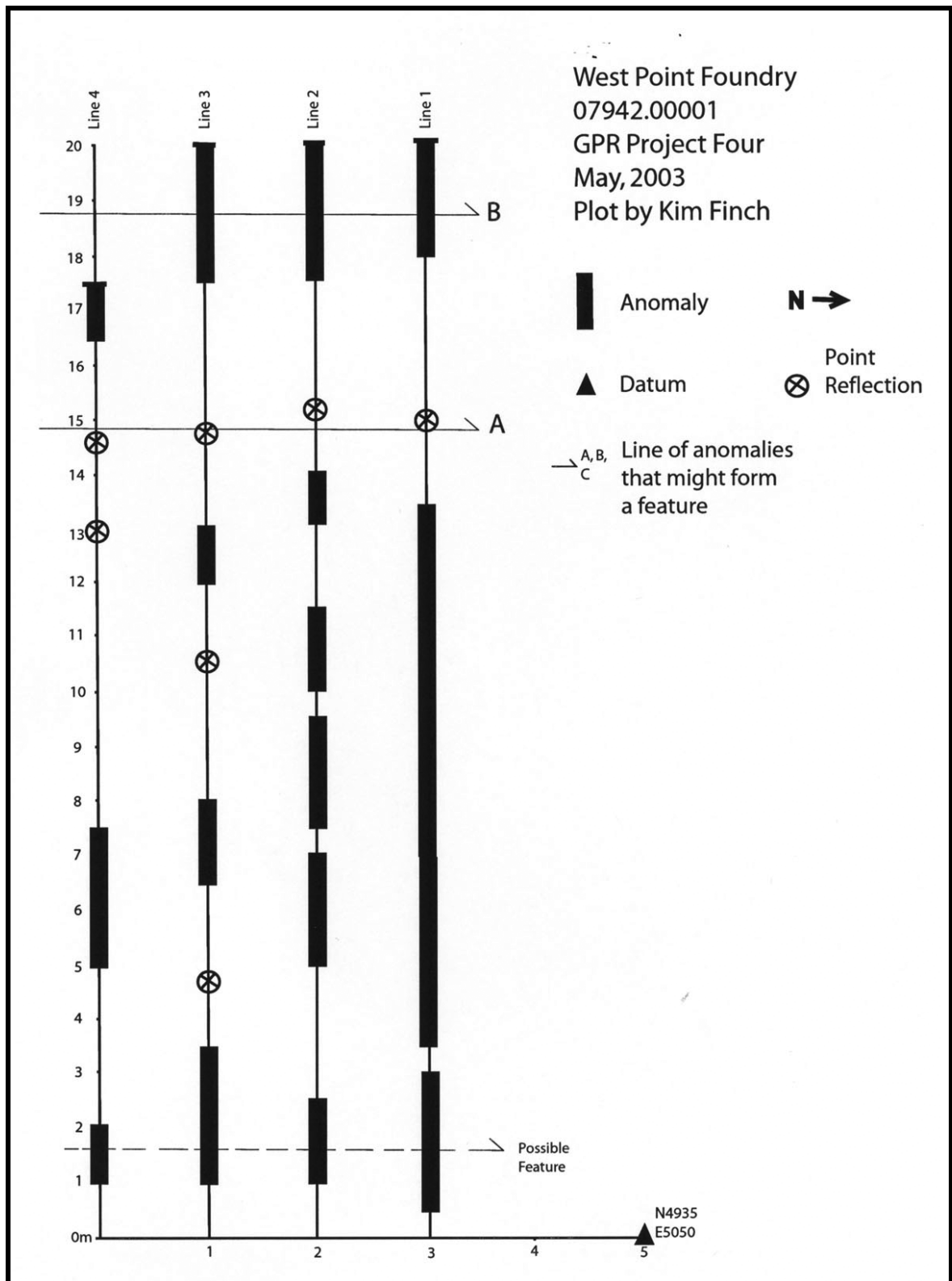


Figure 4-5: Sketch map of GPR project four

the Smart Cart could not roll over. Areas of disturbed soils occurred between 1 and 2 meters, and 5 and 7.5 meters. Point reflections occurred at 13 and 14.5 meters along line four, the latter of which lined up with large reflectors on lines one through three, indicating the possible presence of a pipe.

Project Five:

Project five consisted of three north-south survey transects along the remnants of a brick wall northeast of the boiler house. According to the 1979 historic base map, a tailrace outlet should lay in Foundry Brook by the boiler house. Archaeologists could not discount the possibility that an outlet existed at that point, despite the unauthoritative nature of the historic base map. Visual inspection of the area revealed an area of welling water in Foundry Brook in this area. Placing survey transects in this area enabled archaeologists to note consistency with the historic map and to try to establish the origin of the welling water in Foundry Brook.

The survey crew established survey transects parallel to a brick wall northeast of the boiler house, between N4906 and N4890. The eastern boundary of the survey area, the brick wall, lay along E5056.5. This placement enabled the Smart Cart to pass adjacent to an opening in the brick wall 12.2 meters south of the survey's northern axis, which aligned with the welling water in Foundry Brook. Radar signals penetrated to a depth of approximately one meter. Refer to Figure 4-6 for a sketch map of the survey area, including the location of recorded anomalies.

Students placed line zero 1 meter west of the brick wall. This line terminated at 16 meters, one meter past the opening in the aforementioned brick wall. Anomalies between 1 meter and at 2.5 meters, and between 5 meters and 9 meters were associated with cement fragments visible on the surface. The final anomaly along line zero, a slightly depressed area, occurred between 12 and 15 meters, coinciding with the opening in the brick wall.

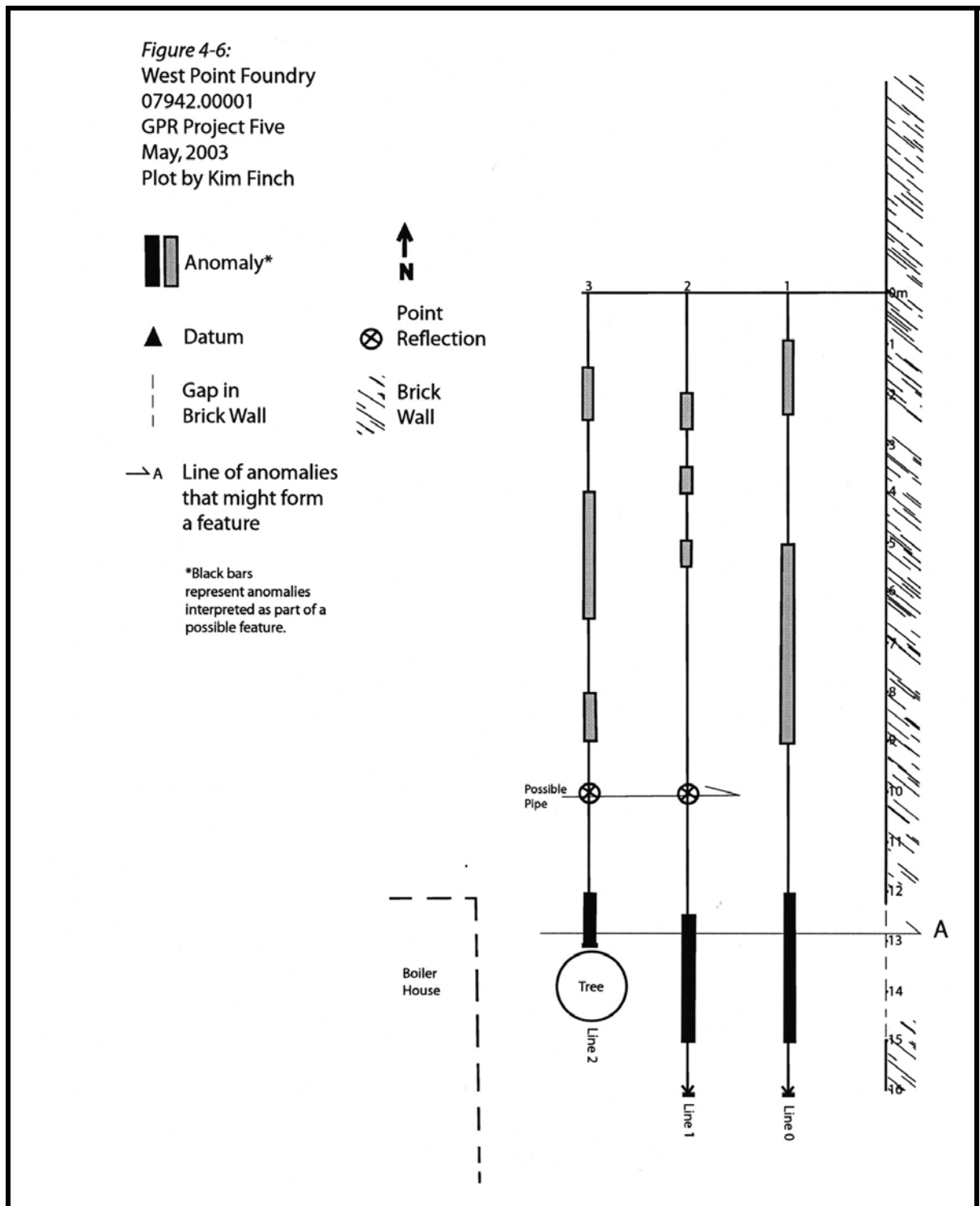


Figure 4-6: Sketch map of GPR project five

Line one, located 2 meters east of the brick wall, extended 15 meters south. Three small anomalies, each less than one meter, occurred at 2, 3.5, and 5 meters. A larger anomaly occurred between 12.5 and 15 meters. A large point reflection also occurred on line one, at 10 meters.

Line two, located 3 meters east of the brick wall, extended only 13 meters south due to a tree located between 13 and 15 meters on the survey line. The largest anomaly on line two occurred between 4 and 6.5 meters. A large point reflection also occurred at 10 meters, similar to the reflection identified in line one. Historic maps indicated the presence of buried pipes in this area, which would potentially produce a line of point reflections similar to those in lines one and two.

Three 1 meter long anomalies also occurred at 1.5, 8, and 12 meters along line two. The latter anomaly probably continued further south, and possibly formed a feature with anomalies located between 12 and 15 meters on lines zero and one. As this area aligned with the opening in the brick wall and with the area of welling water, it held the highest probability of yielding a feature (pattern 'A').

Project Six:

Project six consisted of two, 30 meter survey transects east of the boring mill. Archaeologists established survey lines from Datum D-West, located at N 5075, E4984.91. Survey along each line proceeded from south to north. Brick scatters, large pieces of iron conglomerate, and smaller artifacts such as iron nails and window glass covered the entire survey area. A slightly depressed area containing a large concentration of bricks bisected the northern end of each survey line. Because of these surface features, only two survey transects were possible. Radar signals penetrated to a depth of approximately one meter in project six.

Visual inspection of the boring mill revealed the tailrace inlet on the northeastern wall of the boring mill. Historic maps identified this race as a 45 degree line extending

from the boring mill to the southern end of Foundry Brook. If correct, related anomalies would appear in the first 15 meters of each survey transect. Survey results revealed little activity in the southern half of the survey area and several anomalies along the northern half of the transects. Figure 4-7 illustrates the location of survey transects and anomalies.

Line zero began at N5075, E 4985.91. A small anomaly occurred between 1 and 3 meters along line zero. A two meter long anomaly occurred between 13 and 15 meters. At least four separate anomalies disrupted the subsurface matrix from 16.5 to 30 meters along the survey transect.

Line one originated 1 meter west of line zero, at Datum D-West. A 4 meter long anomaly began at 2 meters, and a 3 meter long anomaly began at 14 meters along line one. At least four anomalies disrupted the subsurface between 19 and 27 meters.

Anomalies on the northern end of each transect had similar characteristics, increasing the possibility that they were related. A visible depression that contained a large quantity of brick correlated with the anomaly that began at 14 meters on line one. Anomalies between 19 and 27 meters may be the result of a tailrace, or brick machine mounts discovered by archaeologists during subsequent excavation (pattern 'A').

Anomalies at 1 and 2 meters on lines zero and one, respectively, may represent the tailrace (pattern 'B'). They had a northwest to southeast alignment, similar to the tailrace identified on the 1979 historic base map. These anomalies may also be the result of a nearby brick wall. Because a pattern cannot be identified from two lines of data, further testing in this area is required.

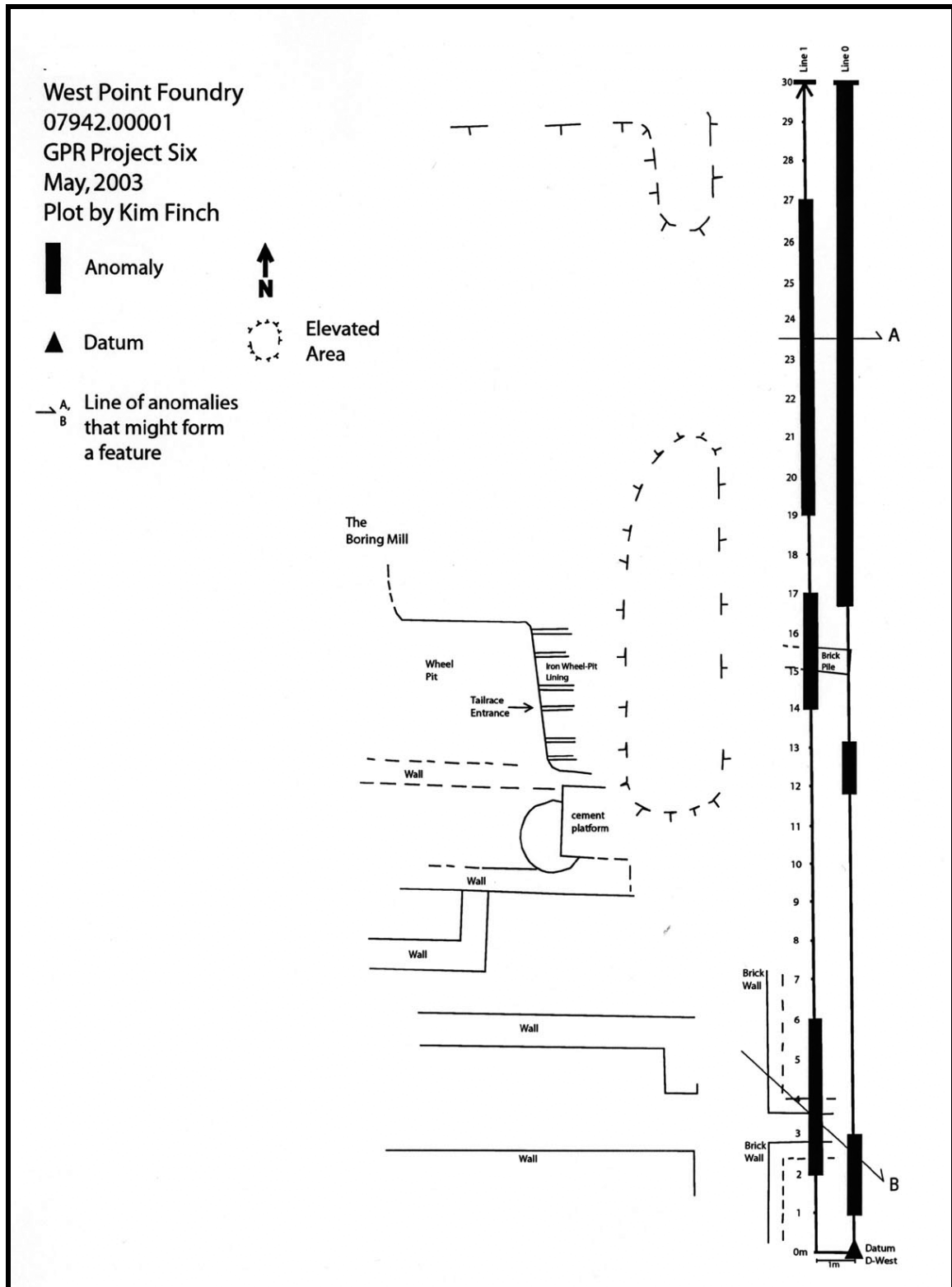


Figure 4-7: Sketch map of GPR project six

Project Seven:

The survey grid for project seven consisted of a 15 meter by 20 meter area south of Battery Pond. Students established the zero point of the grid at Datum H, and ran transects 90 degrees west and north of this point. The GPR survey consisted of six transects. Lines zero through four ran south to north. Line five, a 2 meter transect running northwest from line four, compensated for data missed in line four due to a large log. Line six ran west to east, bisecting lines zero through four. Students employed the step method, capturing data every 10 centimeters along survey transects. GPR transects were placed in this area to note consistency with the historic base map and to try to determine the path of a subsurface drain connected to a pipe outlet at Foundry Brook. Radar signals penetrated to a depth of approximately one meter in project seven.

Several anomalies appeared in data acquired in project seven, one of which appeared consecutively in lines zero through four. Figure 4-8 illustrates where anomalies occurred along survey transects.

Line zero, which began at 13 meters along the grid's western axis, extended 11 meters north toward Battery Pond. Analysis of this line revealed several anomalies consistent with observable surface features. A reflection at 2 meters correlated with a visible drain hole at this point. It is possible that an anomaly that appeared as a depression 0.5 meters below surface between 1.5 meters and 4 meters along the survey line may be connected to this drain hole. A larger depression located between 6 meters and 9 meters along the survey line appeared approximately 0.25 meters to 0.8 meters below surface. There were no surface indications of this anomaly, and it did not appear in other survey transects.

Line one began at 12 meters along the grid's western axis and extended 12 meters north. A disruption in horizontal layers occurred approximately 0.5 meters below surface in the first 2 meters of the survey line. Another anomaly occurred between 5 meters and

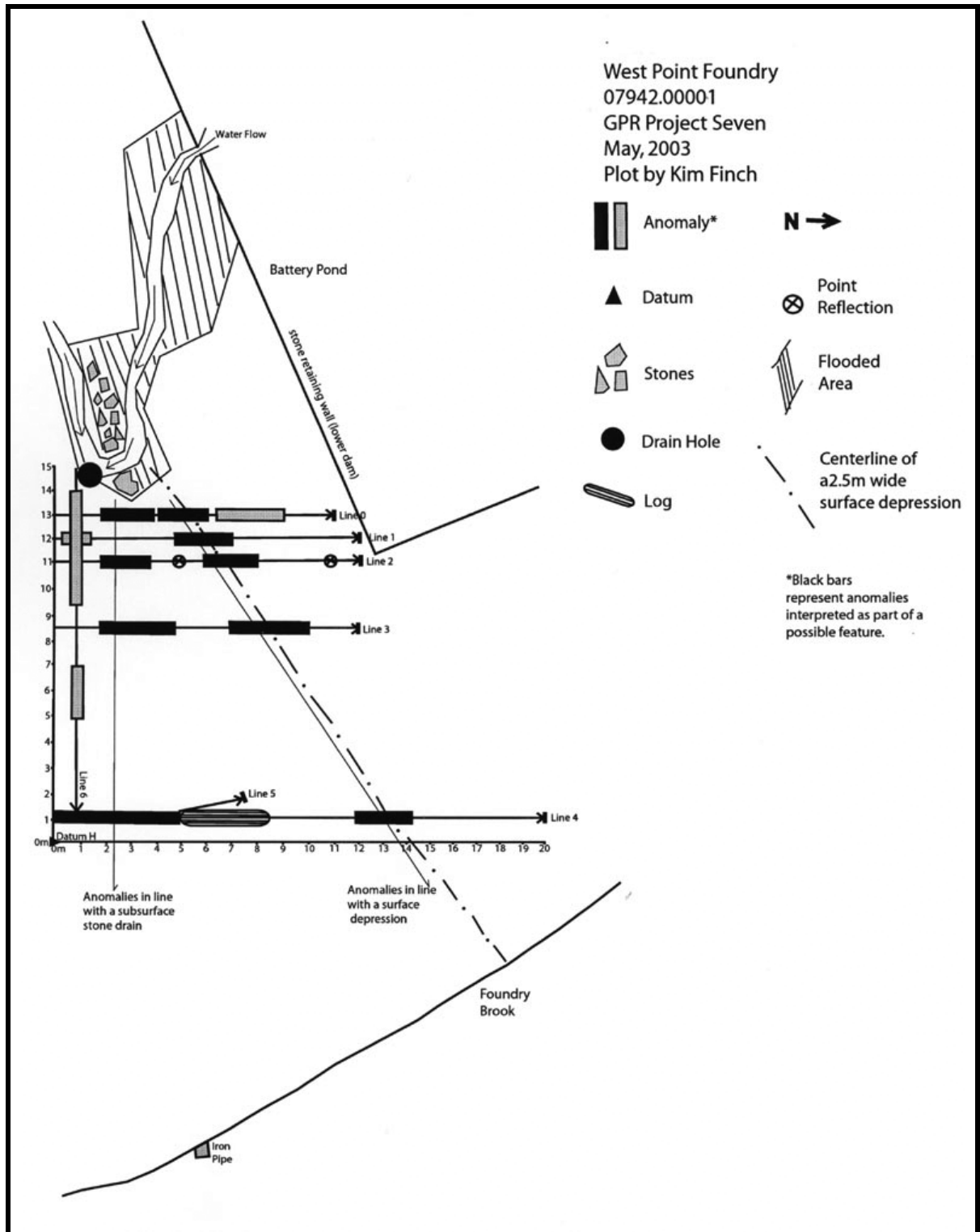


Figure 4-8: Sketch map of GPR project seven

7 meters, an area corresponding to the surface drain that extended from the area of the drain hole northeast to Foundry Brook.

Line two began at 11 meters along the western axis and extended 12 meters north. An anomaly located approximately 0.5 meters below surface existed between 2 meters and 4 meters; this corresponded with the anomaly in the first meters of line zero, and with an anomaly between 2 meters and 5 meters in line three, which also appeared 0.5 meters below surface (see below). Several small anomalies, located at 5, 6, 7, 8, and 11 meters, were also present and probably relate to the surface drain.

Line three began at 8.5 meters along the western axis and extended 12 meters north. The surface drain registered once again on this transect between 7 meters and 10 meters (Figure 4-9). As mentioned above, an anomaly similar to one identified in lines zero and two occurred between 2 meters and 5 meters.

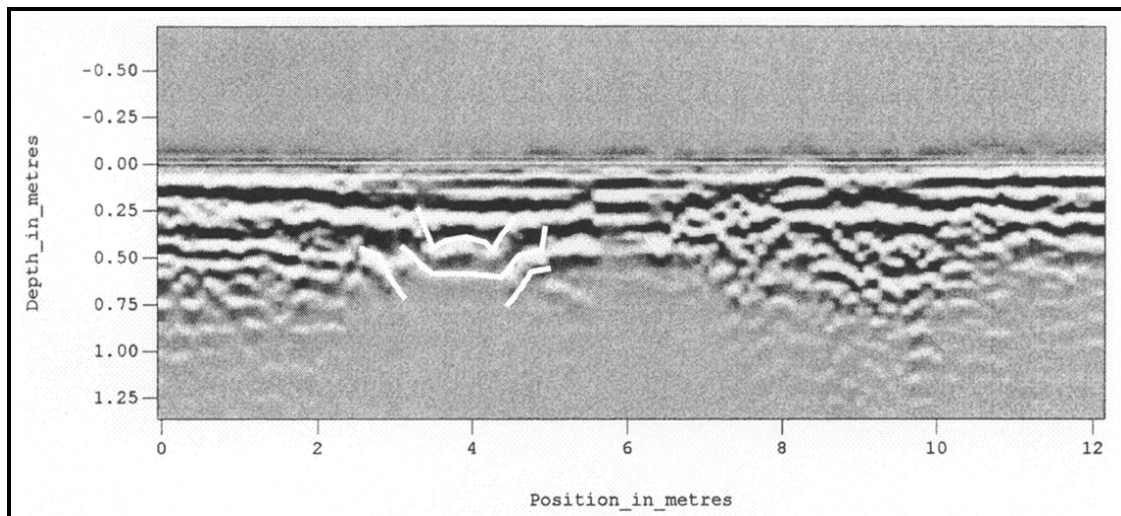


Figure 4-9: Depth section of GPR project seven, line three. Depressed soil layers (outlined in white) might represent the top of the stone-capped drain.

Line four began at 1 meter along the western axis and extended 20 meters north. An anomaly existed between 0 meters and 5 meters; this is probably a continuation of the anomalies apparent in lines zero, two, and three. The surface drain was also apparent as an anomaly that occurred between 12 meters and 14 meters along the survey line. A log

between 5 meters and 7.5 meters disrupted the survey along line four; students lifted the Smart Cart over the log and continued collecting data. Line five, which yielded little data, compensated for these missing data in line four. Line five ran northwest of line four for 2 meters.

Line six began at 15 meters along the western axis and 2 meters along the northern axis. It extended 14 meters east, bisecting lines zero through three, and terminated at survey line four. The beginning of this line ran directly south of the open drain mentioned in line zero; this drain hole probably created the anomaly that occurred between 1 meters and 5.5 meters along line six. It is also possible that this same anomaly was related to the anomaly that appeared in lines zero, two, three, and four. Another anomaly occurred between 8 meters and 10 meters, approximately 0.5 meters below surface. It is difficult to connect this anomaly to the one previously mentioned, but this cannot be ruled out without ground truthing.

Project Eight:

Project eight consisted of six transects adjacent to Foundry Brook in an elevated area denoted as the power house on historic maps. Archaeologists established survey lines in this area to obtain radar signatures of buried iron pipes, two of which ran perpendicular to survey lines and exited into Foundry Brook. Students placed the datum (0,0 meters) of this survey area approximately 8.5 meters west of the western bank of Foundry Brook. Each survey ran south to north. Radar signals penetrated to a depth of approximately 1.25 meters. Refer to Figure 4-10 for a sketch map of the survey area, including the location of anomalies.

Line zero, located 8.5 meters west of Foundry Brook, extended 16 meters north. Four anomalies appeared on this line; a 1 meter long depression began at 0.5 meters, two 1.5 meter disturbances began at 3 and 11.75 meters, a 0.75 meter long disturbance began

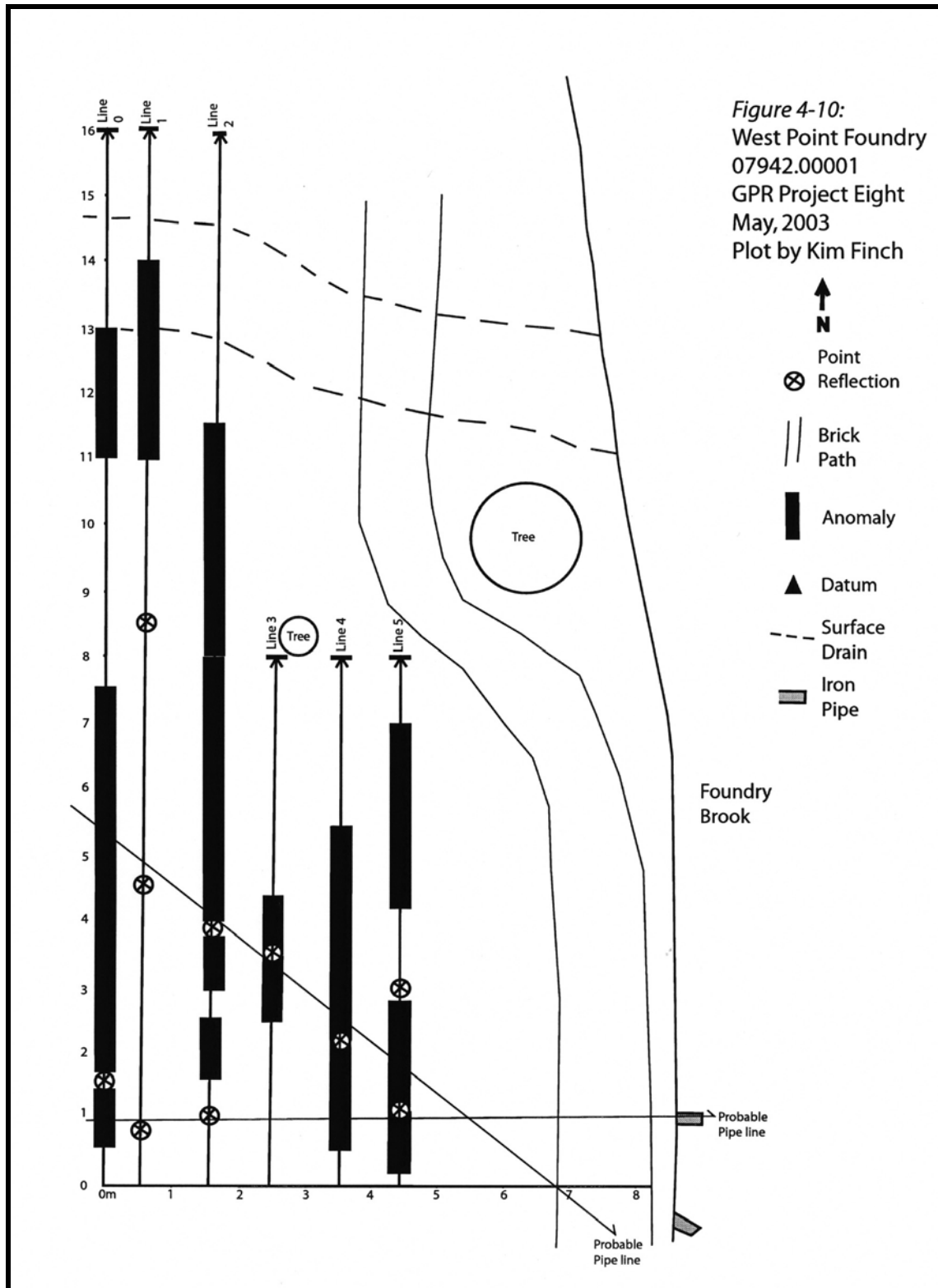


Figure 4-10: Sketch map of GPR project eight

at 11 meters, and a 3 meter disturbance began at 4.5 meters. A point reflection occurred between 0.5 and 1 meter.

Line one, located 0.5 meters east of line zero, extended 16 meters north. Analysis revealed three point reflections: at 0.5 meters, 4.5 meters, and 8.5 meters. A small area of disturbed soil appeared between 8 and 9 meters, and a 3 meter disturbance began at 11 meters.

Line two, located 1.5 meters east of line 0, extended 16 meters north. All anomalies along this line occurred within the first 11 meters, three of which lay adjacent to each other. A point reflection at 1 meter formed a line with the aforementioned point reflections in lines zero and one. A point reflection also occurred between 3.5 and 3.75 meters. The iron pipes visible at Foundry Brook probably caused these reflections. Other anomalies along line two included a small area of disturbed soil between 1.5 and 2.5 meters, and a series of slight depressions between 3 and 4 meters, and 4 and 8 meters. An anomaly between 8 and 10.5 meters was possibly related to tree roots extending across the survey transect.

Line three, located at 2.5 meters east of line zero, extended only 8 meters north due to a trees and tree roots along the survey transect. Only two anomalies occurred along line three. A large point reflection, located at 3.5 meters, lay in the middle of another 2 meter depression that began at 2.5 meters.

Line four, located 3.5 meters east of line zero, also extended 8 meters north. Similar to line three, a point reflection between 2 and 3 meters lay within a larger, 5 meter long disturbance that began at 0.5 meters.

Line five, located 4.5 meters east of line zero, extended 8 meters north. Several anomalies occurred along this line, some of which may have been a result of the proximity of the modern brick walking path at the northern end of the transect. Two point reflections occurred along line five; one between 1 and 2 meters, and one at 3

meters. The first reflection lay within a 2 meter area of disturbed soil that began at 0.5 meters. Another disturbance, possibly caused by the brick path, lay between 4.25 and 7 meters.

Most point reflections in project eight represent subsurface iron pipes that run northwest to northeast and west to east across the survey area. Diffractions at 8.5, 3.75, 3.5, 2.25, and 1.25 meters on lines one, two, three, four, and five respectively, aligned with an iron pipe that exited into Foundry Brook approximately 1 meter south of the grid's southern axis. Diffractions at 0.5, 0.75, 1, and 3 meters on lines zero, one, two, and five, respectively, aligned with an iron pipe that exited into Foundry Brook approximately 1 meter north of the grid's southern axis. Other reflections that did not fall into line with subsurface pipes suggested that there were isolated buried objects such as iron fragments in the survey area.

Larger anomalies, which appeared as depressed areas and areas of disturbed soil on time-depth sections, possibly relate to the buried pipes, as well as natural topographic and stratigraphic changes. Anomalies that contained point reflections represented trenches dug to accommodate the associated pipe (Figure 4-11). A surface depression, labeled 'drain' on historic maps, did not appear during analysis; the large number of bricks, rocks, and roots in the area most likely disguised this feature.

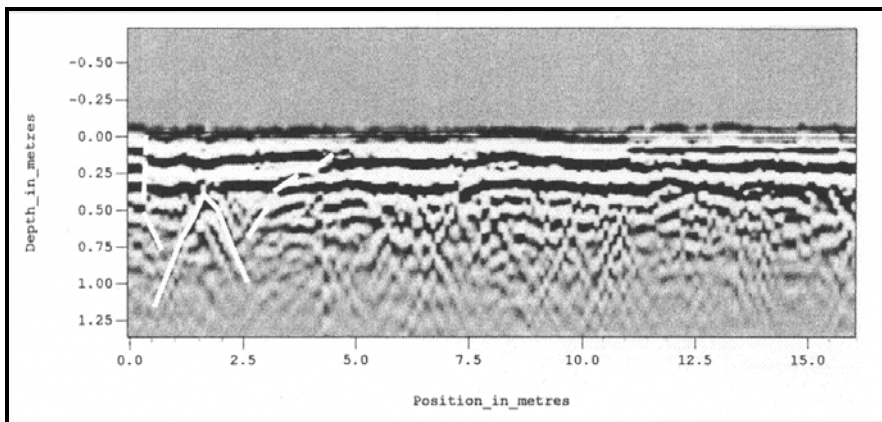


Figure 4-11: Depth section of GPR project eight, line zero. The point reflection within a depressed area of soil (outlined in white) might represent a pipe and pipe trench, respectively.

Project Nine

Project nine consisted of nine transects in a 16 meter by 18 meter area in the old molding shop southeast of the boring mill. The survey crew established the grid's datum at site datum C, and survey along each transect proceeded from east to west. Trees, a large sinkhole, and rubble from a deteriorating brick wall along the grid's x-axis altered the starting point of several lines. Brush along the grid's western boundary also altered stopping points of some lines. Smart Cart operators employed the step method, collecting data every 10 centimeters along survey transects. Radar signals penetrated to a depth of approximately 1.25 meters. Refer to Figure 4-12 for a sketch map of the survey area, including the location of anomalies.

Archaeologists positioned project nine in this location to note consistency with the 1979 historic base map; when plotted on the 2002 survey map, the tailrace identified on the 1979 historic base map crosses the northern boundary of the project nine grid between 9 and 16 meters and exits at the grid's southeast corner. Although anomalies identified in survey data extend along this path, the large number of anomalies throughout the entire survey area make it difficult to positively identify distinct features without further testing. Figure 4-13 illustrates the chaotic nature of anomalies in project nine.

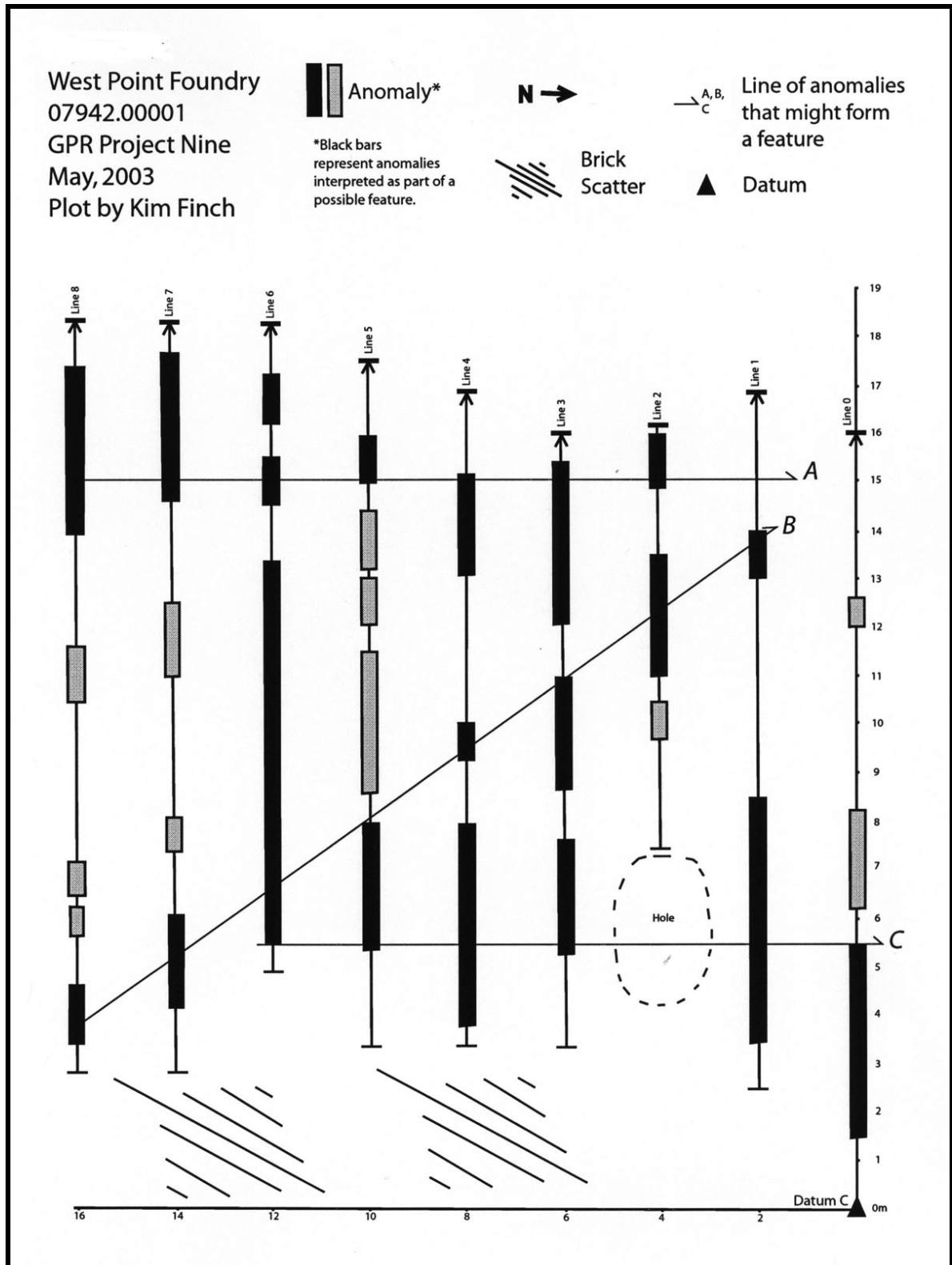


Figure 4-12: Sketch map of GPR project nine

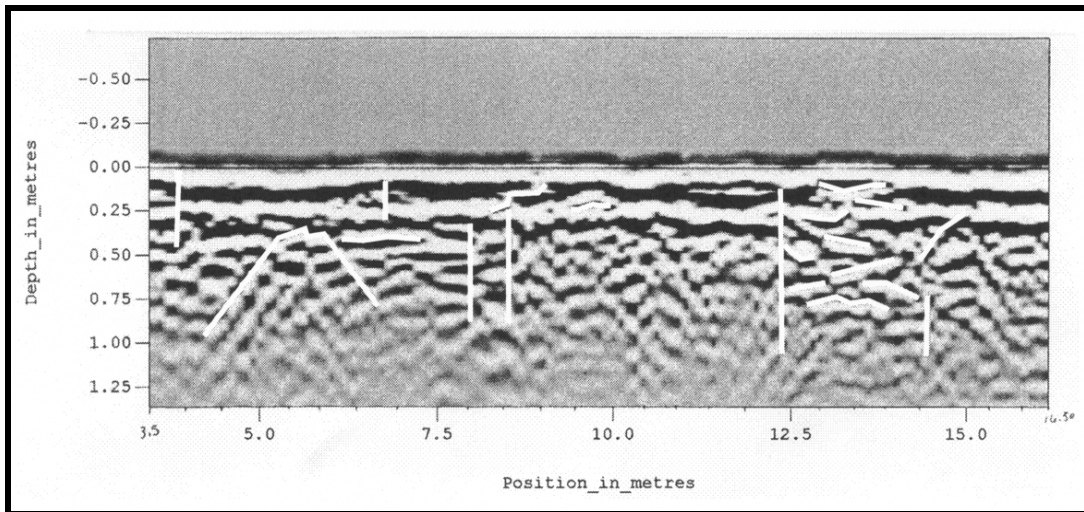


Figure 4-13: Depth section of GPR project nine, line 4. An example of the chaotic nature of anomalies in project nine. A sample of point reflections and disrupted soil horizons are outlined in white.

Line zero began at datum C and extended west 16 meters. Three anomalies appeared on this line: a four meter long anomaly at 1.5 meters, a two meter long anomaly at 6.25 meters, and a 0.5 meter anomaly at 11.75 meters. These appeared as areas of disturbed soil.

Line one began two meters south of datum C and 2.5 meters west of the x-axis due to a large tree. This line extended 16.5 meters west. Two anomalies occurred along line one: a five meter long area of disturbed soil began at 4.75 meters and a 1 meter long depression began at 12.5 meters.

Line two began four meters south of datum C and 7.5 meters west of the x-axis due to the presence of a large sinkhole between 4 and 7 meters along this transect. This line extended 16 meters west. Three anomalies occurred along line two: a 0.75 meter long anomaly at 9.75 meters, a 2.5 meter anomaly at 11 meters, and a one meter long anomaly at 15 meters.

Line three began 6 meters south of datum C and 3.5 meters west of the grid's x-axis due to brick scatter. Line three extended 16 meters west. Two 2.5 meter long

anomalies occurred on this line, beginning at 5.3 and 7.5 meters. A 3.5 meter long anomaly began at 12 meters.

Line four began 8 meters south of datum C and 3.5 meters west of the grid's x-axis due to brick scatter. This line extended 16.5 meters west. Four anomalies occurred along line four: a 3.25 meter long anomaly began at four meters, two 1 meter long anomalies began at 7 and 9 meters, and a 2 meter long anomaly began at 13 meters.

Line five began 10 meters south of datum C and 3.5 meters west of the grid's x-axis due to brick scatter. Line five extended 17.5 meters west. Five anomalies occurred along this line: a 2.5 meter long anomaly began at 5 meters, a three meter long anomaly began at 8.5 meters, one meter long anomalies began at 12 and 15 meters, and a 1.3 meter long anomaly began at 13.5 meters.

Line six began 12 meters south of datum C and five meters west of the grid's x-axis due to surface debris and brick scatter. This line extended 18.25 meters west. Four areas of disturbed soil occurred along line six: a three meter long anomaly at 5.5 meters, and two 1 meter long anomalies at 14.5 and 16 meters. A five meter long depression occurred between 8.5 and 13.5 meters.

Line seven began 14 meters south of datum C and three meters west of the grid's x-axis due to brick scatter. Line seven extended west 18.25 meters. Five small anomalies occurred along this line: a two meter anomaly at 4 meters, a 0.75 meter anomaly at 7.5 meters, a two meter long anomaly at 11 meters, a 2.5 meter anomaly at 14.5 meters, and a 0.5 meter long anomaly at 17 meters.

Line eight began 16 meters south of datum C and three meters west of the grid's x-axis due to brick scatter. Line eight extended 18.25 meters west. Five anomalies occurred along this line: a one meter anomaly at 3.5 meters, two 0.5 meter anomalies at 5.5 and 6.5 meters, a one meter anomaly at 10.5 meters, and a 3.5 meter anomaly at 14 meters.

Despite the large number of anomalies throughout project nine, three potential patterns emerge upon examination of anomalies plotted on a survey grid. One line of anomalies, visible as chaotic soil horizons, had a north-south alignment at the western end of lines one through eight (pattern 'A'). Another group of anomalies, also visible as chaotic soil horizons, had a northwest to the southeast alignment from lines one through eight (pattern 'B'). It is also possible that another with a north-south alignment, denoted by a line of depressions, lay along the eastern edge of the survey grid. However, without further geophysical testing or ground truthing, the presence of features in these locations cannot be ascertained.

Conclusions

Results of the 2003 West Point Foundry GPR surveys demonstrate the effectiveness of geophysical exploration on an industrial site. Despite several external factors that hindered GPR projects, including heavy rainfall and significant concentrations of surface and near surface features, the survey identified the location of several subsurface features and helped identify areas for excavation.

Anomalies in project two coincide with the path of the tailrace identified on the 1979 historic base map. Radar most likely did not reflect the actual tailrace structure; to protect it from surface activity, engineers possibly constructed it between one and two meters below surface. The small waste water drain south of Battery Pond, for example, lies two meters below ground surface where it exits into Foundry Brook. Anomalies in the location of the tailrace, therefore, probably represent fill placed on top of the tailrace. This fill would appear as a discontinuous soil horizon and depression where the ground settled over time.

Ground penetrating radar also identified probable subsurface pipes. In project eight, radar identified iron drain pipes visible at Foundry Brook. A line of point reflections in project five suggested that a buried pipe runs east-west between Foundry

Brook and the boiler house, coinciding with historic map data. Point reflections in projects one, four, five, and eight may also indicate the presence of buried pipes. Ground penetrating radar is often used to identify buried pipes and drains in archaeological and non-archaeological contexts; knowing that this technique is capable of identifying pipes buried amidst industrial debris is beneficial to archaeologists and site developers who need to locate these features prior to excavation.

Despite successful results, characteristics of the foundry site necessitate a re-evaluation of the radar equipment and methods employed during the 2003 field season. Uneven terrain and numerous surface features such as fallen trees and brick piles prevented smooth operation of the Smart Cart and rendered the wheel odometer useless as the cart wheels frequently left the ground. These features easily jostled the Noggin^{Plus}, which hung only inches above the ground surface, and the wheels frequently became clogged by wet leaves that covered the valley floor. These conditions slowed surveys and caused false reflections in survey data as the cart bumped into and over surface features.

Future GPR surveys should employ separate antennas or a cart more suited to the West Point Foundry site. Separate antennas provide better maneuverability and stability, as users manually place them along survey lines at predetermined intervals. This method resembles the step method employed during the 2003 season, but avoids difficulties associated with pushing a cart through the woods.

Archaeologists should experiment with a lower antenna frequency during future surveys. During a survey of an eighteenth-twentieth century sugar factory at the Estate Whim Plantation, U. S. Virgin Islands in 1999, for example, archaeologists and geophysicists employed 200MHz antennas. Although this low antenna frequency

obscured shallow archaeological deposits, it enabled identification of diffractions originating up to 1.2 meters below surface.⁶

The 250MHz antenna used at the West Point Foundry provided subsurface visibility to approximately one meter across most areas of the site, but frequently did not see past near-surface material. As discovered during excavation, most features associated with the water system lay between 0.5 and 2 meters below surface. Thousands of small objects, such as nails, iron fragments, and slate, also lay close to the ground surface, creating point reflections that blocked larger features underneath. Although computer filtering could remove some of these reflections, a lower frequency antenna, such as the one employed in St. Croix, could see past these small objects and provide data for greater depths.

The West Point Foundry survey also demonstrated that dense line spacing and data collection intervals are necessary on industrial sites. Due to the high concentration of surface and sub-surface objects such as iron fragments, even very prominent near-surface features did not appear on every survey transect. A near-surface iron drain in project eight, for example, appeared on only three of five survey lines. Increasing the number of transects in a survey area facilitates recognition of patterns indicative of features. During the 2003 survey, areas in which transect intervals were 1 meter or less with data collection every 5 centimeters along survey transects provided the clearest indication of features. Although the iron drain in project eight did not register on every transect, dense data collection enabled identification of a pattern. Line spacing of 2

⁶ Len Mankowski, et al. "A Geophysical Investigation of a Sugar Can Plantation, St. Croix, U.S. Virgin Islands: Using Multiple Techniques to Assess a Complex Industrial Site." *Proceedings of the Symposium on the Application of Geophysics to Engineering and Environmental Problems*, compiled and edited by M.H. Powers, A.B. Ibrahim, and L. Cramer, p374. The Annual Meeting of the Environmental and Engineering Geophysical Society, February 20-24, 2000, Arlington, Virginia.

meters and use of the step method every 10 centimeters, as employed in project nine, obscured pattern recognition.

Ground penetrating radar surveys at the West Point Foundry demonstrated the overall effectiveness of radar at an industrial site. Despite surface and subsurface materials, as well as a very saturated matrix, radar delineated several anomalies across the site. Archaeologists examined some of these features during excavation.

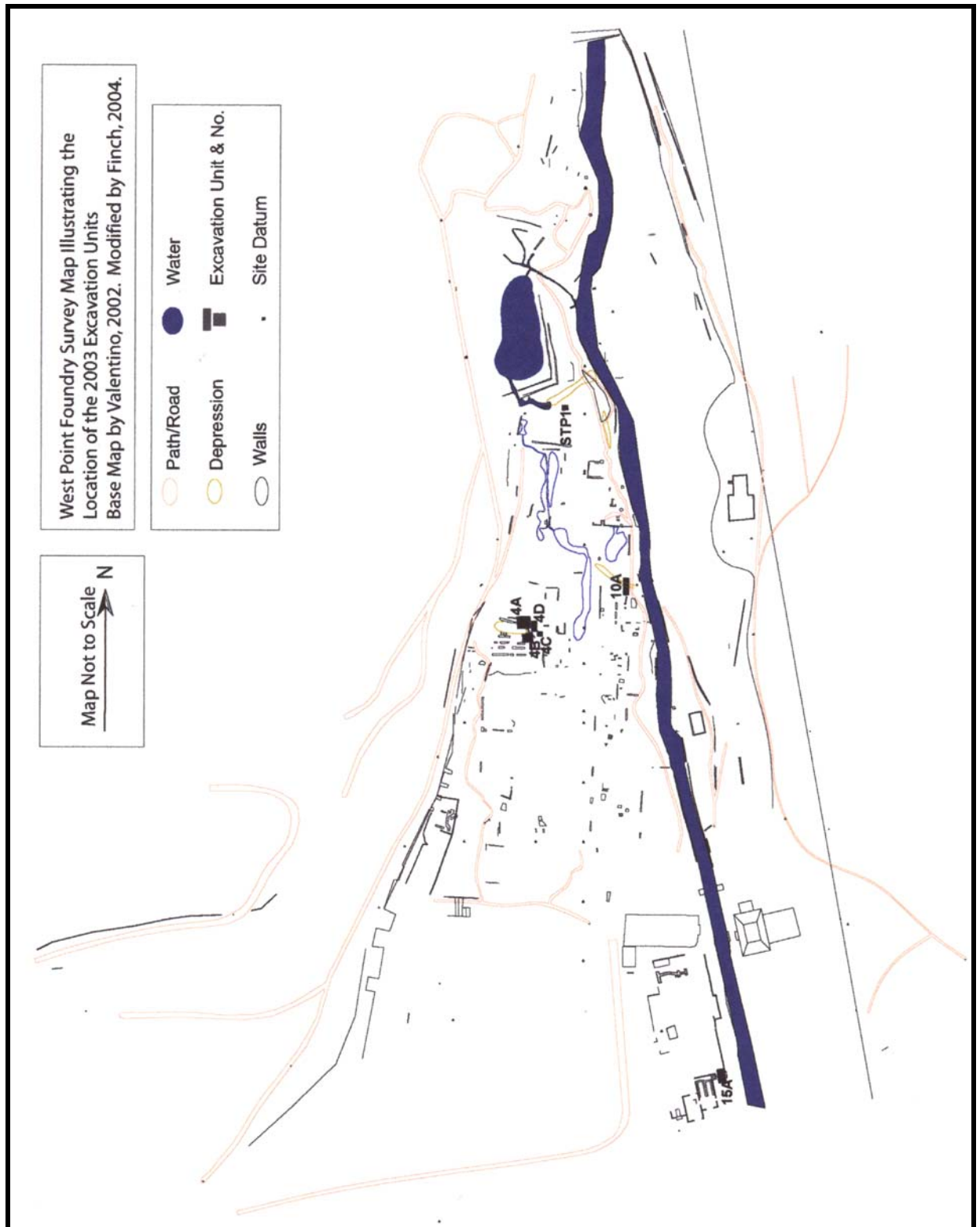
Chapter 5 Excavation

Ground penetrating radar surveys did not provide unambiguous evidence of subsurface features related to the foundry's waterpower system. To determine if features noted in GPR data had archaeological meaning, archaeologists conducted excavation, or ground truthing. Ground penetrating radar surveys justified the placement of one unit at the boring mill, one shovel test pit south of Battery Pond, and one unit at the boiler house. Archaeologists positioned four other units based upon surface features, historical map data, and one line of resistivity data. These included three additional units at the boring mill and one unit north of the power house. Excavation revealed several key features associated with the foundry's waterpower system, as well as architectural details that provided information about operations at the boring mill and the iron turning and planing shop. Map 5-1 illustrates the location of each excavation unit.

Chapter Five describes excavation goals and methodology, and provides an analysis of stratigraphic levels and artifacts recovered from each excavation unit. Chapter Five concludes with a discussion of artifact categorization, including a discussion of artifact percentages in comparison with Stanley South's Carolina and Frontier Artifact Patterns.

Excavation Goals and Methodology

Archaeologists designed excavation to provide details about the foundry's waterpower system, including the location, construction, and function of its different components. Archaeologists were particularly interested in identifying the boring mill wheel pit and tailrace inlet, subsurface drains, and the subsurface tailrace identified on



Map 5-1: 2003 excavation units

historic maps. To help identify activity areas and dates of occupation associated with these areas, archaeologists collected artifacts from each excavation unit.

Archaeology students followed controlled excavation techniques and carefully labeled all excavated material. Excavation levels were both arbitrary and natural; while arbitrary levels of 10 centimeters ensured control over data, observation of natural changes in stratigraphy, artifact concentrations, or discrete depositional events often informed level designation. Students used trowels and shovels during excavation, and sifted material through a 1/4 inch screen. Archaeologists placed artifacts in polyethylene bags and labeled them with the New York State archaeological site number (07942.00001), the unit, level number, date, excavator's name, bag number, and catalogue number. The catalogue number represented the year of excavation, MTU accession number, excavation unit designation, and level; 03-02-4A-1, for example, represents the year 2003 ("03"), the second site on which MTU excavated in 2003 ("02"), the first unit opened in operation four ("4A")¹, and level number 1 ("1").

Archaeologists thoroughly documented each level in each unit with written descriptions, illustrations, and photographs. On prepared field forms, students observed variations in soil characteristics, natural inclusions such as roots and cobbles, cultural inclusions such as brick and mortar fragments, as well as artifact types and concentrations (Figure 5-1). A plan view of the top of each level was included on the back of field forms, facilitating description and interpretation of photographs. The top of each level was also photographed with black and white and color film. Digital photographs recorded important features.

¹ Archaeologists based unit designation on 2002 mapping operations, which arbitrarily divided the site into 19 survey areas. "4A" refers to operation 4 and the first unit opened in this operation ("A").

Michigan Technological University Industrial Archaeology		Approved _____ Excavation Level Form	
Site: <u>West Point Foundry</u>		Catalogue Number: _____	
Test Unit # _____	Level _____	Depth below datum	NW _____ NE _____
Photos		SW _____	SE _____
B&W Roll# _____	Exposure #'s _____	Center _____	
Color Roll# _____	Exposure #'s _____	Location of datum _____	
Digital Chip# _____	Exposure #'s _____		
Feature #'s & description _____			
Soil description (Munsell #'s & colors) _____			
Texture, compactness, inclusions, etc. _____			
Excavation procedure	shoveled _____ troweled _____ other(specify) _____	Matrix treatment	1/4 inch screen _____ not screened _____ other(specify) _____
Artifacts/other remains (# of bags _____ ; # of large artifacts _____) _____			
Noted but not saved: _____			
Samples (slag, ore, soil, wood, etc.; # & type) (# of bags _____) _____			
Description & Interpretation (location of artifacts, nature of deposits & features, changes btwn levels, relation of unit to other cultural and natural features on the site generally, etc.)			

Recorded/excavated by:		Date:	

Figure 5-1: MTU excavation level form.

Upon returning to MTU's archaeology laboratory, students washed and cataloged artifacts recovered in the field. Cleaned artifacts were sorted and bagged by material and functional classes, such as window glass or beer bottle glass. MTU utilizes an historic artifact cataloguing system based upon categories devised by Stanley South in the 1970s.

Each artifact from the 2003 field season was grouped into one of these categories, which consisted of kitchen, architecture, furniture, arms, tobacco, clothing, personal, activities, and other.

Description of Excavation Units

Operation Four: The Boring Mill:

Archaeologists excavated four units at the boring mill: 4A, 4B, 4C, and 4D. These units, based on examination of visible features (4A and 4B), GPR data (4D), and one line of resistivity data (4C), provided data about the boring mill, the iron turning and planing shop, and a key component on the foundry's waterpower system. Figure 5-2 illustrates the location of these units.

Unit 4A and Feature One:

Archaeologists positioned excavation unit 4A (N5089, E4974.91) within the waterwheel pit in the northeastern corner of the boring mill.² This two by two meter unit incorporated a section of iron wheelpit lining, the wheel pit, and what archaeologists believed was the inlet of the tailrace leading from the boring mill to Foundry Brook.

Archaeologists based the location of 4A on visible surface features rather than historic map data. The 1979 historic base map identified a tailrace that extended from the center of the wheel pit to Foundry Brook. Removal of organic material from the surface of the wheel pit revealed a row of cut stones at the pit's eastern end. The stones appeared to form an arch, which suggested an opening lay beneath sediment and architectural debris surrounding the stones. Archaeologists positioned unit 4A based on the stone arch and the possibility that it was the tailrace inlet.

²Unit coordinates (northing and easting) refer to the southwestern corner of each unit.

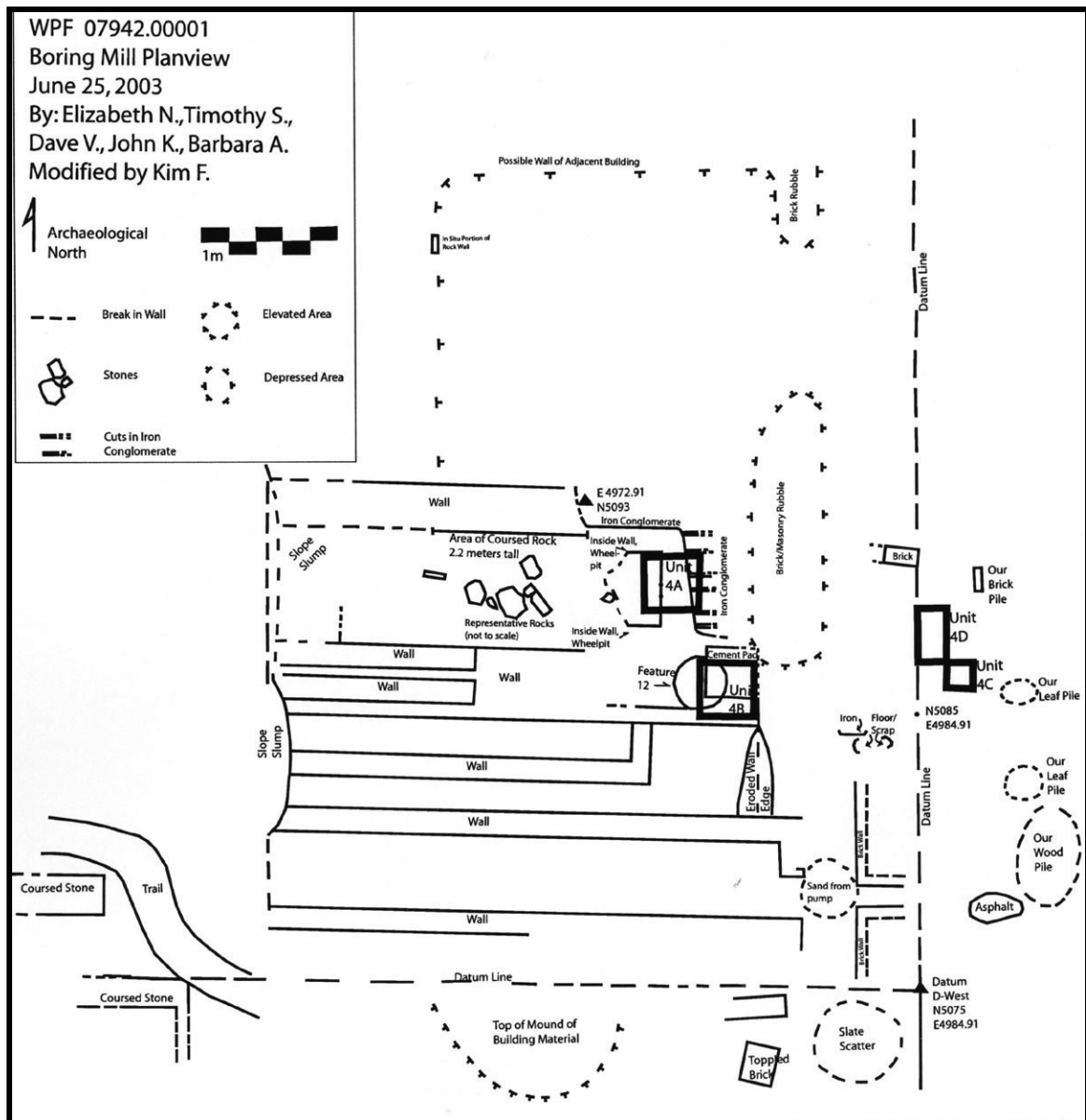


Figure 5-2: Planview drawing of the boring mill at the West Point Foundry outlining excavation units from the 2003 field season.

Excessive organic material, architectural debris, and erosion from the slope of the eastern boring mill wall prompted excavation of 4A via arbitrary levels. Archaeologists began excavation on the upper east side of the unit, atop of the iron wheel pit lining. Figure 5-2 illustrates the lining's position in relation to the wheel pit (eastern edge of unit 4A). Removal of fewer than five centimeters of black sandy-silt from the blocks of iron revealed an iron washer, machine cut nail fragments, and window glass fragments. The

iron blocks themselves consisted of a compacted iron conglomerate approximately five centimeters thick. Ten centimeter wide cuts, or slots, in the conglomerate extended one meter east from the pit edge. Wood fragments and nails associated with these cuts suggested that floorboards or another structural support fit into these spaces. Excavation ceased in this location after archaeologists exposed the top of the conglomerate.

Excavation of the western half of 4A incorporated sediment eroding from the eastern wall onto the top of the cut stone arch, as well as the area immediately west of the cut stones. Sediment above the cut stones consisted of black colored silt. The bottom of the wheel pit consisted of very saturated black, silty sediment that quickly turned to mud as archaeologists excavated the first ten centimeters. Artifacts discovered during wet screening included large iron bolts, machine cut nails, iron spikes, iron fragments, and window glass.³ Mortar, gravel, and iron bits eroding from the pit lining also occurred throughout the western half of 4A. These artifacts represented architectural debris from building decay, as well as materials deposited during the boring mill's operation. Archaeologists also removed several large stones that must have fallen into the wheel pit from a southern wall.

Archaeologists removed stone rubble and approximately 20 centimeters of sediment above and below the cut stones, revealing a two meter long cut-stone wall and archway designated as Feature One (Figures 5-3 and 5-4). A 30 centimeter wide and 50 centimeter tall keystone occupied the center of this wall, forming the top of the arch. Water lay at the base of the keystone. As archaeologists removed rock rubble and mud from the front of the keystone, a two meter wide, water filled hole became visible beneath the archway. By removing rocks by the keystone, archaeologists unblocked the hole, and water quickly flooded the western third of 4A. This hole extended at least two

³ Wet screening involves placing muddy sediment within the screen and pouring water over it. This washes the mud away, revealing artifacts underneath.

meters east, and sloped down under the keystone approximately 80 centimeters. Due to increasing water levels in front of the arch, archaeologists abandoned conventional excavation techniques and expanded excavation beyond the boundaries of unit 4A.



Figure 5-3: Eastern wall of the boring mill waterwheel pit (Feature One). Note the stone arch and central keystone, which marks the inlet to a subsurface tailrace. Photograph by Mike Deegan.

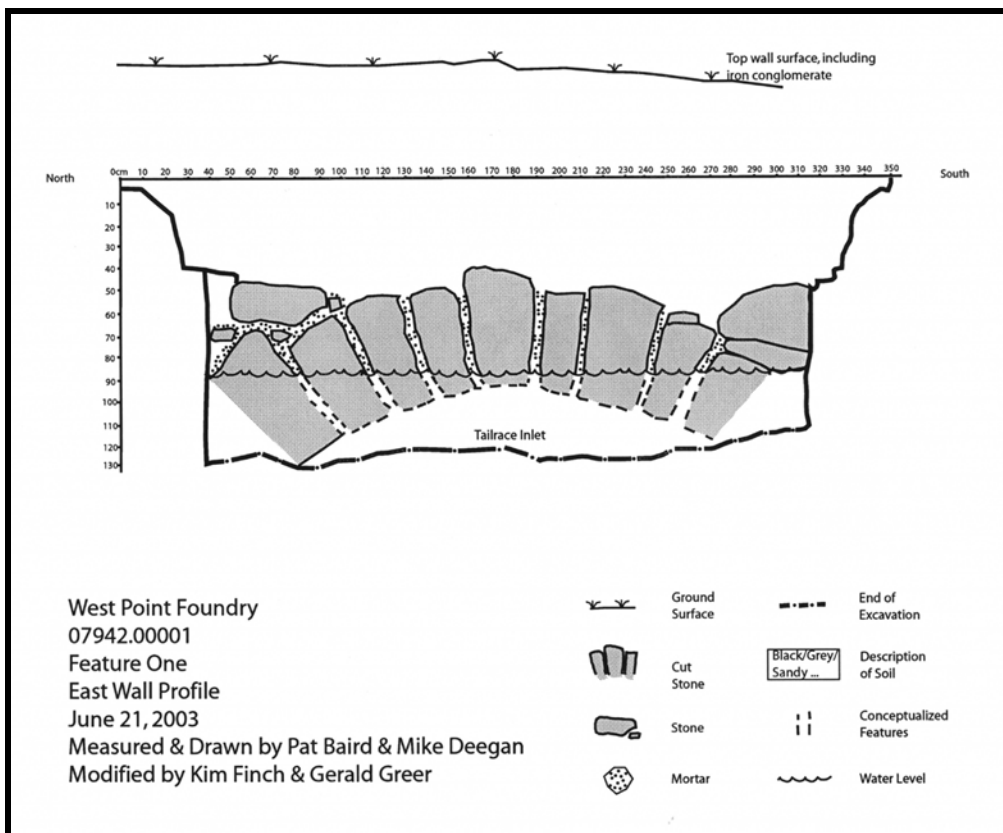


Figure 5-4: Detail of a stone arch marking the entrance to a subsurface tailrace at the boring mill

Archaeologists continued excavation along the entire eastern end of the boring mill wheel pit using a six inch diaphragm pump and shovels. A hose inserted under the keystone pumped water, sand, and leaves out of the hole and into an area to the southeast. Figure 5-2 illustrates the location of the sand pile created by pumping. Archaeologists removed large timbers and stones extending across the area of excavation, placing them further west of the arch. Intent only on exposing the interior face of the wheel pit, archaeologists did not screen sediment or excavate by levels.

Excavation of Feature One revealed a three meter wide cut-stone and mortared wall, including an archway over the entrance to a subsurface tailrace (Figure 5-5).⁴ Walls on the northern and southern edge of the wheel pit consisted of cut stone blocks, which extended west for 1.4 meters and 1.9 meters, respectively (Figure 5-6). The western edge of the northern stone wall met a mortared stone wall above the wheel pit. Large blocks in the wheel pit along the southern wall suggested a similar wall existed but collapsed after the building's abandonment. Large holes drilled into several of the large stones suggested that these walls supported substantial machinery or structural components, perhaps related to the water wheel.

Despite the crew's best efforts, the pump did not keep up with rising water levels in the area surrounding the arch. Archaeologists closed Feature One after taking final measurements, photographs, and notes. To protect the tailrace inlet from the elements and facilitate future access, archaeologists constructed pillars on the north and south sides of the wheel pit with bricks removed from units 4A and 4D. Archaeologists placed boards across these pillars, covered them with plastic, and backfilled over the plastic.

⁴ This measurement is north to south from the outside of the walls. The interior of the pit, north to south, is 2.76 meters.

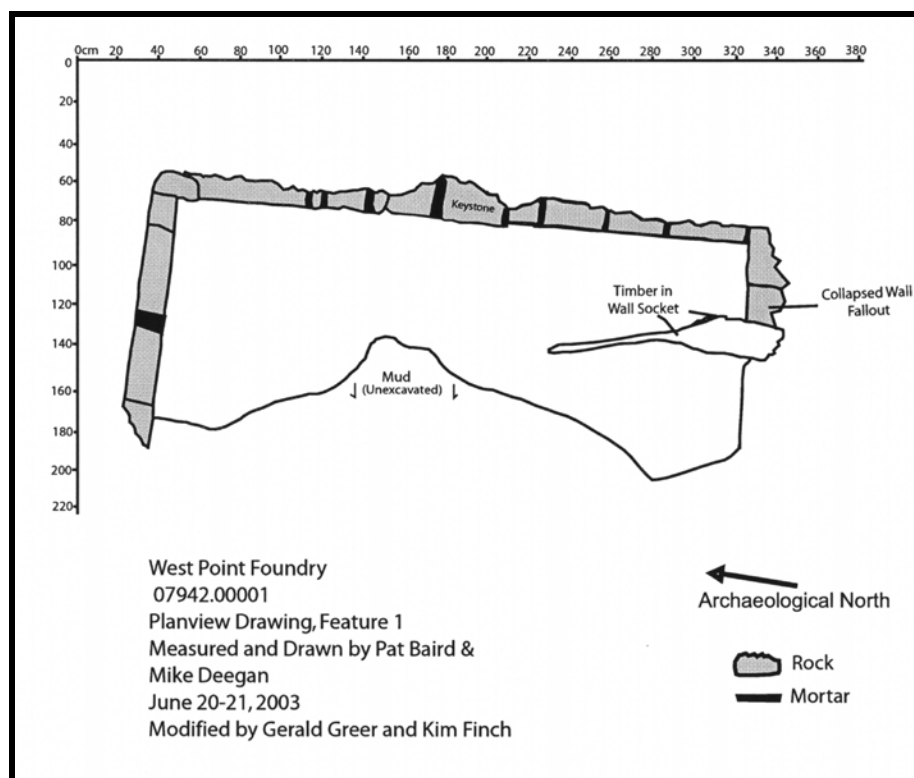


Figure 5-5: Planview drawing of the eastern end of the boring mill wheel pit

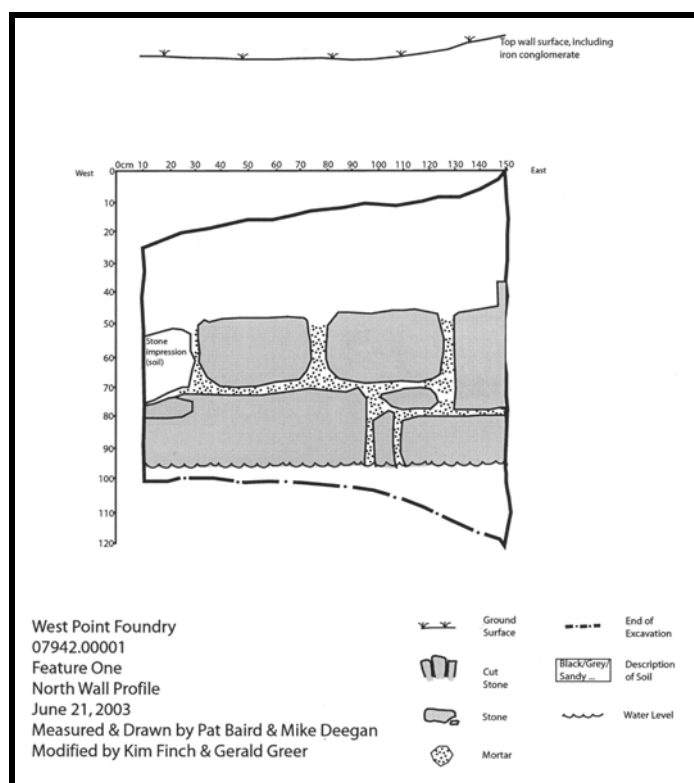


Figure 5-6: Profile drawing of the northern wheelpit wall in the boring mill

Unit 4B:

Unit 4B (N5085, E4976.91) was a two by two meter unit located along the eastern wall of the boring mill. This unit incorporated half of a 2.25 by 2 meter circular, stone-lined pit and an associated stone platform (Feature Twelve). Figures 5-7 and 5-8 illustrate Feature 12 within unit 4B. Archaeologists excavated this feature because of its proximity to the assumed tailrace inlet in the boring mill wheel pit. A break within a wall separating the wheel pit and southern sections of the boring mill suggested a connection between these features. However, the absence of iron conglomerate associated with water-related features such as the water wheel pit and Battery Pond suggested that this feature was not related to the boring mill's waterpower system. Holes six centimeters in diameter in the stone platform and within stones in the pit itself suggested that heavy machinery possibly related to vertical boring or casting once stood near or over this pit.



Figure 5-7:
Feature Twelve, a
round, stone and
mortar lined pit
within unit 4B.
Photograph by Joe
Wilson.

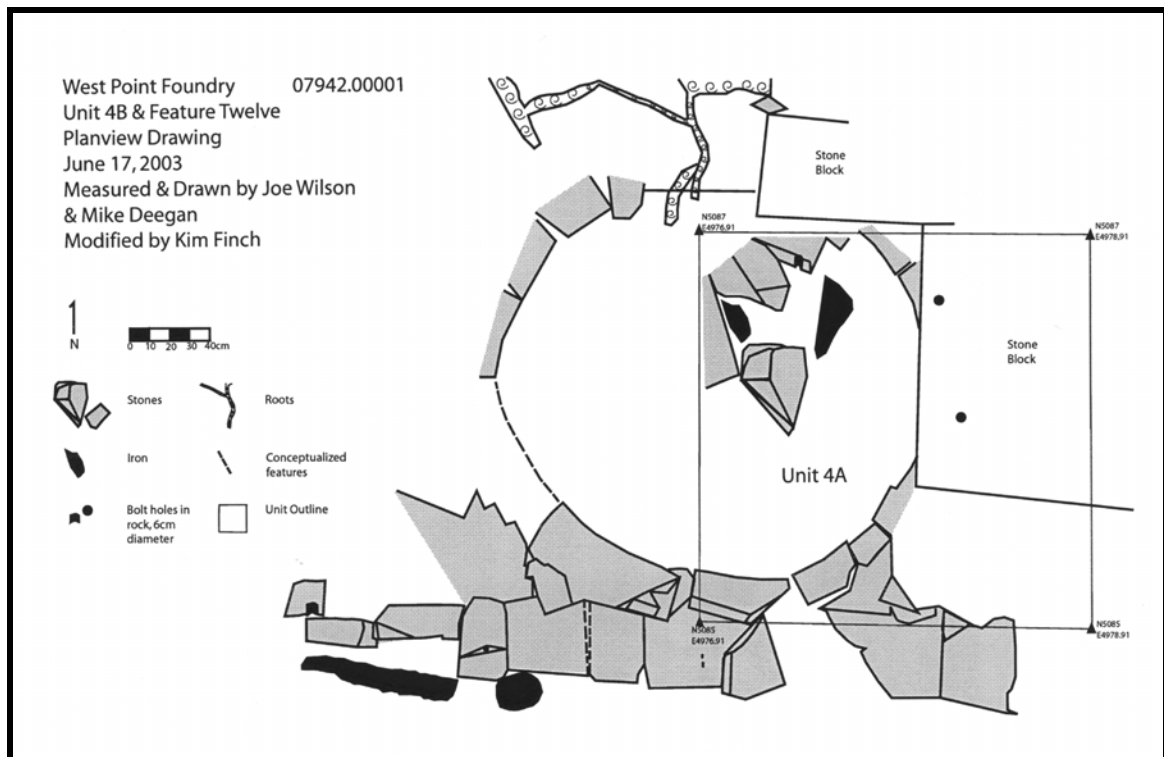


Figure 5-8: Planview drawing of Feature Twelve, including unit 4B

Archaeologists excavated the eastern half of the circular, stone-lined pit, obtaining necessary data without obliterating the feature. Archaeologists excavated this unit in four arbitrary levels of approximately ten centimeters. Excavation proceeded in larger increments in the northwest and northeast corners of the unit due to the presence of uncoursed brick and large stones. High water levels forced the closure of unit 4B in level four.

Level one consisted of a loosely compacted, black sandy-silt with root and gravel inclusions. Several large stones, many with bolt holes, covered the surface of level one, along with mortar, slag, window glass, nails, brick, slate, and modern trash. Archaeologists uncovered two 6 centimeter diameter holes along the western edge of the stone platform situated above the pit. The holes extended at least 30 centimeters down through the stones lining the circular pit. Wood floorboards lay alongside these holes.

This level consisted primarily of architectural debris from the boring mill roof, walls, and the decaying stone-lined pit.

Level two consisted of a loosely compacted, black sandy-silt with fewer root and gravel inclusions than in level one. Architectural debris similar to that found in level one also appeared in this level. Artifacts included bottle glass, a pipe bowl, a bone fragment, ceramic insulator fragments, and large pieces of wood. Archaeologists removed the remaining sediment from the top of the stone platform, as well as from the southeastern corner of the unit. The presence of architectural debris and modern nails suggested that level two represented a disturbed context that resulted from structural decay.

Wood pieces discovered at the bottom of level two probably represent wood floorboards from the boring mill. These boards were approximately 47 centimeters long, 10 centimeters wide, and ranged from 1 to 7 centimeters thick. These boards also contained large knots. Thicker floorboards were often used in industrial buildings, especially in structures subjected to higher risk of fire; while the surface of these floorboards became charred, hot materials or fire were less likely to destroy the entire floor.⁵ As hot boring waste frequently fell onto the boring mill floor, thicker floorboards would have prevented fast wear.

Level three consisted of black, wet, sandy-silt with few root inclusions. Archaeologists recovered significantly fewer pieces of architectural debris from level three. Excavation also revealed the shaft of a skeleton key, large bolts, pieces of brazing rod, lead, and a 50 centimeter long iron rod. Fragments of wooden timbers appeared along the eastern edge of the stone pit. A large piece of rusted sheet metal also appeared along the western unit boundary within the stone pit. Large stones from the walls of the

⁵ Robert B. Gordon and Patrick M. Malone. *The Texture of Industry. An Archaeological View of the Industrialization of North America* (New York: Oxford University Press, 1994), 302.

stone pit protruded from level three, suggesting that this level also represented rubble from the pit walls and the boring mill.

Level four also consisted of black, wet, sandy-silt with few root inclusions. Due to increasingly wet sediment, archaeologists created a working platform and excavated only the northeastern half of the circular pit. Archaeologists recovered a large piece of sheet iron, 15 centimeter long iron spikes from a large iron block in the northern half of the pit, iron shavings, iron washers, nails, asphalt fragments, wood flooring, and some brick. Despite efforts to work in the muddy unit, heavy rainfall during excavation flooded the unit, which did not dry out during the remainder of the field season. Over 15 centimeters of water covered the floor of the circular pit, forcing the closure of unit 4B after excavating only 35 centimeters.⁶

Archaeologists obtained relatively little information related to industrial activities associated with this feature. A large rock protruding from the center of 4B in level four suggested that archaeologists did not excavate past rubble from building collapse; a group of vertically oriented objects is often indicative of collapsed or fallen material, whereas flat-laying objects more likely represent an intentional deposit. Prior to backfilling, archaeologists covered the bottom of the unit with plastic and large rocks; archaeologists should continue excavation of unit 4B during subsequent field seasons.

Unit 4C:

During a demonstration of resistivity survey equipment, Dr. Charles Young gathered two lines of resistivity data. This included one line of data along line zero of GPR project six (from datum D West) and one line 1 meter east of this. While data gathered along line zero did not provide clear evidence of an anomaly, an area of low

⁶ 35 centimeters is the average excavated depth within the circular stone pit. Archaeologists excavated approximately 27 centimeters on top of the stone blocks east of the pit.

resistance on the second transect suggested that a feature lay between 11 and 12 meters (Figure 5-9). Archaeologists positioned unit 4C based on this data.

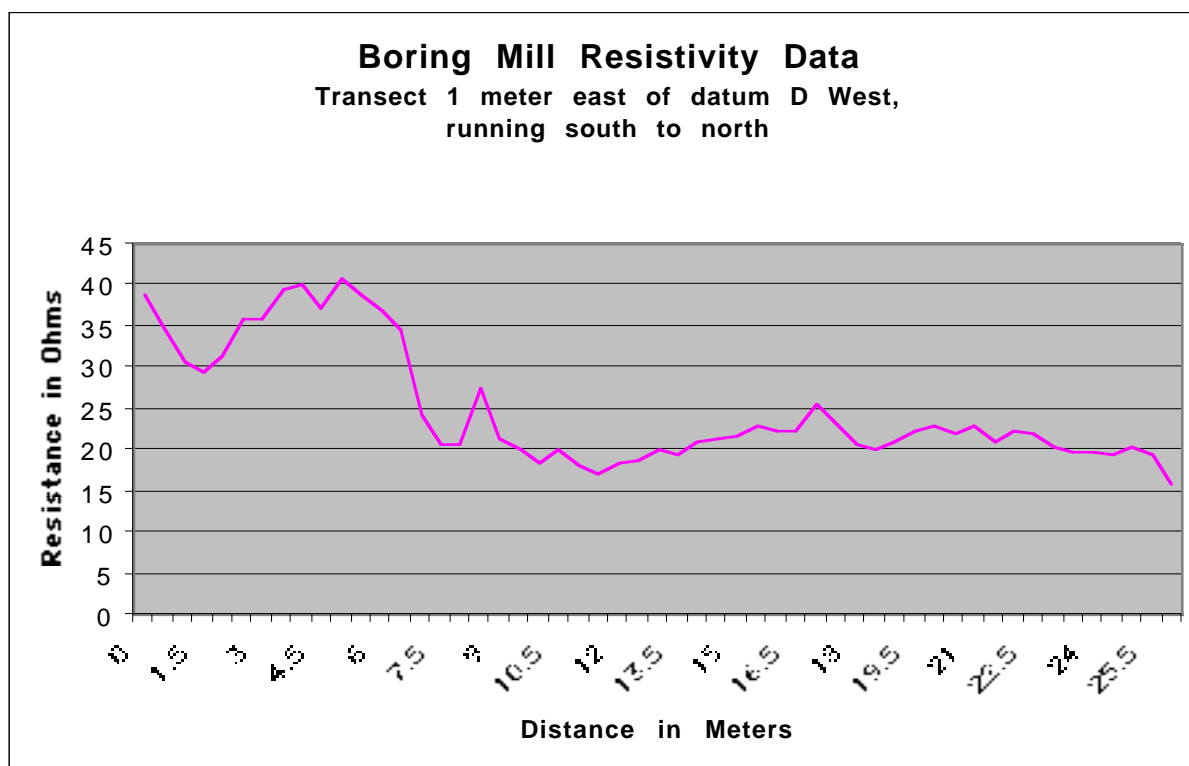


Figure 5-9: Resistivity data from a transect beginning one meter east of datum D West. Note the area of low resistance between 11 and 12 meters, which suggested a possible anomaly lay in this area.

Excavation unit 4C (N5086, E4985.91), located 1 meter east and 11 meters north of datum D-West, was 1 meter square and approximately 17 centimeters deep.

Archaeologists followed the natural stratigraphy of this unit, excavating three levels ranging from 4.7 to 6.2 centimeters deep.⁷ Excavation stopped upon reaching a layer of iron conglomerate that covered the bottom of the unit. As neither artifacts nor resistivity data indicated a feature lay beyond this conglomerate, archaeologists closed unit 4C.

⁷ These figures represent an average depth of the northwest, southwest, northeast, and southeast corner, as well as the center of each level.

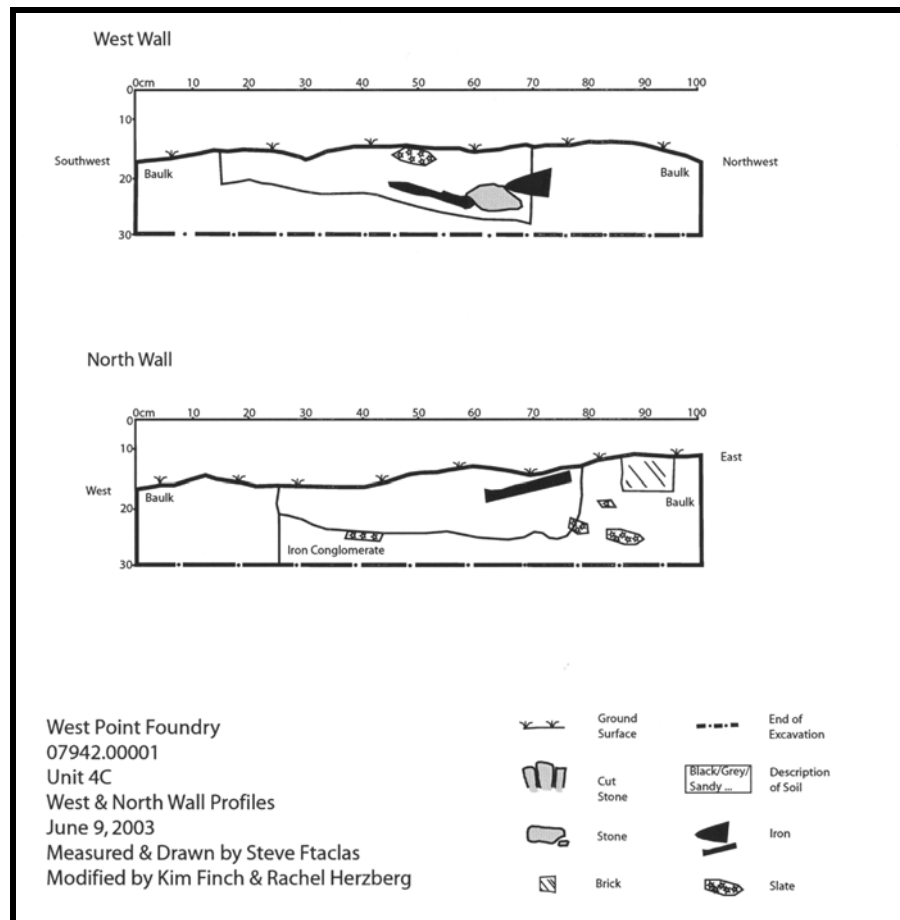


Figure 5-10: West and north wall profile, unit 4C

All three levels in 4C consisted of a black silty, sandy loam of medium to hard compaction (Figure 5-10). Each level contained inclusions of decayed leaves, coal, slag, iron fragments, brick fragments, and mortar. Recovered artifacts included window glass, lead, charcoal, and roofing slate. The presence of modern nails and architectural debris indicate that these levels represent a disturbed context.

Unit 4D

Unit 4D (N5087, E4984.91) was a one by two meter unit located 1 meter west and 12 meters north of datum D-West. Unit 4D was excavated to a depth of 108 centimeters. Archaeologists excavated 4D in seven levels that ranged from 6.7 to 47.8 centimeters deep. Both natural stratigraphic levels and arbitrary levels of six to ten centimeters

guided excavation. Thicker levels represented levels that demonstrated no stratigraphic or artifactual changes. Figure 5-11 illustrates stratigraphy and features in unit 4D.

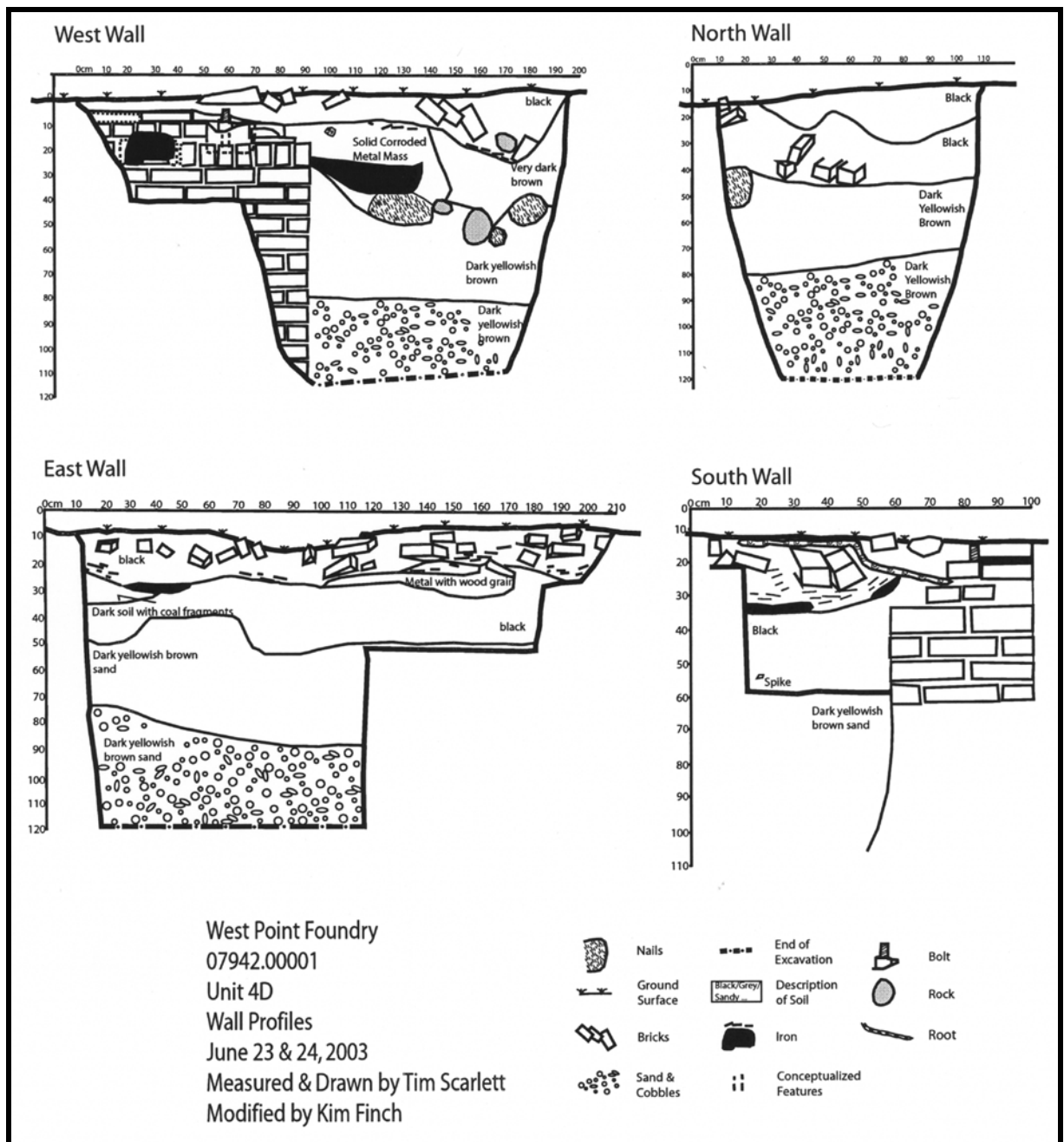


Figure 5-11: Wall profiles, unit 4D

Archaeologists placed unit 4D along line zero, GPR project six, based on anomalies identified during preliminary analysis of GPR data, as well as the presence of a slight depression filled with bricks visible on the ground surface to the north (Figure 5-

12). By positioning 4D south of the east-west oriented brick filled depression, archaeologists hoped to reveal the edge of associated subsurface features. GPR data filtering removed background noise and clarified the presence of an anomaly between 12 and 13 meters on line zero. Excavation revealed a possible brick machine mount in the southwestern quadrant of 4D, which was consistent with the position of a GPR anomaly.

The three uppermost levels of unit 4D consisted of a black colored sandy-silt with rock, mortar, roots, and decaying leaf inclusions. Small fragments of window glass and iron, along with machine cut nails, roofing slate, slag, coal, wood fragments, and bricks occurred throughout these levels. Large sections of compacted iron conglomerate appeared in the southern half of 4D in level two. This conglomerate consisted of iron nails, window glass, wood bits, and iron fragments embedded in a solidified, four to five centimeter thick iron mass. Archaeologists removed the conglomerate in levels three and four, revealing a thin layer of charcoal embedded between thin fragments of wood

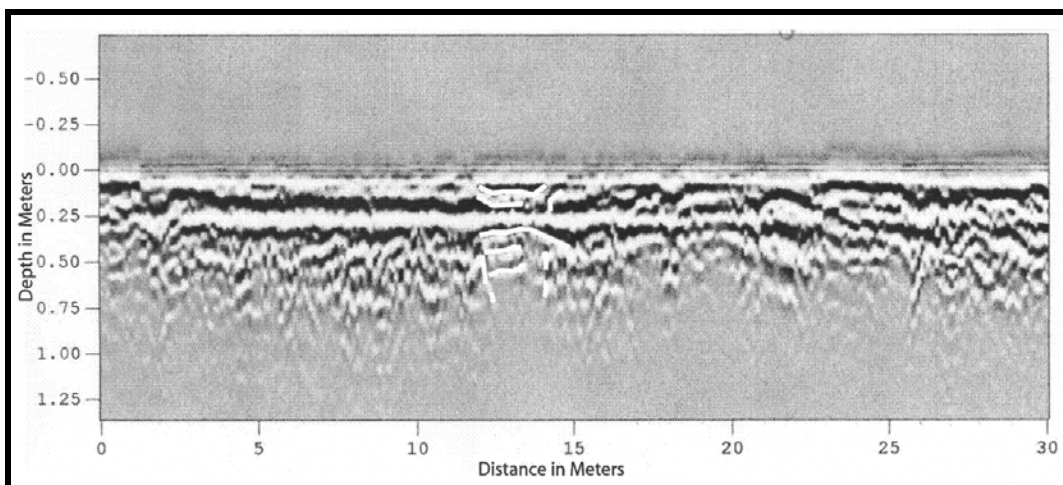


Figure 5-12: Depth section of project 6, line 0 outlining an anomaly between 13 and 15 meters.

underneath the iron masses. Fewer pieces of architectural rubble lay underneath the conglomerate. Modern (round) nails and the presence of architectural debris suggested that levels one through three represented disturbed contexts, the result of structural decay.

Large quantities of brick, window glass, and roofing slate in levels one through three represented structural decay from the boring mill and surrounding structures. The iron conglomerate in 4D, which was similar to the conglomerate identified in level three, unit 4C, represented waste iron that fused with iron shavings, nuts, washers, and other debris located on top of a wooden floor in the iron turning and planing shop. The thin layer of charcoal likely formed as the hot iron hit the wooden floor, burning the top of the floor.

The northern half of level four consisted of a black colored sandy silt, and the southern half of level four consisted of a reddish-black sandy silt. The entire level contained inclusions of iron shavings, and significantly fewer bricks, slate fragments, and window glass fragments underneath the extracted conglomerate. Artifacts within level four included nails, iron screws, slag, lead, and copper fragments. The reddish-black colored sediment in the southern half of the unit was the result of a higher concentration of iron, including nails, bolts, and bits of iron conglomerate. Building rubble and waste from building operations remained in level four, therefore it is unlikely that level four consisted of an undisturbed context.

Level five also contained areas of different sediment colors; the northern half of this level consisted of a brown sand with gravel inclusions, and the southern half of the level consisted of a reddish-black sandy-silt. The northern edge of the unit consisted of a compacted black sandy-silt. Artifacts within level five included leather fragments, iron shavings, and iron fragments. Archaeologists recovered over 700, three centimeter long nails from a dark stain in the west wall of level five. Brown sand surrounded the stain, which was created by the corroded nails. With the exception of the concentration of corroded nails, there was significantly less architectural material in level five, which suggested that archaeologists reached the end of rubble from structural collapse.

Archaeologists recovered only one modern nail amidst nineteenth century materials such

as boring waste, iron tools, and a leather fragment related to machine operation, which suggested that level five was a primary, or undisturbed context.

An area of yellow sand with gravel inclusions appeared in the northeastern quadrant in level five. Archaeologists designated this Feature Eight and excavated its southern half, revealing a sterile layer of sand. Archaeologists excavated the remaining half of Feature Eight and continued excavation throughout the unit, revealing a sandy matrix with gravel inclusions throughout the bottom of level five. Archaeologists concluded that Feature Eight was only a lens of sand protruding from level six. The loose matrix of 4D undermined archaeologists' attempts to maintain unit boundaries and wall stability. As a result, archaeologists excavated only the northern half of unit 4D beginning at level six.

Level six consisted of a dark yellowish-brown sand, with an area of very dark brown sand along the northern edge of the level. Cobbles, gravel, iron fragments, and roots occurred throughout this level. Artifacts included a few window glass fragments, nails, a leather strap, and iron shavings. The presence of machine cut nails placed this level between the 1830s and 1890s. Archaeologists closed level six when a higher frequency of larger stones appeared throughout the unit.

Level seven consisted of a dark yellowish-brown sand with pebble, large stone, and cobble inclusions throughout. Artifacts were more numerous than in level six. These included glass fragments and nails. The presence of a machine cut nail suggested that level seven dated from the 1830s to 1890s. Unfortunately, archaeologists reached the water table approximately 108 centimeters below ground surface, forcing the closure of unit 4D at level seven.

Archaeologists discovered a possible brick machine base, Feature Four, in the southwestern quadrant of 4D (Figure 5-13). The excavated portion of this feature, which was 80 centimeters long and 30 centimeters wide, became apparent at the bottom of level

one, and continued through level seven. A 15 centimeter square hole in the northern end of the feature held a threaded iron bolt. A high concentration of iron shavings recovered from this unit suggested that this base supported a lathe. The 1887 and 1897 Sanborn maps identified this structure as the iron turning and planing shop, which also supported this hypothesis.

Unit 4D provided a clear indication of stratigraphy within the iron turning and planing shop. Layers of brick rubble and slate, followed by slabs of iron conglomerate, a thin charcoal lens, wood, and sand with gravel and cobble inclusions represented structural decay following the structure's abandonment, iron build-up on top of a wooden floor during the structure's use, and sand and gravel fill that formed the structure's foundation. Unfortunately, archaeologists did not find a sterile subsurface due to high water levels. Excavation during drier seasons may reveal this layer.

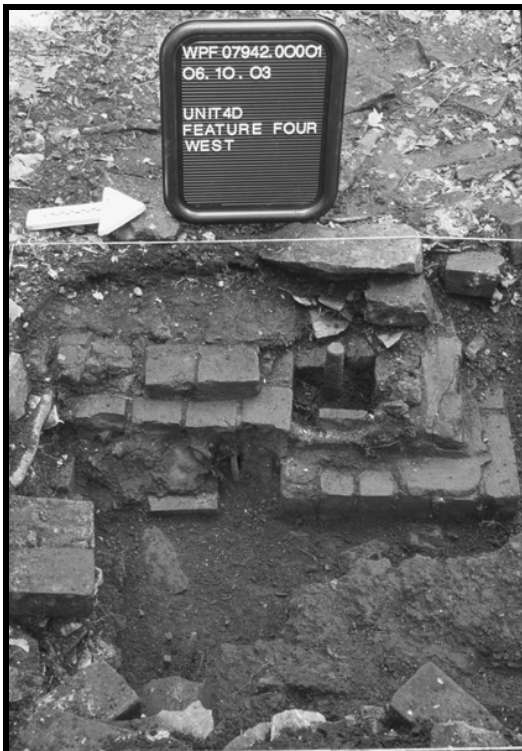


Figure 5-13:
Feature four, a brick machine
base in the southwestern
quadrant of unit 4D.
Photograph by Mike Deegan.

Operation Ten: The Power House

Unit 10A

Excavation unit 10A (N5107.5, E5015) was a one by three meter unit west of the modern brick walking path north of lines three, four, and five in GPR project eight. Unit 10A bisected a depression labeled 'drain' on the 1979 historic base map, which began in the southwestern corner of the blacksmith complex and ended in Foundry Brook.

Archaeologists hoped to identify a drain outline consistent with the path of the drain identified on the historic base map. Concerned primarily with structural detail, archaeologists employed shovels and trowels during excavation, and did not screen excavated sediment. Figure 5-14 illustrates this unit's stratigraphy and features.

Level one consisted of approximately 20 centimeters of black silty sand with leaf, root, and mortar inclusions throughout. Large rocks lay in the southern half of the unit, just south of the center depression. A layer of concentrated mortar and bricks lay north of the depression. Artifacts uncovered during excavation included large bolts, nails, wire, washers, window glass, and ceramics. Level one ended as a layer of sheet metal appeared in the southern third of the unit, and a layer of sandy became apparent north of the large rocks.

Level two consisted of approximately 15 centimeters of yellowish-red sandy clay in the southern half of the unit, and black silty-sand in the north. Roots, mortar, and charcoal continued throughout level two. Excavation exposed a large piece of sheet metal, which covered the southern third of the unit. Archaeologists also recovered mortar, fabric, glass, and a large iron pipe from this area. The northern third of 10A contained iron conglomerate, mortar concentrations, bricks, glass, and iron spikes. The sandy area along the southern edge of the depression continued throughout level two. Archaeologists closed level two when a compact layer of cinder and charcoal appeared

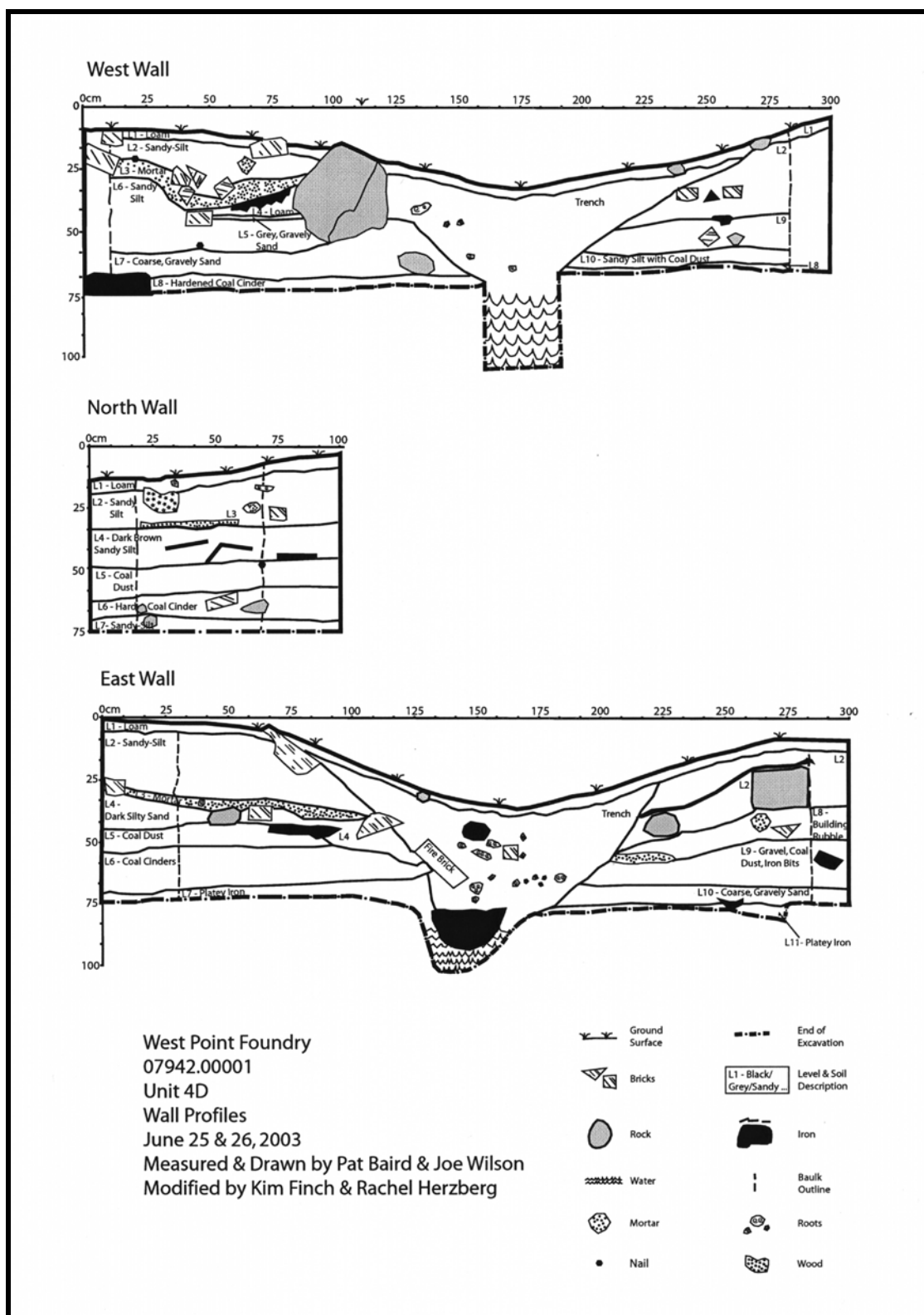


Figure 5 -14: Wall profiles, unit 10A

north of the depression, which suggested the beginning of a new occupational layer, possibly a floor.

Level three consisted of approximately ten centimeters of dark grey, sandy-clay sediment. Artifacts recovered from level three included coal, iron, and mica. The edges of a possible drain became visible in level three, defined on the south by more compact sandy-clay and on the north by very compacted layer of cinder and charcoal. The center of the drain became muddy as archaeologists reached the end of level three.

Level four consisted of approximately 16 centimeters of light grey sandy-clay north of the drain, and very dark greyish brown sandy-clay south of the drain. The drain itself became very muddy as archaeologists reached the water table. The top (water level) of the drain was 90 centimeters below datum.⁸ The bottom of the drain, which was approximately 110 centimeters below datum, consisted of gravel with brick inclusions. The 11 centimeter layer of coal cinder ended in level four, followed by an iron rich sandy-silt and a large, flat rock. Archaeologists closed unit 10A upon reaching the bottom of the ditch, rock to the north, and sterile soil to the south.

Archaeologists successfully defined the surface drain extending from the blacksmith shop to Foundry Brook (Figure 5-15). The drain was 37 centimeters wide at the western unit edge and 50 centimeters wide along 10A's eastern edge. It formed a 45 degree angle across the center of 10A, from the northwest to northeast sides of the unit. Large stones lined the final meter of this drain where it entered Foundry Brook; similar stones lined the southern boundary of the drain in 10A, but they were not present along the northern boundary. Stones were also absent along the drain's path between the blacksmith complex and 10A, suggesting that stones were only placed at the drain's terminus. It is also possible that stones had been displaced since the drain went into disuse, like many of the bricks across the site. Although the actual purpose of this drain is

not known, it probably channeled waste water from the blacksmith complex into the brook.



Figure 5-15:

Closing photograph of unit 10A, looking north. Water in the center of the unit defines a potential surface drain. Photograph by Pat Baird.

Operation 15: The Boiler House

A ground penetrating radar survey in operation 15 revealed a subsurface anomaly along a brick wall adjacent to the boiler house (Figure 5-16). This anomaly aligned with a tailrace outlet and several pipes identified on the 1979 historic base map, and with an area of welling water in Foundry Brook. Archaeologists placed unit 15A over this anomaly and revealed a subsurface brick structure and possible drain.

⁸ The datum for unit 10A was 4cm above ground surface.

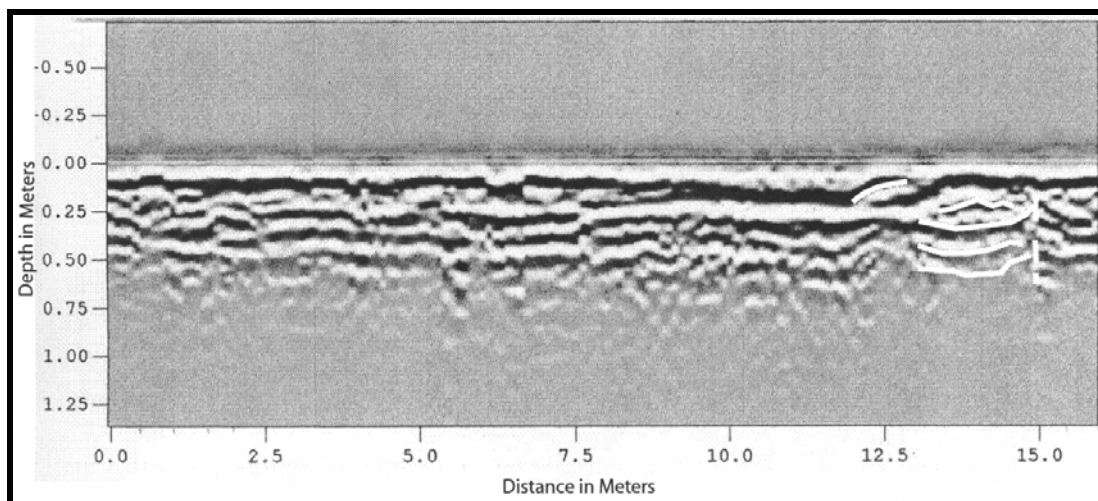


Figure 5-16: Depth section, project 5, line zero. Note the anomaly outlined between 12 and 15 meters.

Unit 15A

Excavation unit 15A consisted of a one by two meter unit east of the boiler house. Following natural stratigraphy, archaeologists excavated this unit in one level using shovels and a 1/4" screen. With the exception of an area of light brown sandy soil, designated Feature Seventeen, different strata were not apparent within the unit. The matrix consisted of a black, saturated silty-sand. Artifacts recovered during excavation reflect late construction and occupation dates of the boiler house. Archaeologists excavated to a depth of 91 centimeters below ground surface (Figure 5-17)

Large roots and modern artifacts compromised the integrity of the first 30 centimeters of 15A. Artifacts within the first 30 centimeters included light bulb filaments, mica, wire fragments, modern nails, cola bottle glass, and steel screws. A thick layer of roots at 28 centimeters gave way to fewer artifacts and roots.

Approximately 58 centimeters below surface, archaeologists discovered a ten centimeter lens of light brown sandy-silt located along the northern unit boundary. Artifacts from this lens, Feature Seventeen, included iron fragments, steel screws, and

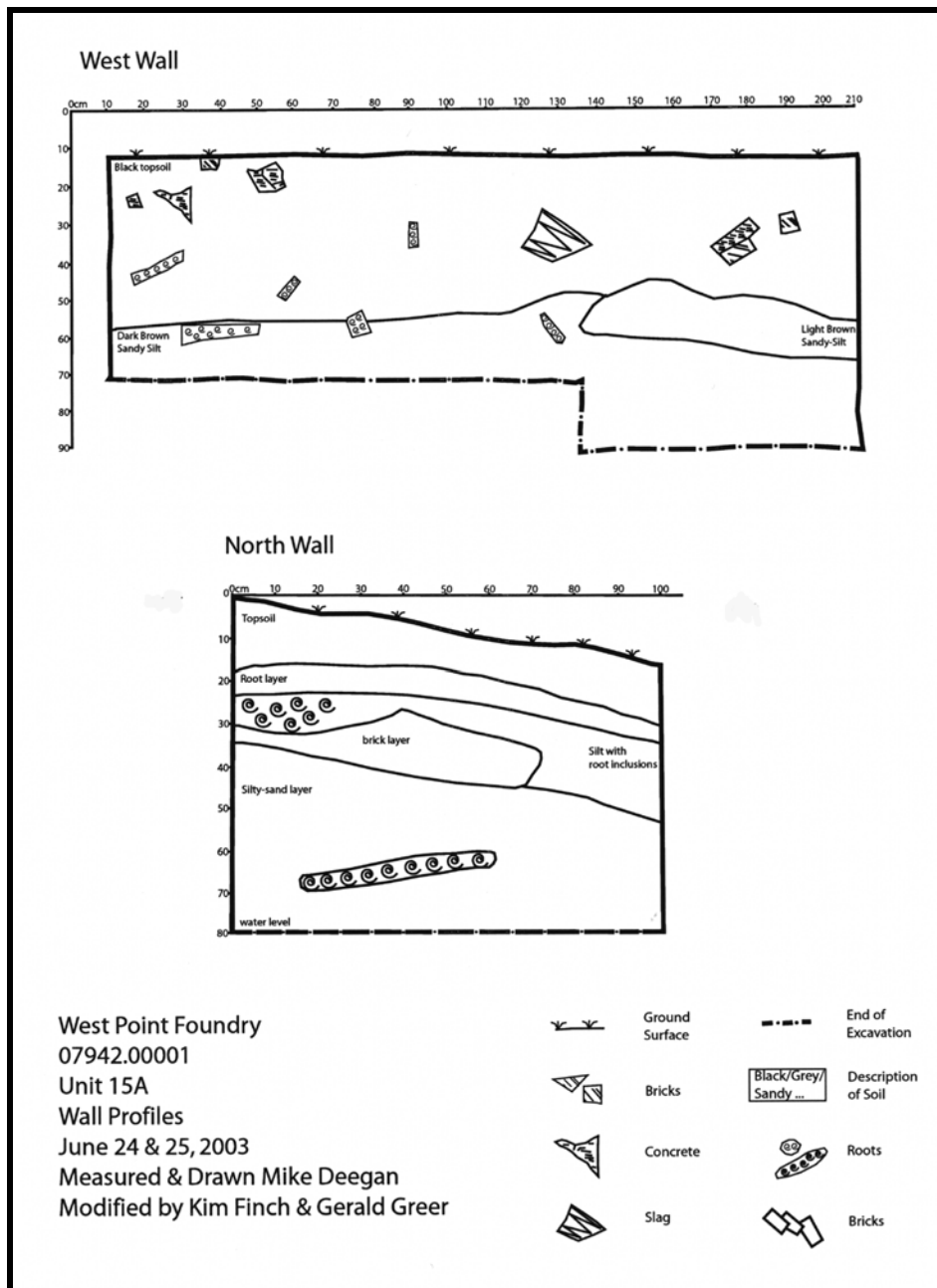


Figure 5-17: Wall profiles, unit 15A

fragments of brick, mortar, and coal. Decaying mortar from bricks located underneath this lens may have combined with the surrounding matrix, creating Feature Seventeen.

Archaeologists removed brick rubble underneath Feature Seventeen and revealed a layer of cobbles and coursed brick along the northern edge of 15A. Upon removal of the cobbles, water flowed from the northwest corner of the unit, quickly flooding it.

Although archaeologists were not able to determine the cause or origin of the flowing water, it could form part of the tailrace or pipes identified on historic maps. Figure 5-18 provides a closing photograph of unit 15A.



Figure 5-18:
Closing photograph of unit 15A, looking north. Notice water pooling along the northern wall and the masonry in the north wall. Photograph by Mike Deegan.

Operation Eight: Battery Pond

A GPR survey and visual inspection of an area south of Battery Pond revealed features related to water draining from Battery Pond into Foundry Brook. Archaeologists noted a large water leak from Battery Pond channeling into a hole within the ground south of the pond. Visual inspection of the area also revealed water flowing from an iron drain pipe into Foundry Brook slightly downstream from the surface drain hole. Anomalies on GPR time-depth sections aligned with these two features. To determine the relationship between these features, archaeologists placed a shovel test pit (STP1) on this line of anomalies.

Shovel Test Pit One (STP1):

Shovel test pit one (STP1) was a 1.5 by 1.4 meter unit south of Battery Pond. Ground penetrating radar data, a featured labeled 'drain' on the 1979 historic base map, as well as the presence of a drain hole with flowing water that aligned with an active drain

pipe emptying into Foundry Brook, justified the placement of this test pit (Figure 5-19).

Seeking only structural detail related to a possible subsurface drain, archaeologists employed shovels and trowels, and did not screen sediment removed from this unit.

Figure 5-20 illustrates stratigraphy and features of STP1.

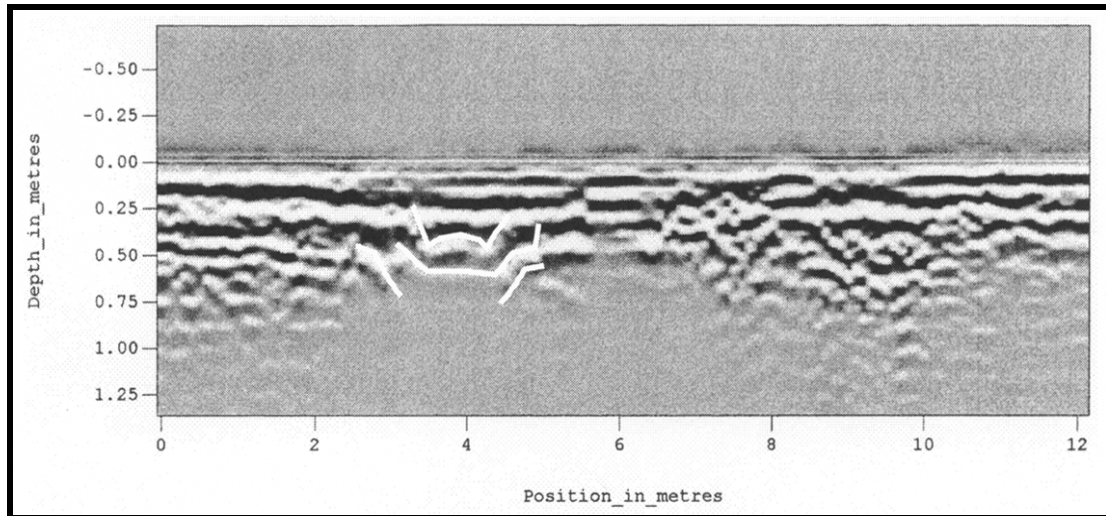


Figure 5-19: Depth section of GPR project seven, line three. Depressed soil layers (outlined in white) might represent the top of the stone-capped drain

Excavation of STP1 revealed a stone drain channeling water into Foundry Brook from a drain hole south of Battery Pond. Figure 5-21 illustrates the top of this drain. Excavation of the first 25 centimeters revealed a black colored silty-sand, followed by ten centimeters of a dark grey silty-sand. The next 30 to 40 centimeters consisted of dark brown and brown sand with root inclusions. Archaeologists reached the top of the drain, a large capstone, approximately 65 centimeters below ground surface. Excavation to approximately 82 centimeters below ground surface revealed stone side supports under the capstone. A break between stones revealed water flowing through this drain from west to east. Figure 5-22 provides a conceptual cross section of STP1. A water dye test conducted during excavation established that water flowing into the drain hole to the west flowed through this drain and exited into Foundry Brook at the iron pipe visible southeast of the shovel test pit.

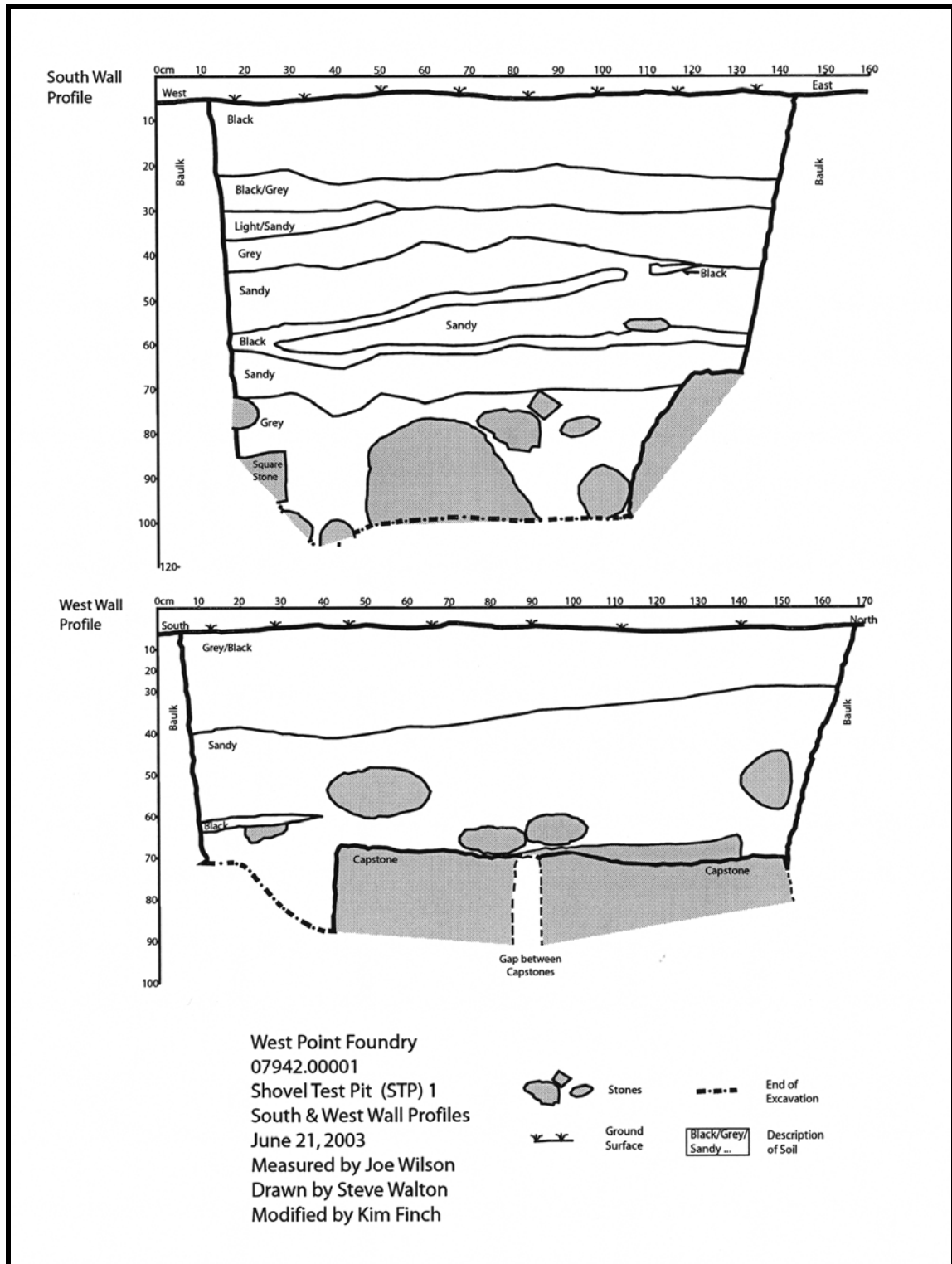


Figure 5-20: Wall profiles, STP1



Figure 5-21:
Planview of STP1,
a subsurface stone
drain leading to
Foundry Brook.
Photograph by
Kim Finch.

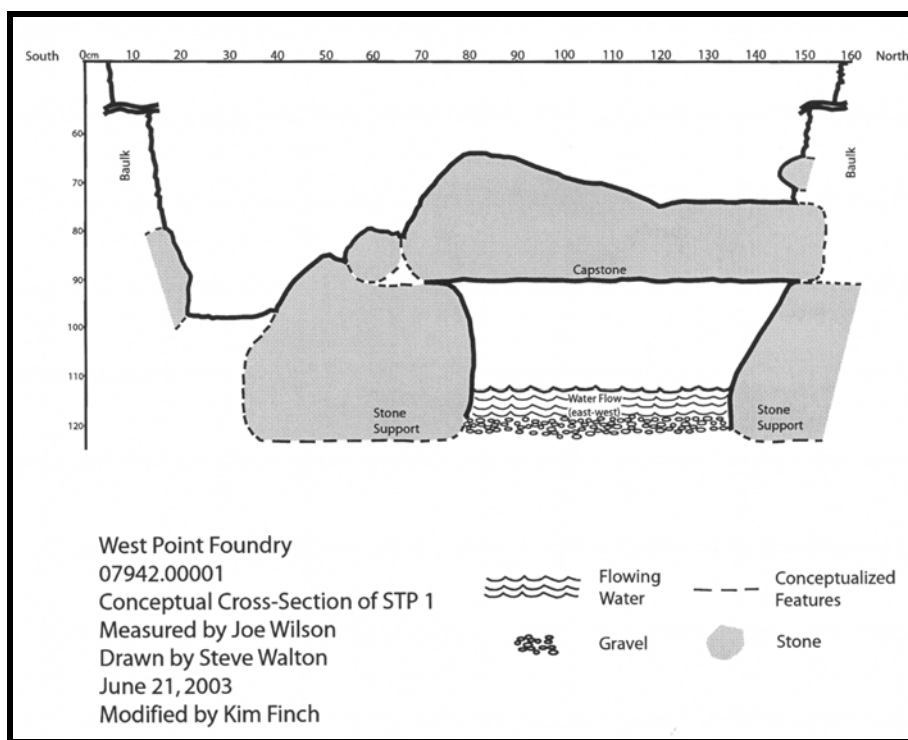


Figure 5-22: Conceptual cross-section of STP1

Artifact Categorization

Archaeologists recovered 3747 artifacts from seven excavation units across the West Point Foundry. MTU archaeologists grouped artifacts by material and functional classes, and placed them into one of nine categories based upon Stanley South's artifact pattern system (Figure 5-23). Using these categories, South compared artifact frequencies from several North American site types and summarized their assemblages,

identifying the Carolina Artifact Pattern and the Frontier Artifact Pattern to describe historical and frontier sites respectively. These patterns, which are based upon the mean percentages of artifact groups, assume broad regularities of cultural activity and process against which other sites can be compared. In conjunction with other historical sources, these patterns can assist archaeologists' comparisons of site type and use patterns.

Artifacts recovered from the 2003 excavation demonstrated that South's categories are not the most appropriate way to catalog artifacts on industrial sites. Table 5-1 provides a comparison between the West Point Foundry provisional industrial pattern, the Carolina Pattern, and the Frontier Pattern. Although the high percentage of architectural artifacts resembled the Frontier pattern, artifacts from the personal and arms groups were absent and there were significantly fewer artifacts from the kitchen group. This was not surprising, as the boring mill, iron turning and planing shop, power house, boiler house, and area near Battery Pond did not resemble the residences, fort and trading post midden deposits, or cellar deposits from which South devised his patterns. South's patterns did not accurately represent the functional identities of all artifacts from the foundry site; fabric found at the boiler house, for example, may have been part of an oil rag or associated with a piece of machinery and not an article of clothing as designated by South.

HISTORIC ARTIFACT CATALOG CARD	
MICHIGAN TECHNOLOGICAL UNIVERSITY	
Site Name: _____	Site No.: _____
Catalogue No.: _____	Provenience: _____
KITCHEN GROUP	CLOTHING GROUP
Ceramics _____	Buckles _____
Canning Jar _____	Buttons _____
Stove Parts _____	Pins/Needles/Thimbles _____
Glassware _____	Hook & Eye _____
Kitchenware _____	Scissors _____
Utensils _____	Shoe _____
Tumbler _____	Fabric _____
Case Bottle _____	Other _____
Beer _____	<i>Total Clothing</i> _____
Wine/Liquor _____	
Other _____	
<i>Total Kitchen</i> _____	
ARCHITECTURE GROUP	PERSONAL GROUP
Window Glass _____	Pencil _____
Window Framing _____	Mirror _____
Round Nails _____	Toothbrush _____
Square Nails _____	Coins _____
Wrought Nails _____	Pocket Knife _____
Slate _____	Pharmaceutical _____
Construction Misc. _____	Other _____
Brick Fragments _____	<i>Total Personal</i> _____
Door Hardware _____	
Wood Samples _____	
Mortar Fragments _____	
Other _____	
<i>Total Architecture</i> _____	
FURNITURE GROUP	ACTIVITIES GROUP
Lamp Chimney _____	Fishing/Hunting _____
Other _____	Tools _____
<i>Total Furniture</i> _____	Toys _____
	Military _____
ARMS GROUP	Agriculture/Husbandry _____
Shot _____	Clay _____
Cartridges _____	Coal/Charcoal _____
Gun Parts _____	Slag _____
Other _____	Sheet Iron _____
<i>Total Arms</i> _____	Iron Scrap _____
	Brass Hook _____
TOBACCO GROUP	Brass Scrap _____
Stems _____	Copper _____
Bowls _____	Lead _____
Other _____	Other _____
<i>Total Tobacco</i> _____	<i>Total Activities</i> _____
	OTHER
	Bone/Shell _____
	Modern _____
	Other _____
	<i>Total Other</i> _____
	GRAND TOTAL _____

Figure 5-23: Historic artifact card utilized by MTU.

	West Point Foundry Industrial Pattern	Carolina Pattern	Frontier Pattern
Kitchen	2.4	63.1	27.6
Architecture	62	25.5	52
Furniture	0	0.2	0.2
Arms	0	0.5	5.4
Tobacco	0.1	3.0	1.7
Clothing	0.6	0.2	0.2
Personal	0	5.8	9.1
Activities	34.6	1.7	3.7
Other	0.3	Not included in this pattern.	Not included in this pattern.

Table 5-1: Mean percentages of artifacts from the West Point Foundry industrial pattern, the Carolina pattern, and the Frontier pattern.

Artifacts from the West Point Foundry formed a provisional industrial pattern related to industrial building architecture, heavy machinery, and iron products manufactured during the 19th and early 20th centuries. A high percentage of architecture- and activities-related artifacts resulted from structural decay and refuse from activities such as cannon boring and finishing. A low percentage of artifacts in the kitchen, furniture, arms, tobacco, and personal groups suggested that domestic and recreational activities occurred away from the foundry grounds. Future cataloging for the West Point Foundry collection should utilize a system that reflects more accurately the industrial nature of the site. Artifact categories in Table 5-2, which are based upon artifacts recovered during the 2003, provide suggestions for future artifact classification.

With this in mind, however, South's classification system provided a convenient way to order and quantify artifacts in the 2003 collection. Classifying and quantifying artifacts according to South's method provided a tool to compare a specifically industrial artifact pattern to those found at historic and frontier sites.

<i>IRON</i> Sheet Iron Fragments Conglomerate	<i>DOMESTIC</i> Ceramics Bottle Glass Beer Bottle Glass Wine/Liquor Glass Lamp Chimney Glass Pipe Bowls/Stems Clothing
<i>MACHINE PARTS</i> Gears/Gear Fragments Pipe Joints Couplings Leather Carbon Brushes	<i>TOOLS</i> Files Wedges
<i>ELECTRICAL</i> Ceramic Insulator Wire	<i>REFUSE</i> Slag Gun Cartridge fragments
<i>BUILDING MATERIALS</i> Modern/ Machine Cut/ Wrought Nails Wood Fragments Window Glass Brick Slate Door Hardware (locks, hinges, etc.) Mortar Spikes Bolts Washers Screws	<i>DEGRADABLE</i> Fabric Bone Shell
<i>OTHER</i>	

Table 5-2: Suggested categories for artifact classification at the West Point Foundry.

The 2003 Assemblage

Architectural materials formed 62% of the 2003 assemblage, followed by activity-related materials at 34.6%, and kitchen-related materials at 2.4%. Artifacts within the tobacco, clothing, and 'other' artifact groups formed approximately 1% of the total assemblage. Appendix B provides a complete list of artifacts by unit, level, type, and sub-type. Table 5-3 provides total number of artifacts and percentages by excavation unit.

Table 5-4 provides a breakdown of artifact classes as a percentage of each excavation unit's total.

Unit	Total No. Artifacts	% of Total	% of Total by Operation
4A	69	1.8	82.5
4B	966	25.8	
4C	238	6.4	
4D	1818	48.5	
10A	213	5.7	5.7
15A	324	8.6	8.6
STP1	119	3.2	3.2
Total	3747	100	100

Table 5-3: Artifact totals and percentages by excavation unit.

	4A	4B	4C	4D	10A	15A	STP1
Kitchen	4.3	1.8	0	0.3	17.4	7.7	0.8
Architecture	46.4	63.7	46.2	73.4	28.6	40.4	3.4
Tobacco	0	0.1	0	0.06	0.5	0	0
Clothing	0	0.1	0	0.6	1.9	1.9	0
Activities	49.3	30.4	53.8	25.1	50.2	46.6	95.8
Other	0	0.2	0	0.2	1.4	3.4	0

Table 5-4: Artifact classes as a percentage of excavation unit totals.

Summary of Artifacts by Functional Category

Kitchen Group:

Artifacts within the kitchen group consisted primarily of bottle glass and ceramic fragments. Glass included cola bottle fragments, soda water fragments, beer bottle glass, and liquor glass. Ceramics included porcelain electrical insulator fragments and brown, salt-glazed utility pipe fragments.

Architecture Group:

Window glass, nails, and slate fragments formed the majority of the architecture assemblage. Archaeologists also recovered fragments of brick, wood, mortar, and asphalt. These materials formed 62% of the total 2003 assemblage, which reflected the extensive amount of structural decay visible at the foundry.

Tobacco Group:

Artifacts within the tobacco group included pipe stem fragments and pipe bowl fragments. One bowl contained the initials "T.D." surrounded by thirteen stars, a mark generally placed on pipes in the first half of the nineteenth century.⁹

Clothing Group:

Various scraps of fabric and clothing accoutrements formed the majority of artifacts in this assemblage. Leather and fabric recovered during excavation most likely formed part of machine belts and rags utilized in activity areas such as the boiler house, rather than pieces of clothing. Archaeologists also recovered metal snaps and eyelets.

Activities Group:

Artifacts in the activities group formed 34.6% of the total assemblage. Artifacts included tools such as files, waste materials such as slag, iron fragments, and boring waste (lathe shavings). Archaeologists also recovered coal, charcoal, electrical fittings, pipe fittings, nuts, bolts, and washers.

Other Group:

Artifacts in this group included bone fragments, shell fragments, and modern trash such as aluminum foil.

⁹ Murphy, James L. "Tobacco Pipe Fragments from Schoenbrunn, Tuscarawas County, Ohio" in Byron Sudbury, ed. *Historic Clay Pipe Studies*, Volume 3 (Oklahoma: Byron Sudbury, 1986), 65.

Conclusion:

Excavation during the 2003 field season revealed several features connected to the site's waterpower system. Archaeologists identified the boring mill waterwheel pit, a tailrace inlet and possible outlet, as well as drains near the furnace, Battery Pond, and the power house. Foundry builders constructed subsurface stone and gravel lined drains that directed subsurface and possibly surface water flow between activity areas and Foundry Brook. Unfortunately, archaeologists did not identify the path of the subsurface tailrace that directed water from the boring mill to Foundry Brook. Table 5-5 provides correlations between anomalies identified during geophysical surveys, excavation, and features identified during excavation.

Geophysical Evidence (if applicable)	Excavation Unit	Feature
n/a	4A	Feature 1: Tailrace inlet at the boring mill
n/a	4B	Feature 12: Possible vertical boring or casting pit
Resistivity Data	4C	Not feature identified
Project 6, Line 0	4D	Feature 4: Possible brick machine mount
n/a	10A	Possible drain
Project 5, Lines 1-3	15A	Possible drain
Project 7, Line 3	STP1	Feature 22: Stone drain

Table 5-5: Correlation between geophysical evidence, excavation units, and features.

Excavation also revealed features related to activities such as cannon boring and finishing. Excavation east of the boring mill exposed a possible brick machine base accompanied by a large quantity of lathe waste. These findings were consistent with historical map data, which identified the area east of the boring mill as the planing and turning shop. Excavation within the boring mill provided data concerning a circular, stone-lined pit that may be the remnants of a vertical boring or casting pit.

Archaeological deposits at the foundry had moderate integrity. Modern trash from twentieth century dumping littered many areas of the site, especially near the

boring mill. Between 30 and 40 centimeters of architectural debris, including slate, brick, mortar, window glass, and nails, covered historical deposits that dated as early as the 1830s. A layer of iron conglomerate lay underneath architectural deposits near the boring mill. Underneath building rubble and iron waste, sediment consisted of layers of sandy loam and sand, with root and cobble inclusions. Unfortunately, heavy rainfall before and during the field season saturated the site and prevented complete excavation of most units. As a result, archaeologists did not determine the maximum depth of historical deposits.

Artifacts did not provide significant information about the waterpower system. However, collection during the 2003 field season provided a comparative collection for future excavation and facilitated the development of a cataloging system more suited to the foundry site.

Subsequent field investigations should re-examine the boring mill wheelpit, the circular stone pit (Feature Twelve) in unit 4B, the area of welling water in Foundry Brook by unit 15A, and the subsurface tailrace between the boring mill and Foundry Brook. Identification and delineation of structural components such as building foundations at the boring mill and turning and planing shop also require further excavation. Further excavation in the wheelpit requires strategic planning, since water flowing into the pit from the tailrace inlet inhibited excavation during the 2003 field season.

Chapter 6 The West Point Foundry Waterpower System

The West Point Foundry relied on an intricate network of elevated surface and subsurface drains, races, flumes, waterwheels, turbines, dams, and ponds that powered operations and regulated water flow throughout the site. The locations of many of these features, as well as details of their construction and functions, are not well understood. Historic maps do not provide a clear progression of building the components of the water system, and historic documents, maps, and illustrations provide incomplete and contradictory information about these systems. In 2003, geophysical and archaeological evidence provided insight into features identified on historic sources and revealed features not included in these sources, raising new questions concerning the development and function of waterpower in the foundry's history.

Chapter Six combines historical, geophysical, and archaeological evidence in an analysis of the waterpower system at the West Point Foundry. This chapter is divided into three sections. The first examines four activity areas that relied extensively upon waterpower: 1) the furnace, including Battery Pond and the foundry dams, 2) the blacksmith shop, 3) the boring mill, and 4) the power house. Analysis of each area includes an overview of available historic map data, photographs and illustrations, documentary evidence, and archaeological and geophysical evidence that suggest how the foundry's water system functioned. Other water-related features outside of these activity areas are also discussed. Section one also includes a provisional summary of water flow throughout the site, which traces the path of water as it flowed through

different parts of the foundry's water systems, from the middle dam to the southern end of Foundry Brook.¹ Maps referred to in section one are located in Appendix A.

Maps utilized in section one include a Cold Spring town map from circa 1840, the 1853 Bevan map, the 1867 Beers map, the 1872 Scofield map, the 1887 Sanborn map, the 1897 Sanborn map, an anonymous map from circa 1900, and the 1996 Badey and Watson map. Although research by Valentino in 2003 revealed inaccuracies in Sanborn data and inconsistencies among other historic maps due to the differing intentions of the mapmakers, researchers should not immediately discard information on these maps. For example, while Sanborn maps place structures as much as 15 meters away from their actual locations, they still indicate what structures existed and their relative locations at the time the maps were made. The 1979 historic base map by Cultural Resource Management Services, Inc. consisted of features overlaid on a Sanborn map. As a result, this map is useful only as a reference for features evident on the site in 1979 and not as an authentic primary source.

Section two provides a provisional overview of the water system during five phases of site development. These phases, identified based on foundry ownership and available map data, consist of:

- 1) 1817-1857: the beginning of foundry operation until the end of Kemble's term as foundry manager,
- 2) 1858-1867: the beginning of Robert Parrott's term as manager to the withdrawal of Parrott and the introduction of steel into the economy,
- 3) 1868-1875: the rise of the popularity of steel to the death of Kemble, including a seven year production boom for the foundry,
- 4) 1876-1896: the foundry's decline,

¹ Although many sources number each dam, there is no historical basis for the assigned numbers. Therefore, this document addresses dams in terms of upper, middle, and lower (otherwise addressed as dam numbers 3, 2, and 1, respectively).

- 5) 1897-1920: the Cornell period to the purchase of the site by the Astoria Silk Works, the beginning of non-foundry activity.

The third section compares the West Point Foundry's waterpower system with those of other nineteenth century iron foundries in the United States. This places the West Point Foundry in an historic context and enables evaluation of the nature of the water system in terms of comparative technological advances and effectiveness.

Section One ~ An Examination of Waterpower in Four Activity Areas

I. The Furnace and Battery Pond

In 1827, laborers constructed a stone blast furnace near the middle dam that supplied the foundry's iron until 1844. Water stored in upper mill ponds on Foundry Brook provided power for the furnace. Calculations based upon the measurement of discharge from Foundry Brook by the United States Geological Survey (USGS) in 1954 suggest that between 6.48 and 12.27 horsepower was available at the furnace (See table 6-1).² Initial analysis of historical illustrations and maps indicated the complex nature of the furnace's waterpower system; an upper dam and water storage pond regulated water levels in Foundry Brook before water reached the middle dam; water traveled to the furnace via a flume from the middle dam; water from the flume may have powered a large overshot waterwheel, which in turn powered furnace bellows; water traveled from the furnace to Battery Pond via a tailrace on the south side of the furnace; and a surface drain north of the tailrace entrance into Battery Pond directed overflow to Foundry Brook. At least one drain regulated water levels within Battery Pond, a key reservoir that

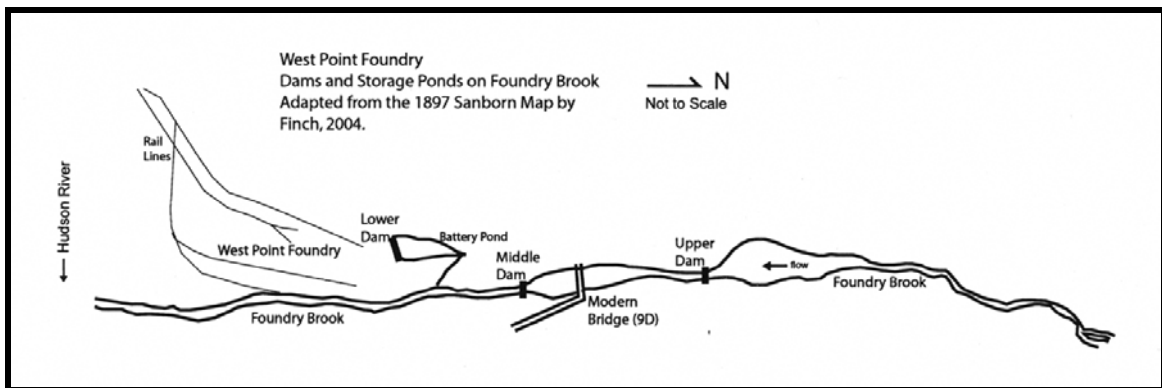
²Calculations assume an overshot wheel 36 feet in diameter.

Calculations of horsepower in chapter six are based upon the lowest discharge measured (2.64 cfs) and the mean of discharge measured near and at Cold Spring (approximately 5 cfs). Refer to Table 6-1. The formula used for all calculations of horsepower: $hp = 62.5(HQn/550)$, where H = the head in feet, Q = quantity in cubic feet per second, and n = efficiency of waterwheel (0.6 for an overshot wheel, 0.3 for an undershot wheel, and 0.8 for a turbine).

supplied water for operations such as cannon boring. Map 6-1 illustrates the location of dams and storage ponds along Foundry Brook.

Stream	Point of Discharge Measurement	Drainage Area (square miles)	Date	Discharge (cubic feet per second)
Foundry Brook	Near Cold Spring	1.65	3-25-54	3.64
	At Cold Spring	5.36	3-24-54	8.45
	N/A	N/A	9-29-54	2.64

Table 6-1: Discharge measurements of Foundry Brook, Putnam County, New York. From Grossman, I.G. The Ground Water Resources of Putnam County, New York. Bulletin GW-37 (Albany, New York: United States Geological Survey, 1957) 6.



Map 6-1: West Point Foundry dams and storage ponds along Foundry Brook.

Several questions arose from historical and archaeological examination of the furnace's waterpower system. At the West Point Foundry, features interpreted as a tailrace and a subsurface stone drain went directly under the furnace hearth. Because molten iron creates steam when it comes into contact with water or moisture, archaeologists wished to determine why builders constructed these features directly under surfaces that held molten iron. Archaeologists also wished to determine the mechanism that powered the furnace blast.

Historical Map Data

A map from circa 1840 contained the first representation of the furnace. It illustrated the middle dam, the furnace, an unidentified building to the north of the furnace, another unidentified building southeast of the furnace, and Battery Pond.

The 1853 Bevan map also included the middle dam, the furnace and unidentified structures to the north and southeast, as well as Battery Pond. The profile of the structure north of the furnace changed from a rectangle to a T-shape. The profile of Battery Pond also changed; the Bevan map illustrated the Pond as an elongated body of water that extended from the furnace to an area north of the blacksmith shop. This map did not include the Pond's southern retaining wall (the lower dam).

Composite Map Data

The 1979 historic base map identified previously unlabeled structures and included a flume route, a tailrace, and several drains associated with the middle dam and the furnace. This map identified a structure north of the furnace as an air pump, and a structure southeast of the furnace as a casting shed. An approximate flume route extended from the northwest side of the middle dam to the air pump. A tailrace extended from the southern furnace wall to Battery Pond and included an overflow drain from the tailrace to Foundry Brook. The 1979 map also included a dam on the southern side of Battery Pond (the lower dam) and a wastewater drain from this dam to Foundry Brook. However, archaeologists cannot rely upon these interpretations, as Cultural Resource Management Services Inc. did not indicate where or how they obtained information used to identify the air pump, casting shed, flume route, or drains.

Historical Illustrations and Photographs

Several historical illustrations and photographs show details about the foundry during its operation. Most of these illustrate particular products, machinery, and

structures at the southern end of the site. An 1865 painting by John Gadsby Chapman, however, provided significant detail about the furnace and its power source (Figure 6-1).

This painting illustrated what appears to be a large overshot waterwheel on the northern side of the furnace and a wooden structure, most likely a penstock, situated above the wheel. Water appears to flow from this wooden structure onto the wheel, turning it in a clockwise direction. The illustration also included a wooden charging deck that backed onto the valley hillside west of the furnace stack, as well as the middle dam and a casting shed south of the furnace.



Figure 6-1:
1865 painting of the West Point Foundry blast furnace. Note the possible waterwheel north (right) of the furnace. Image courtesy of the Putnam County Historical Society and Foundry School Museum.

Archaeological Evidence:

Although little remains of the furnace or associated structures, archaeological survey of the area in 2002 and 2003 revealed features identified on historic maps, as well as previously unrecorded features. Archaeologists cleared brush from an area south of the furnace and uncovered a presumed tailrace lined with coursed stones (Figure 6-2).

Furnace rubble blocked the north end of the race. Archaeologists also observed water draining from the tailrace to Foundry Brook in an unlined depression in the vicinity of the overflow drain labeled on the 1979 map. An exit to a subsurface stone drain lay at the edge of the west bank of Foundry Brook, directly north of this depression (Figure 6-3). The presence of the drain and the absence of lining in the aforementioned depression

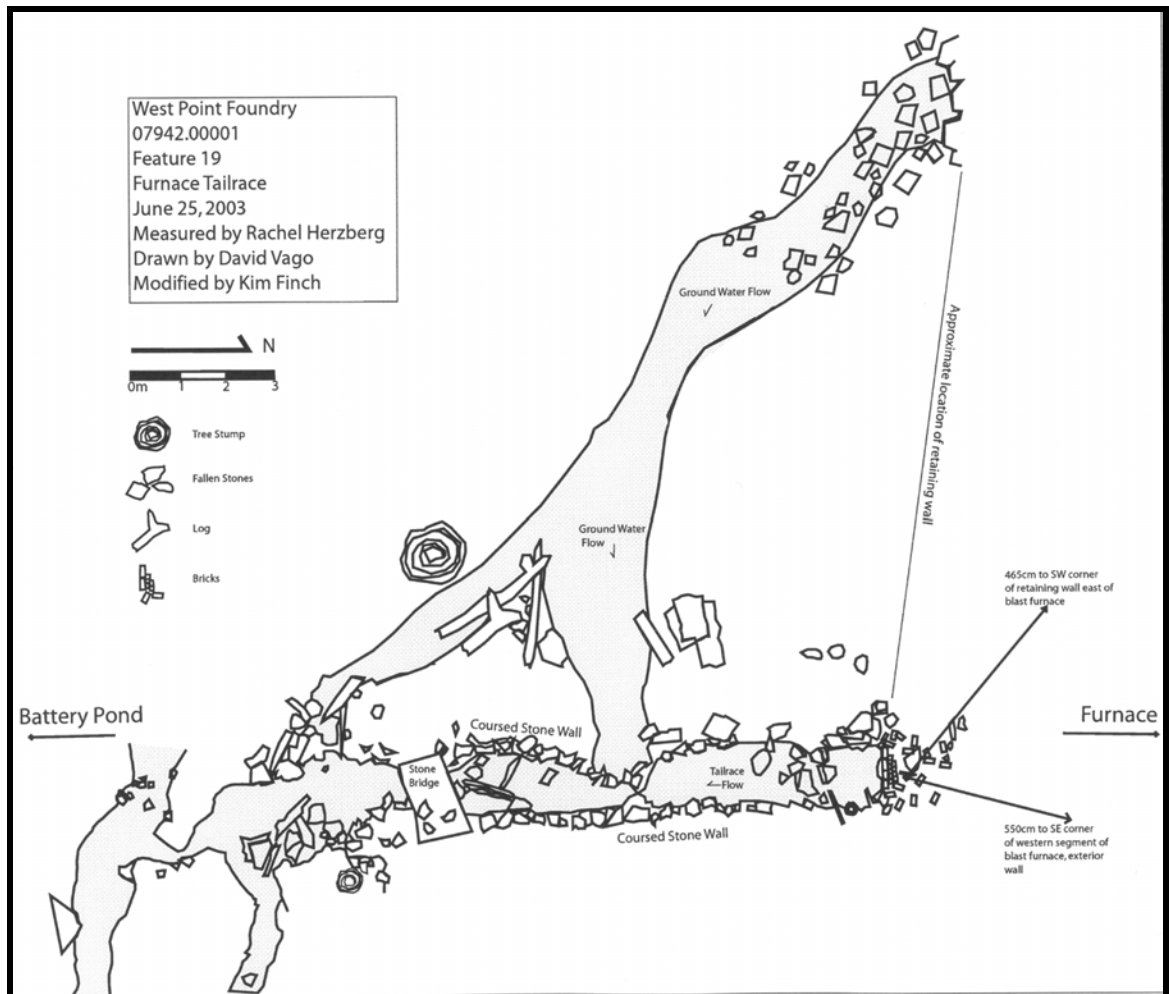


Figure 6-2: Planview drawing of the coursed stone furnace tailrace



Figure 6-3:
Feature Sixteen. Subsurface
stone drain outlet south of
the furnace on the west bank
of Foundry Brook.
Photograph by Rachel
Herzberg.

suggested that overflow from the tailrace once flowed through this drain into Foundry Brook. The drain most likely became blocked after the furnace went into disuse, causing water to follow the path of least resistance along the surface and into the brook.

Archaeologists discovered a similar stone drain that ran directly under the furnace. Figure 6-4 illustrates the location of the stone drains in relation to Battery Pond, the furnace, and Foundry Brook. Unlike the overflow drain, this slightly smaller drain remained unblocked, clearly extending between 30 and 40 feet west from Foundry Brook. Due to its small size and the risk of explosion related to moisture gathering under the furnace hearth, it seemed unlikely that builders designed this drain for heavy or constant water flow. Findings from archaeological investigation of a thirteenth and fourteenth century furnace at Markische Sauerland, Central Europe, provided insight into this feature. Archaeologists from the University of Muenster identified "a special drainage...built of stones beneath the furnace to protect it from water."³ Archaeological investigation of two American furnaces by Roland W. Robbins in the 1950s provided further evidence of subsurface drainage channels associated with blast furnaces.

³ Jockenhover, Albrecht et al. "Archaeological Investigations of the Beginning of Blast Furnace-Technology in Central Europe."

<<http://www.uni-muenster.de/GeschichtePhilosophie/UrFruehGeschichte/kier1.htm>>

Robbins' investigation of a mid-seventeenth century blast furnace in West Quincy, Massachusetts, revealed a drainage system that consisted of "a major drain channel and several smaller 'sub drains' that emptied into the principal channel. The entire system drained into the raceway and kept the furnace area free of dangerous water seepage."⁴ Robbins also found two furnaces that were "protected from water infiltration by subterranean drainage channels" at the eighteenth century Sterling Iron Works.⁵ The

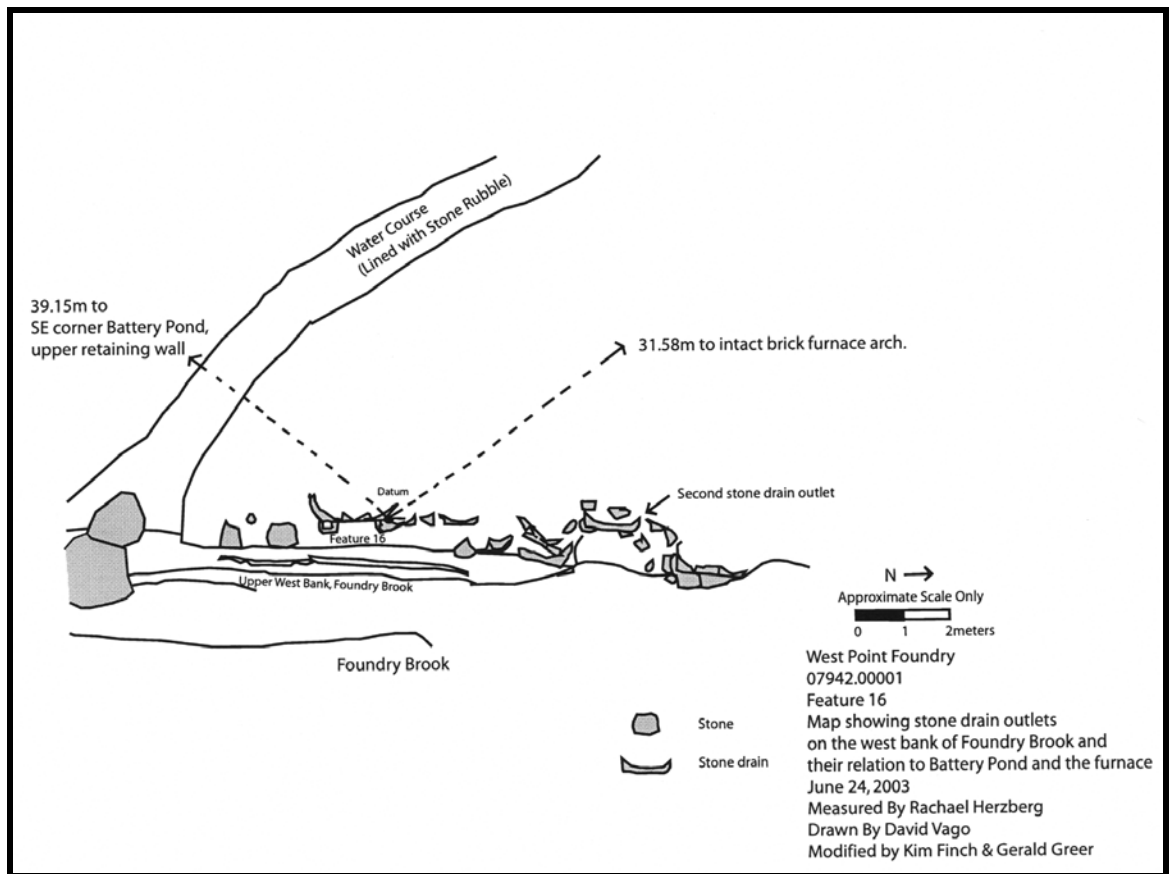


Figure 6-4: Planview drawing illustrating stone drain outlets on the west bank of Foundry Brook, inbetween the furnace and Battery Pond

stone drains at the West Point Foundry possibly served a similar purpose, protecting the furnace from water build-up under the hearth.

⁴ Linebaugh, Donald W. "Forging a Career: Roland W. Robbins and Iron Industry Sites in the Northeastern U.S. " In *Journal for the Society for Industrial Archaeology* Vol. 26, No. 1, 2000: 19.

⁵ Linebaugh 2000: 22.

However, this does not address why builders constructed a tailrace under the furnace instead of diverting it into Foundry Brook. An explanation for the location of the tailrace relates to the importance of water re-use at the foundry. Water traveled through the tailrace and into Battery Pond, a storage reservoir that supplied water for operations at the boring mill. Running this water underneath the furnace provided the most direct route to Battery Pond.

Battery Pond played an essential role in the foundry's water system. Archaeologists examined the reservoir and an area to its south during the 2003 field season. Figure 6-5 illustrates features near Battery Pond. A break in the lower stone dam on the south side of the pond marks the presumed origin of a flume that delivered water to the boring mill (Figure 6-6). Archaeologists noted water leaks at this opening, as well as from several other locations on the south wall. Examination of a flooded area south of the break in the dam wall revealed an opening in the ground through which water appeared to flow west. An exit to an iron drainpipe lay east of this hole in the west wall of Foundry Brook, approximately one meter from the brook's surface (Figure 6-7). A slightly depressed, saturated, 2.5 meter wide feature also extended northeast of the aforementioned drain hole. With the exception of large stones at the end of the depression on the west bank of Foundry Brook, the feature was not lined with stones, which suggested that the depression was probably created by water following a path of least resistance into Foundry Brook. Based on data gathered during physical examination of these features, as well as on preliminary GPR analysis, archaeologists excavated a shovel test pit (STP1) along the drain's projected path and revealed a stone drain.

A water dye test identified the drain's water source as the leaks coming from Battery Pond. However, this did not provide indications of the drain's previous use. The profile of this stone drain resembled that of aforementioned overflow drain near the furnace. This suggested that this drain served a similar purpose, perhaps directing

overflow from Battery Pond into Foundry Brook. A pond drain at the Dover Union Mill, an early nineteenth century Iron mill in Dover, Massachusetts, provided a possible explanation for this stone drain at the West Point Foundry. The Dover millpond contained an outlet deep in the pond that allowed operators to flush wastewater and sediment from the pond without passing it through the waterwheel.⁶ The drain at West Point may have served a similar purpose, allowing wastewater to bypass the flume that delivered water to a waterwheel at the boring mill.

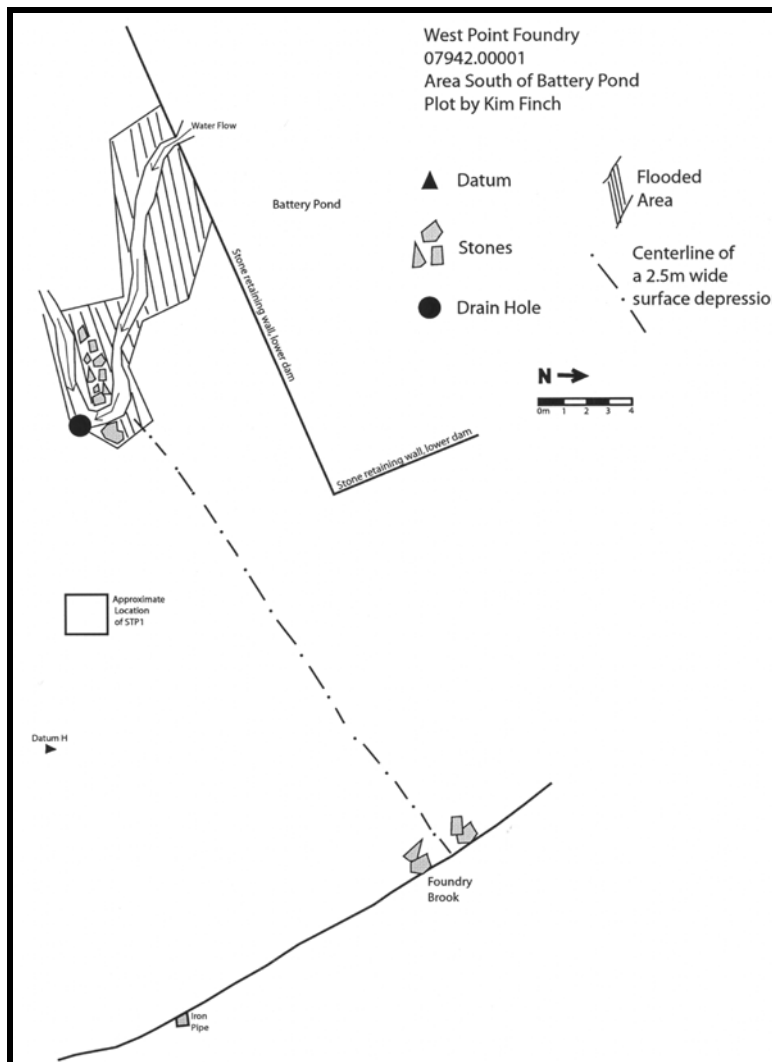


Figure 6-5: Sketch of area south of Battery Pond

⁶ Hart Vara, Richard. *The Dover Union Iron Mill* (USA: Richard Hart Vara, 2003), 26.



Figure 6-6:
Southern extent of Battery Pond (lower dam). Note the break at the western (left) side in the uppermost wall, which marks the possible origin of a flume to the boring mill. Photograph by Larry Mishkar.



Figure 6-7:
Iron drainpipe in west retaining wall of Foundry Brook, east of STP1. Photograph by Larry Mishkar.

The mechanism that provided the furnace blast also remained unclear. In surveying the middle dam, archaeologists identified a one-meter diameter iron pipe that lay approximately 2.6 meters from the top of the dam and 7 meters east along its face (Figure 6-8). This pipe may represent the origin of a flume that carried water to the furnace or areas south of the furnace (refer to the discussion of the power house below). However, archaeologists found little evidence of mechanisms that utilized this water.



Figure 6-8:
Iron pipe in the middle
dam. Photograph by
Larry Mishkar.

The 1865 painting contained a large waterwheel north of the furnace and a wooden platform, presumably a penstock, above it. Examination of the area revealed a depressed area that might represent the remains of a wheel pit. Iron pipes are also visible north of the furnace.

The depression near the furnace and the 1865 painting by John Gadsby Chapman indicate that a waterwheel may have resided north of the furnace stack. Waterwheels were the primary source of power at industrial sites until the transition to steam power in the latter half of the nineteenth century. At blast furnaces, waterwheels produced power that was transformed from a horizontal to vertical plane with a cam shaft, which drove large bellows and provided the furnace blast. Illustrations by Weitzman and Diderot (Figures 6-9 and 6-10) provide examples of waterwheels powering the blast for furnaces.

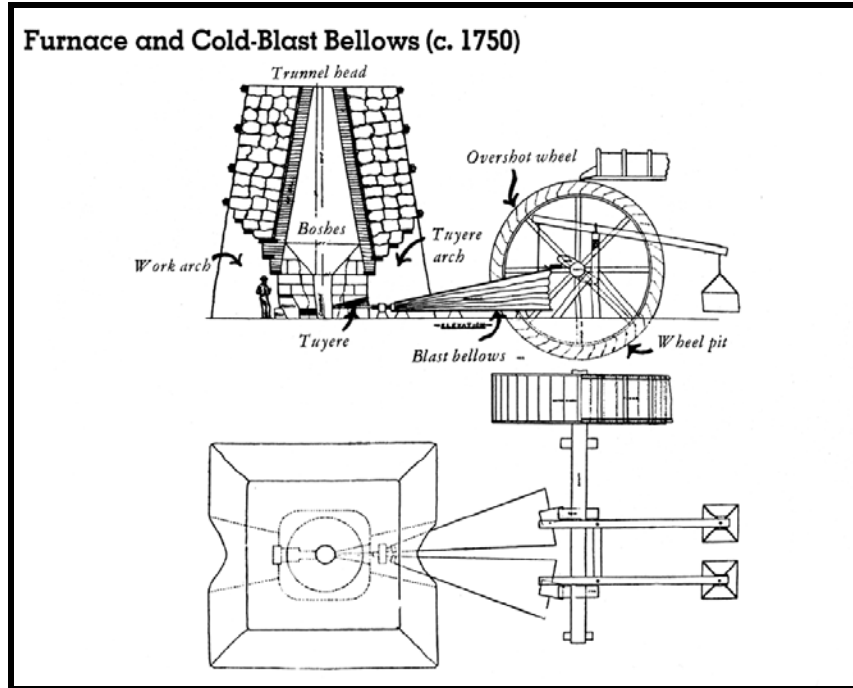


Figure 6-9: Furnace and Cold Blast Bellows (c.1750), Illustrating Water-Wheel Function and Location. Water leaves penstock and falls into buckets on the waterwheel. A shaft transfers power from the wheel to the bellows, which provides air for the furnace blast. From: Weitzman, David. *Traces of the Past: A Field Guide to Industrial Archaeology* (New York: Charles Scribner's Sons, 1980), 168.

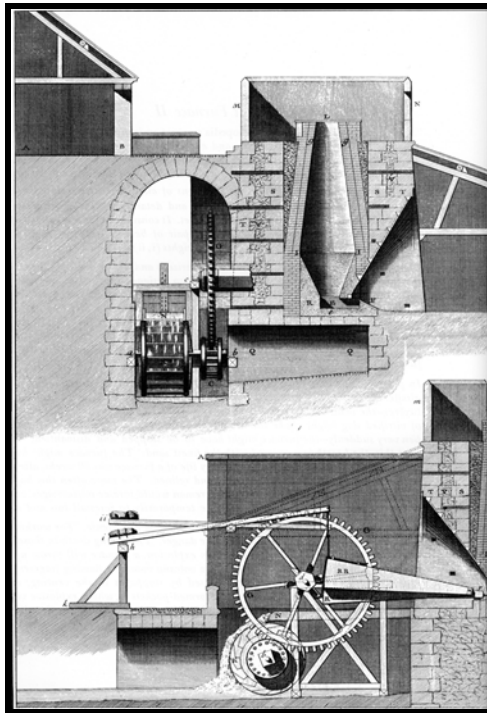


Figure 6-10:
Diderot, plate 87. Blast furnace interior, c. 1770. From: Diderot, Denis. *A Diderot Pictorial Encyclopedia of Trades and Industry, Manufacturing and Technical Arts in Plates Selected from "L'Encyclopedie, ou Dictionnaire Raisonne des Sciences, des Arts et des Metiers"* of Denis Diderot. Vol. I (New York: Dover Publications, Inc., 1959).

An alternate explanation for the wooden structure illustrated north of the furnace is that it contained a medieval trompe. Introduced in Italy during the seventeenth century, this water-blowing engine compressed air for furnace blasts using gravity and water. The trompe consisted of one or more 5 to 9 meter high vertical tubes with air holes, a sealed chamber, also known as a wind box, underneath these tubes, and an air outlet into the furnace (Figure 6-11).⁷ Gravity pushed water down through the tubes and air entered through small holes near the top. The water fell into the wind box, pushing the trapped air up through a vent that led to the furnace. Water escaped the windbox via an opening in the bottom of the chamber. Operators controlled blast pressure by raising or lower water levels within the wind box.⁸ The trompe became characteristic of the Catalan forge, a shallow, stone-lined hearth furnace that received air from a single tuyere.^{9, 10}

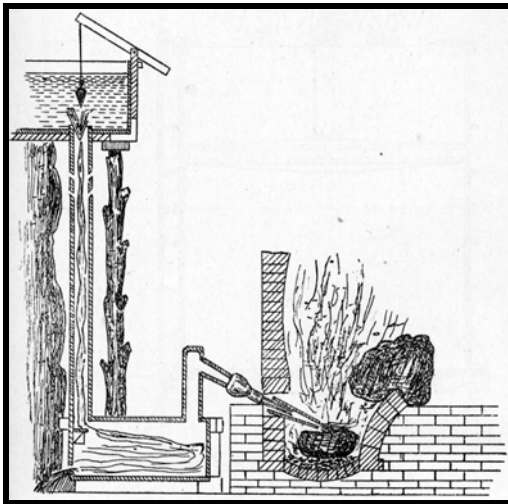


Figure 6-11:
Catalan Forge and trompe.
From: Sexton, A. Humboldt. *An
Elementary Text-Book of
Metallurgy*. Sixth Edition
(London: Charles Griffin &
Company, Limited, 1922), 67.

⁷ Ferragni, Daniela et al. . "The Blast Furnaces of Capalbio and Canino in the Italian Maremma." In Rockwell, Cynthia and Monica Garcia, eds. *Ironworks and Iron Monuments; Study, Conservation and Adaptive Use*. Symposium at Coalbrookdale, UK, October 23-25, 1984. (Rome: ICCROM 1985), 193.

⁸ Knight, Edward H. *Knight's American Mechanical Dictionary*, Volume III (Boston: Houghton, Mifflin and Company, 1884), 2630.

⁹ Tomas, Estanislau. "The Catalan Process for the Direct Production of Malleable Iron and its Spread to Europe and the Americas." In *Contributions to Science* Volume 1(2): 225-232. (Barcelona: Institute d'Estudis Catalans, 1999), 230.

Several Catalan-style furnaces operated in the United States during the nineteenth century. Scandinavian author Akerman specifically cited the states of New York and New Jersey as areas in which the Catalan procedure was in use during the mid-nineteenth century.¹¹ One forge in the town of Split Rock, New York, still used the trompe for iron making in 1825.¹² Although iron foundries in the United States utilized the trompe during the nineteenth century, there is no evidence that it was utilized at the West Point Foundry.

The trompe was primarily used in association with the Catalan forge, a shallow, brick hearth that did not have a stack. Unlike the small Catalan forge, the furnace at the West Point Foundry had a tall, stone stack. Aside from the remnants of one furnace arch, archaeologists have not identified concentrations of brick or stone masonry near the furnace, materials typically employed in trompe construction.¹³ This lack of evidence does not prove that a trompe did not exist at the foundry. A systematic investigation of the furnace area is required before archaeologists can ascertain if a trompe or waterwheel provided power for the furnace blast.

II. The Blacksmith Complex

Erected in 1817, the blacksmith shop lay at the heart of the foundry, between Battery Pond and the boring mill. Forges, furnaces, and large hammers probably operated within the smith shop's walls. Unfortunately, little historical or archaeological evidence of what powered these devices remains visible on the surface.

¹⁰ Sexton, A. Humboldt. *An Elementary Text-Book of Metallurgy*. Sixth Edition. (London: Charles Griffin and Company, Limited, 1922), 67.

¹¹ Akerman, J. *Tidskrift for svenska Bergshandteringen* for ar 1844, Fahlun, 1844.

¹² Tomas 1999: 230.

¹³ Feragni 1985: 181.

Historical Map Data

Historical maps provide very little data concerning waterpower at the blacksmith shop. The 1867 Beers map indicated that a flume that carried water along Foundry Brook terminated at the blacksmith shop's northeast corner. The 1887 and 1897 Sanborn maps illustrated a flume that ran west along the southern blacksmith shop wall. However, they did not clearly indicate a connection with the smith shop. The 1912 Sanborn map included a surface drain that extended from the southwest corner of the vacant blacksmith shop to a vacant powerhouse at Foundry Brook. Sanborn data suggest that the blacksmith shop functioned with waterpower from a flume that ran along Foundry Brook between 1887 and 1897. However, maps did not depict the blacksmith shop's waterpower source during the foundry's first 70 years or its last 30 years of operation.

Documentary Evidence:

A letter written by Irish immigrant David Wylie in 1849 included a description of the blacksmith complex, its machinery, and its power sources.¹⁴ According to Wylie, a blacksmith at the foundry from 1849 through 1857, the smith shop consisted of three buildings. Inside at least one building, a waterwheel and a steam engine powered an eight-ton trip hammer, two tilt hammers, two air furnaces, and eleven hearths. While these features were not included on maps and little physical evidence remains, this first hand report establishes early power sources employed at the smith shop.

Archaeological Evidence

Field survey during the 2003 field season revealed a feature in the southwestern corner of the blacksmith shop that may relate to a drain illustrated on the 1912 Sanborn map. Archaeologists designated this Feature Three (Figures 6-12 and 6-13). Feature

¹⁴ Letter from David Wylie to Andrew Wylie, June 4 1849. Edited by Barbara Smith. Letter provided by Barbara Smith, Cold Spring, New York. Transcript on file at MTU.

Three consisted of an approximately one meter deep channel filled with mud and water. A concrete wall lined each side of the channel. Scattered brick lay along the east side of the channel, and a machine base with four threaded bolts lay on the west wall. An iron gutter at the southeast corner of the channel may have guided water away from the feature.

Archaeological evidence suggests that a substantial piece of machinery once rested alongside the channel in Feature Three. Waterwheels often supplied power for large tilt and trip hammers that operated in smith shops (Figures 6-14 and 6-15). It is possible that Feature Three represents the remains of a hammer base and wheel pit described in Wylie's letter. Assuming an undershot wheel 20 or 30 feet in diameter operated at the blacksmith shop, USGS flow data from 1954 suggest that between 2.7 and 5.11 horsepower (for a 30 foot head) or between 1.8 and 3.41 horsepower (for a 20 foot head) was potentially available.¹⁵



Figure 6-12: Feature Three, showing machine base and water-filled channel. Photograph by Mike Deegan.



Figure 6-13: Feature Three, showing machine base and iron drain pipe. Photograph by Steve Ftaclas.

¹⁵ Calculations assume the presence of an undershot waterwheel due to the need for fast rotation speed to power the hammers. Refer to table 6-1 for original measurements.

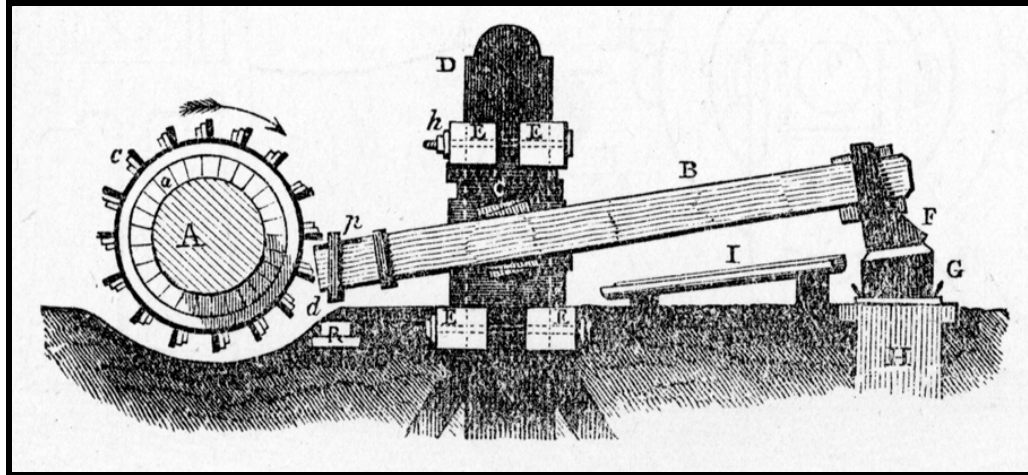


Figure 6-14: Tilt Hammer. Note the cam shaft on the left, which transmits power from a waterwheel to the hammer. From: Sexton, A. Humboldt. *An Elementary Text-Book of Metallurgy*. Sixth Edition (London: Charles Griffin & Company, Limited, 1922), 67.

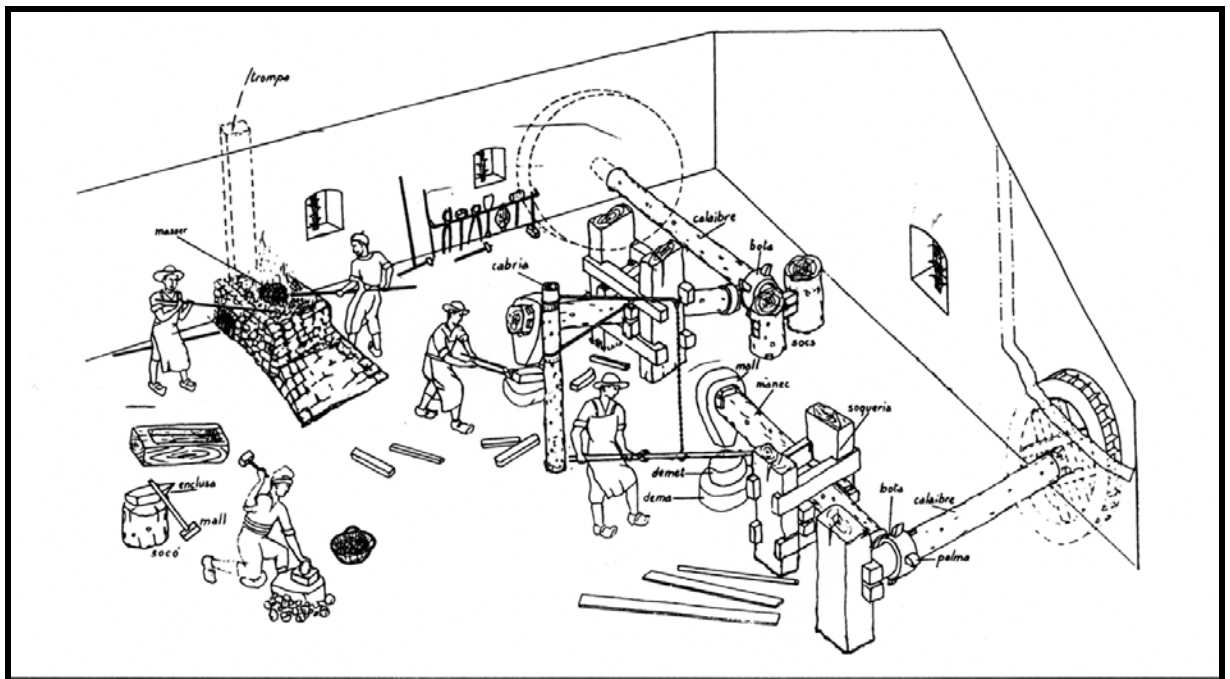


Figure 6-15: Illustration showing the layout of a smith shop. Note the large tilt hammers driven by waterwheels. From: Tomas, Estanislau. "The Catalan Process for the Direct Production of Malleable Iron and its Spread to Europe and the Americas." In *Contributions to Science* Volume 1(2): 225-232. (Barcelona: Institute d'Estudis Catalans, 1999), 225.

Feature Three aligned with a drain identified on the 1912 Sanborn map. The drain began at the blacksmith shop and terminated at Foundry Brook. Archaeologists

excavated a one by three-meter unit at the eastern end of this drain (unit 10A).

Excavation exposed the outline of a small trench, which cut across the center of the unit at a 45-degree angle (Figure 6-16). This may merely represent the path of least resistance through which water drained from the center of the site into Foundry Brook. However, large stones aligned with an exit point at the brook, as well as the 1912 map illustration, suggest that this trench represented the remnants of an early twentieth century surface drain from the blacksmith shop.



Figure 6-16:
Unit 10A. Closing
photograph, shooting north.
The water in the center of the
unit outlines the trench
delineated by archaeologists
during excavation.
Photograph by Pat Baird.

III. The Boring Mill

Erected circa 1817, the boring mill operated through much of the nineteenth century. Inside, horizontal and vertical boring machinery and lathes finished cannon cast at the foundry. Sanborn maps from 1887, 1897, and 1912, as well as an anonymous map from circa 1900, indicated that a flume transported water from Battery Pond to a 36-foot waterwheel located on the northern side of the boring mill. Calculations based upon 1954 USGS flow data suggest that between 6.48 and 12.27 horsepower was available at the boring mill. Excavation revealed the entrance of a presumed tailrace and a wheel pit.

This feature appeared only on the 1979 historic base map. With the exception of the wheel pit and tailrace entrance at the boring mill, little archaeological evidence of the boring mill's water system remains.

Historical Map Data

The boring mill first appeared on the 1853 Bevan map. The 1853 map labeled the boring mill as one building attached to the molding house. The map did not indicate the presence of a flume, tailrace, or waterwheel.

A structure in the location of the 1853 boring mill appeared in the 1867 Beers map. However, the Beers map did not label it as a boring mill. The structure in its location was attached to the smith shop, also unlabeled. A flume traveled along Foundry Brook to the smith shop, probably providing waterpower for the shop and possibly the boring mill. This map did not illustrate a flume, tailrace, or waterwheel in the location of the boring mill.

The 1872 Scofield map identified the boring mill and outlined the location of the waterwheel along the west side of the structure. This map also did not include a flume or tailrace.

A flume that delivered water to the boring mill first appeared on the 1887 Sanborn map. The flume began at an area just south of Battery Pond and terminated along the boring mill's south wall. This map also denoted the location of a wheel on the west side of the mill and identified an iron turning and planing shop on the north side of the boring mill. A tailrace was not identified.

The 1897 Sanborn map identified three separate activity areas within the boring mill, as well as a flume from Battery Pond. The structure now contained a boring mill, cylinder bed, and iron turning and planing shop. The flume first denoted on the 1887 Sanborn map now began at the lower dam on the south side of Battery Pond. The 1897

Sanborn also identified the location of a waterwheel on the west side of the structure. A tailrace was not identified on this map.

An anonymous map that dates to circa 1900 also included a flume from Battery Pond. However, this map identified the structure as a heavy tool shop and turning and planing shop. This map did not identify a waterwheel or tailrace.

A Sanborn map from 1912 included the flume and outlined the location of the waterwheel on the west wall. This map placed the old boring mill at the northern end of the structure previously identified as the iron turning and planing shop. It placed a 'not used' old machinery shop on the southern side of the structure. This map did not include a tailrace.

Composite Map Data

On the 1979 historic base map, archaeologists located the drains and flume routes noted on the aforementioned maps, and also located an approximate tailrace route from the boring mill to southern Foundry Brook. A flume originated at Battery Pond and terminated at the wheel pit in the boring mill. The tailrace began at the wheel pit and terminated in Foundry Brook, east of the pattern shop complex. However, Cultural Resource Management Services, Inc. did not identify how or where they obtained information pertaining to the tailrace or water flume.

Historical Illustrations and Photographs

One historical illustration documented the presence of a flume entering the rear of the boring mill (Figure 6-17). This undated image, by P. Maverick Durand & Co. Sc., includes the boring mill and a detail of a cannon-boring lathe. Barely visible, an elevated flume entered the north (right) side of the boring mill. The flume appears to be a wooden, box-like structure. The detail of boring machinery at the foreground of the image consists of a cannon mounted on a lathe, with a boring instrument powered by a wheel boring the center of the cannon. This machinery resembles horizontal boring

machinery illustrated in Louis de Tousard's *American Artillerists' Companion* (Figure 6-18). Figure 6-18 illustrated a large wheel driving boring machinery, a set-up that might be similar to the boring mill at the West Point Foundry.

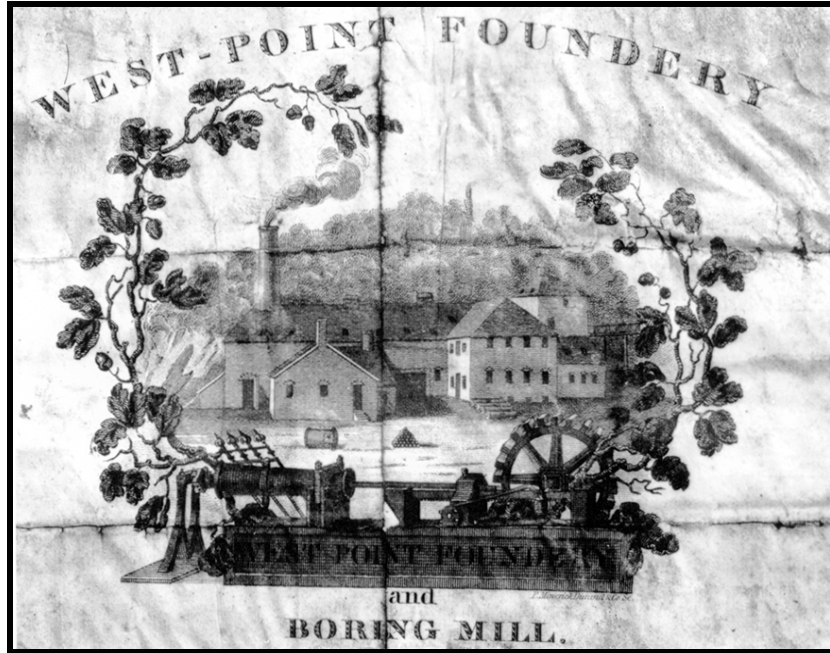
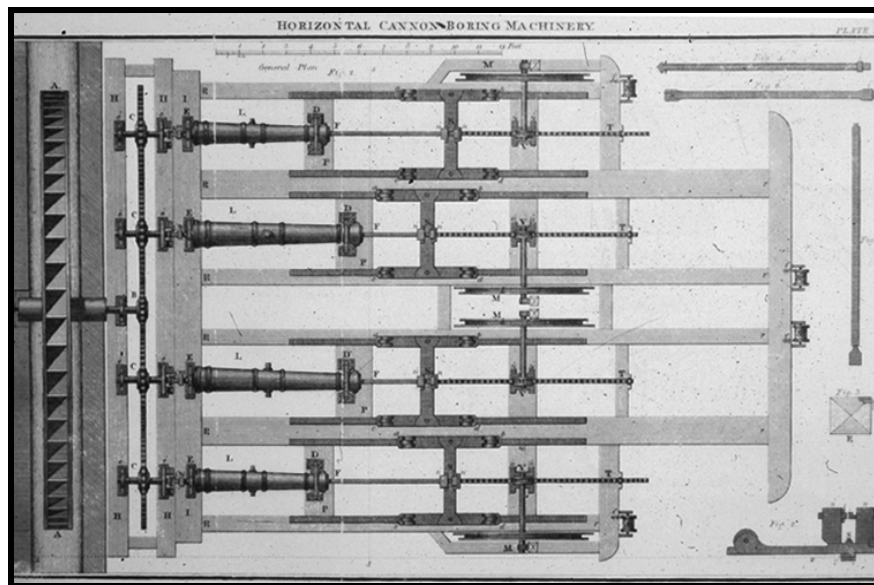


Figure 6-17: "The West Point Foundry and Boring Mill." Undated image by P. Maverick Durand & Co. Sc. Image courtesy of the Putnam County Historical Society and Foundry School Museum



*Figure 6-18: Horizontal boring machinery. Note the wheel powering the machinery. From: Tousard, Louis de. *American Artillerists' Companion or, Elements of Artillery, Treating All Kinds of Firearms in Detail, and of the Formation, Object, and Service of the Flying or Horse Artillery* (Philadelphia: C. & A. Conrad, 1809-1813), pl.lix.*

Archaeological Evidence

During the 2003 field season, archaeologists identified the boring mill wheel pit, as well as the inlet to the tailrace identified on the 1979 historic base map. Figure 6-19 illustrates the location of the waterwheel pit and tailrace inlet in the boring mill.

Archaeologists did not find remnants of the flume or 36 foot waterwheel within the wheel pit; only a small area was excavated.

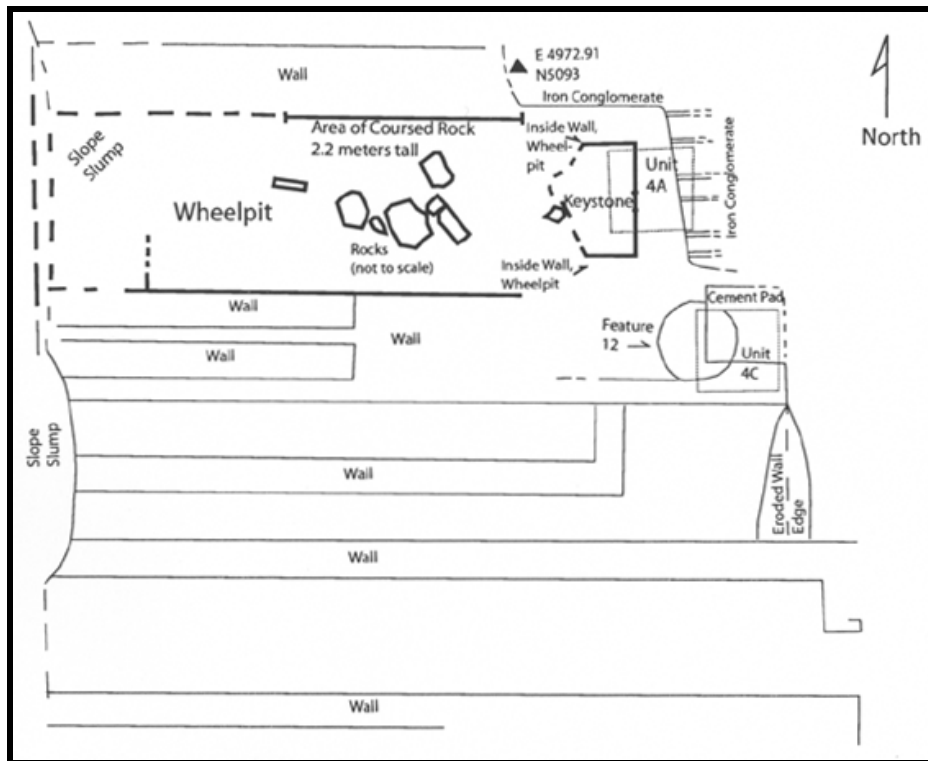


Figure 6-19: 2003 map of the West Point Foundry Boring Mill. The wheelpit is highlighted along the northern wall of the structure.

IV. The Power House

From circa 1900, a powerhouse straddled Foundry Brook at the northern end of the machine shop complex, southeast of the blacksmith shop. The proximity of the machine shops suggests that turbines within the powerhouse provided power for these buildings. Archaeological evidence, as well as an historic photograph and historic map data, suggests that an iron flume transported water from the middle dam to turbines in the

power house. Calculations based upon 1954 USGS flow data suggest that between 20.78 and 39.35 horsepower was potentially available at the power house.

Historic Map Data

Sanborn fire insurance maps, the 1853 Bevan map, the 1867 Beers map, the 1872 Scofield Map, the 1896 Badey and Watson map, and the 1979 historic base map helped delineate the development of features related to the power house, a structure first identified on an anonymous 1900 map of the foundry site. A flume route that began at Foundry Brook, southeast of the furnace, and terminated at the powerhouse first appeared on the 1887 Sanborn map. This map also included a flume route that extended west from the location of the powerhouse and terminated at the rail line in the center of the site. The 1887 Sanborn did not identify the powerhouse. However, a building labeled 'illegible' on the north end of the machine shop complex and terminus of the flume suggested that the power house, or an early form of this building, existed at that time.

Several apparent changes related to the flume and powerhouse appeared on the 1897 Sanborn map. The 1897 map delineated a flume route along Foundry Brook. However, the path of the route was not the same as the path depicted on the 1887 Sanborn. The flume began southeast of Battery Pond, well onto the west bank of Foundry Brook. The flume did not cross the brook as it did on the 1887 map, and it did not end at a structure adjacent to the machine shops. Instead, the flume wrapped around the southeastern corner of the blacksmith shop and terminated at the rail line. The 1897 map did not depict a structure in the location of the powerhouse.

An anonymous map from the Cornell period of occupation, circa 1900, identified a flume route along Foundry Brook, as well as a structure identified as a power house. The flume route on the 1900 map followed the same path as the flume illustrated on the 1887 Sanborn map. This flume path, however, extended further south than previous routes; it passed through the powerhouse and terminated in Foundry Brook at the

northern wall of the machine shop. A flume route did not extend west toward the rail line.

The 1912 Sanborn map, also from the Cornell period, illustrated a new feature leading from the blacksmith shop to the powerhouse. The flume route and position of the powerhouse remained the same on this map. However, the map identified the powerhouse as 'vacant'. The 1912 Sanborn also delineated a drain that extended from the southwest quadrant of the blacksmith shop and terminated within the vacant powerhouse.

Documentary Evidence

A letter written by J.E.B. dated October 1, 1962, provided an indication of the source of water used by the turbines and the extent of waterpower available during the Baldwin Steel Company's occupation of the foundry site. J.E.B.'s letter indicated that the Baldwin Laboratory utilized water from a spring "... near the lower foundry dam where was located the gate valve to control water flow to the hydraulic turbine to furnish waterpower for the foundry."¹⁶ However, J.E.B. also stated that "there was never enough water available to make this a factor of any consequence." If water from Foundry Brook did not provide sufficient power for foundry operations, auxiliary steam engines such as those referred to by Wylie in 1849 and in Blake's 1849 *The History of Putnam County* might have formed an essential part of the foundry's power system.

Archaeological and Photographic Evidence

Archaeological survey during the summers of 2002 and 2003 revealed several features that helped archaeologists understand some of the features denoted on historic maps. Survey revealed several masonry columns along the east and west side of Foundry Brook (Figures 6-20 and 6-21). These columns might represent remnants of supports for

¹⁶ From a copy of a typed letter by J.E.B. dated October 1, 1962, speaking about what he remembered regarding the Baldwin Steel Company. Available at the Putnam County Historical Society and Foundry School Museum, Research Material Box 2, Series 02-3 Cornell. J.E.B. refers to the middle dam, not the dam at Battery Pond.

the flume that carried water from the middle dam to the powerhouse. These columns coincide with flume routes identified on the 1887, 1912, and 1927 Sanborn maps, as well as the circa 1900 map. However, site survey revealed that these columns extended as far north as the middle dam, whereas map data suggested that the flume did not extend north of the southern retaining wall of Battery Pond. Perhaps one reason for this discrepancy is due to the specific concerns of the mapmaker;¹⁷ if the Sanborn Map Company, for example, did not identify specific fire concerns associated with the flume north of battery pond, flume features may have been excluded from its maps.



Figure 6-20:
Presumed masonry
flume support along
the east side of
Foundry Brook.
Photograph by Larry
Mishkar.



Figure 6-21:
Presumed masonry
flume support along
Foundry Brook.
Photograph by Larry
Mishkar.

¹⁷ Valentino, Alicia. "Visualizing the Past at the West Point Foundry. Cold Spring, New York." Master's thesis, Michigan Technological University, 2002: 91,93.

Comparing the 1887 and 1897 Sanborn maps revealed that there was a flume route change along the western bank of Foundry Brook. Archaeologists identified a linear depression on the upper west bank of Foundry Brook, consistent with the flume route change illustrated on the 1897 Sanborn map. This route change might reflect a period of repair or improvement to the original flume route, or an attempt to decrease friction by decreasing the number of turns in the flume. However, without documentation, investigators cannot ascertain the reason for this change.

A hypothetical composite photograph illustrates the iron flume entering the powerhouse from the northern end of Foundry Brook (Figure 6-22). The flume appears to lie along the west bank of Foundry Brook. Flume supports are not visible.

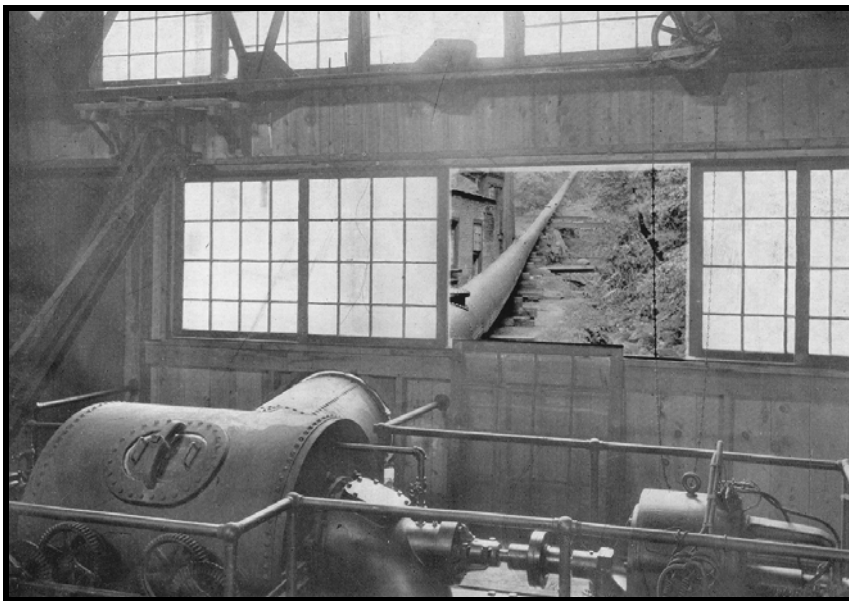


Figure 6-22:
Hypothetical
composite photograph
showing Iron flume
pipe along Foundry
Brook. Images
available at the
Putnam County
Historical Society and
Foundry School
Museum.

Other Water-Related Features: Feature Thirteen, Fire Plugs, and Feature Twenty

Feature Thirteen

During a pedestrian survey in the summer of 2003, archaeologists identified a square, stone-lined pit, designated Feature Thirteen, east of the rail line within the northern end of the machine shop complex (Figure 6-23). The 1853 Bevan map identified a fire engine house in the vicinity of this feature. Feature thirteen might be associated with the fire engine house, possibly functioning as a well or access point over an

underground tailrace, but this cannot be ascertained based solely on its location; archaeological investigation is needed before this can be determined.



Figure 6-23:
Feature Thirteen. A square, stone-lined pit at the northern end of the machine shop complex. Photograph by Steve Ftaclas.

Fire Plugs

Archaeologists also identified fire plugs north of the pattern shop and in an area north of the molding shop complex (Figure 6-24 and 6-25). These plugs formed part of the extensive fire suppression system in place at the foundry from 1857 to 1867, during Parrott's term as manager. An excerpt from the *Highland Democrat* on January 2, 1864, suggests that "A serious fire [was] impossible at the foundry at [that] time, as they have the whole pond with a fall of 100 feet and hydrants and hose in every exposed place throughout the whole establishment."¹⁸

Thirty years later, a report on the foundry's fire suppression system filed by W. F. Buck of the Associated Factory Mutual Insurance Company on March 3, 1893, indicated that fire protection was not adequate at the site. Buck reported that the foundry's sole protection against fire consisted of 21 hydrants located along two pipes fed by water from

¹⁸ "Cold Spring Items" in the *Highland Democrat*, January 2, 1864.

site dams.¹⁹ The hydrants had only 39 pounds of pressure and therefore were considered insufficient for fire protection.²⁰



Figure 6-24: Fire Plug north of pattern shop.
Photograph by Larry Mishkar.



Figure 6-25: Fire plug north of molding shop complex.
Photograph by Larry Mishkar.

Feature Twenty

During the 2003 field season, archaeologists identified an area of bubbling water in Foundry Brook. This area, designated as Feature Twenty, lay east of the boiler house. It also lay east of unit 15A and a break within a brick wall that ran parallel to the old pattern shop complex on the west bank of Foundry Brook. Archaeologists cleared gravel and debris from the area during low tide and revealed a stone and masonry structure to the east of the bubbling water (Figures 6-26 and 6-27). On the 1979 historic base map, archaeologists placed the exit of the boring mill tailrace in the vicinity of Feature Twenty. In 2003, excavation in unit 15A uncovered a feature that contained flowing water. This feature may represent the exit of the aforementioned tailrace, or it could represent the

¹⁹ Insurance Report, 3 March, 1893. Putnam County Historical Society and Foundry School Museum. Box: WPF Collection, 02-3 Physical Plant; 02-4 Machinery Folder: B2: Inspection Certificate, 3 March, 1893. P.2.

²⁰ Insurance Report, 3 March, 1893. P. 3.

remnants of a drain from the boiler house to Foundry Brook. Before archaeologists can identify this feature, further investigation is required.

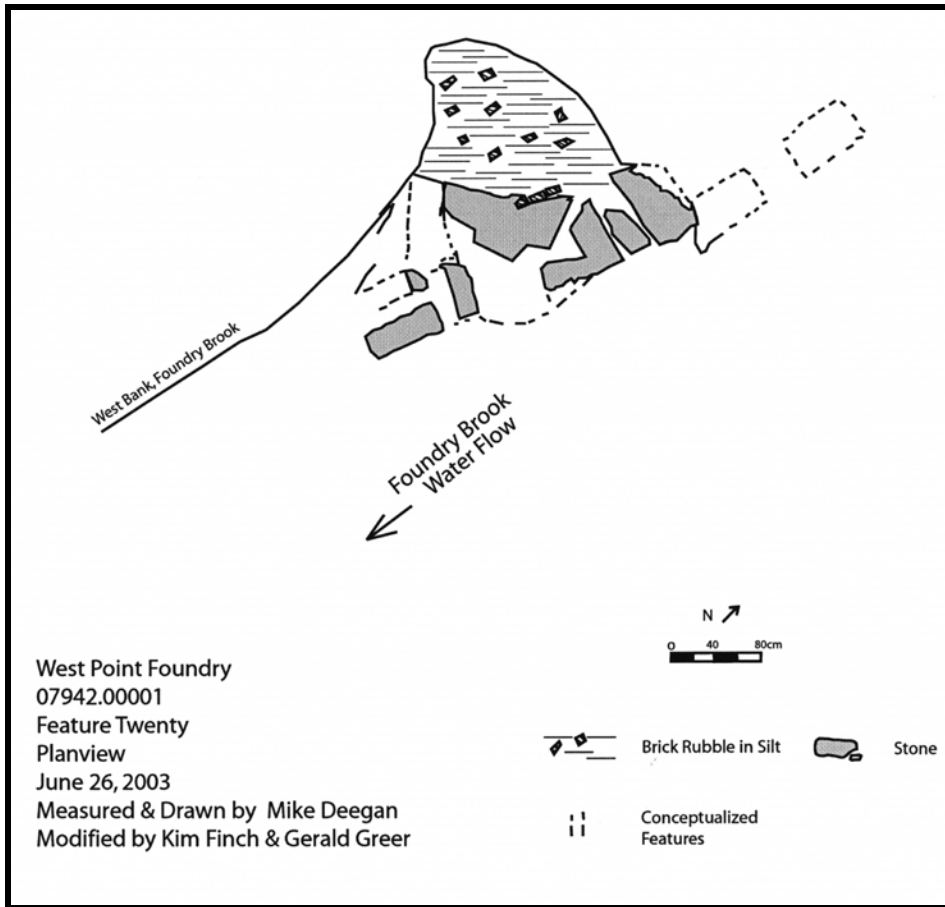


Figure6-26: Planview drawing of Feature Twenty



Figure 6-27:
Feature Twenty. Welling water and surrounding structure in Foundry Brook, E. of the boiler house. Photo: looking east (top of photo), showing brick structure to the west (middle of photo).
Photograph by Kim Finch.

A Provisional Summary of Water Flow throughout the West Point Foundry

Foundry Brook formed the most important part of the foundry's water system. Foundry Brook travels approximately 470 meters between the middle dam and the presumed outlet of the tailrace at the southern end of the pattern shop complex. Topographic survey in 2003 indicated that the brook drops approximately 34 meters between these points. Figure 6-28 illustrates elevation changes along Foundry Brook and includes the location of various activity areas in relation to the brook.

Two dams (the upper and middle dams), and storage ponds controlled water entering Foundry Brook, which provided waterpower for foundry operations. Flumes and races carried water from the middle dam to the furnace, to Battery Pond, and into the southern section of the site, while various drains carried wastewater from activity sites back into Foundry Brook. The following paragraphs trace the path of water as it flowed throughout the site. Map 6-2 illustrates provisional routes through which water flowed.

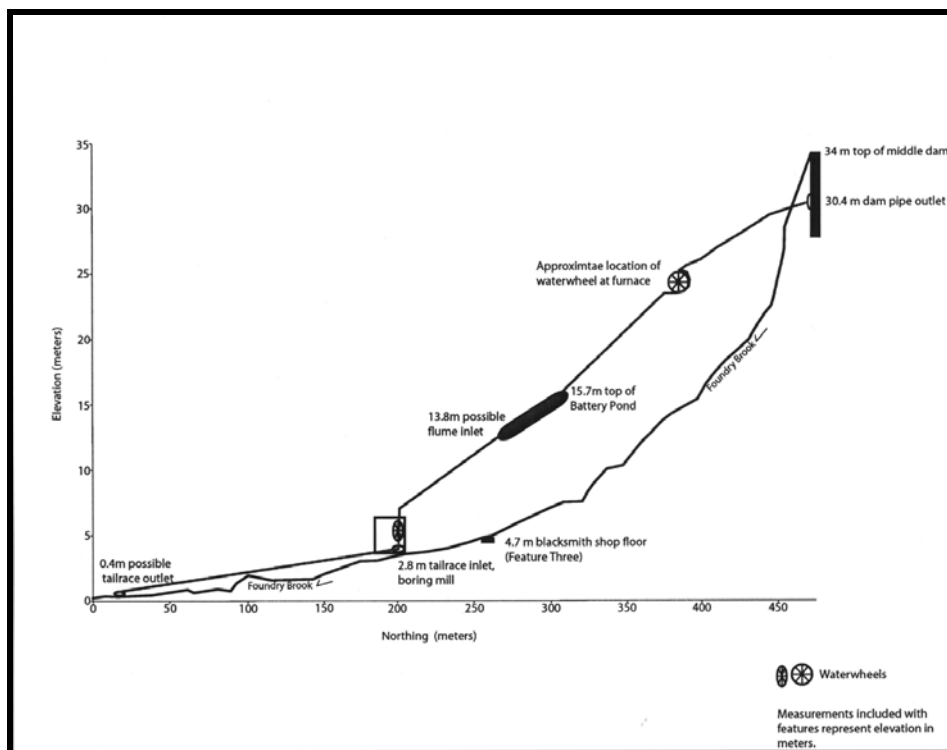
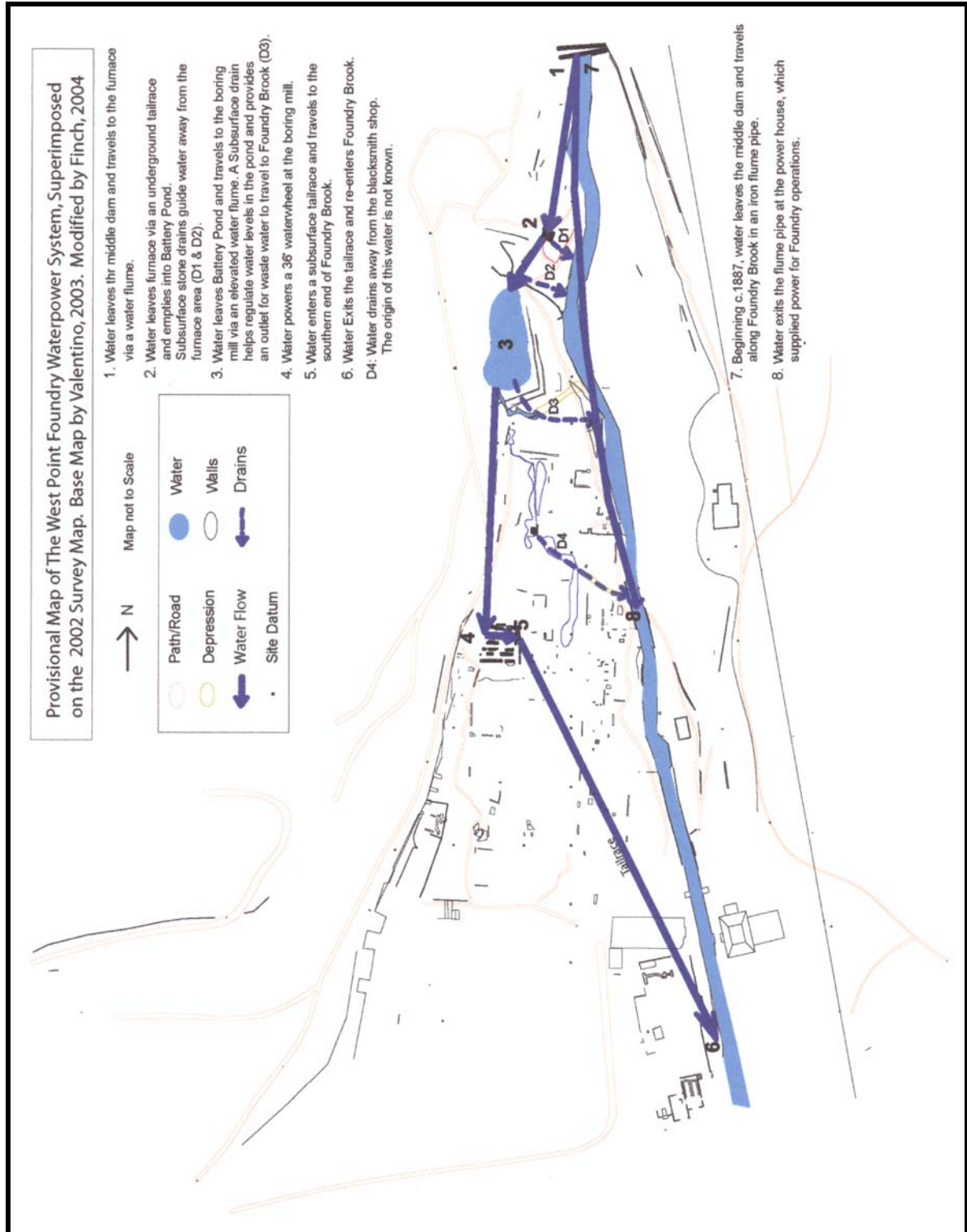


Figure 6-28: Cross-section of elevation changes in Foundry Brook and water-related features. Plot by John Krenzel, 2003. Modified by Kim Finch, 2004.



Map 6-2: Provisional map of the West Point Foundry waterpower system

Water entered Foundry Brook after passing through an upper dam, a storage pond, and the middle dam. From the middle dam, water flowed to the furnace, where it presumably powered a waterwheel that provided power for the furnace blast. Water flowed from a wheelpit, through a tailrace located underneath the blast furnace, and into Battery Pond. Subsurface stone drains underneath and south of the furnace channeled water away from the furnace hearth and protected the tailrace from overflow. Water left Battery pond via an elevated flume and traveled to a 36 foot waterwheel at the boring mill, which supplied power for cannon-boring machinery. Waste water from the wheel entered a subsurface tailrace at the east end of the boring mill wheel pit and re-entered Foundry Brook south of the pattern shop complex.

By at least 1867, 23 years after the furnace ceased operations, an elevated flume carried water from the middle dam, along Foundry Brook, to an area adjacent to the blacksmith shop. Water from this flume or from Battery Pond presumably powered hammers and forge bellows within the blacksmith shop. Archaeological evidence suggested that a drain might have guided waste water from the blacksmith shop to Foundry Brook. By 1900, a flume carried water from the middle dam to a turbine located in a powerhouse at the northern end of the machine shop complex. Waste water from drains and the turbine presumably re-entered Foundry Brook and drained into the Hudson River.

Section Two ~ A Provisional Overview of the Development of the West Point Foundry Waterpower System

Table 6-2 offers a provisional chronology of the development of the West Point Foundry waterpower system, based upon available historical maps, illustrations, documents, and archaeological evidence. Some features, such as stone drains and flume pillars, were not included in aforementioned historical sources; these were inserted into

the chronology where they inferentially made the most sense. Some features, such as the boring mill wheel pit, were not identified on maps until the latter half of the nineteenth century. However, in order for the boring machines to function, a wheel and wheelpit must have been in place when the mill began operation. Features such as these are therefore included in an appropriate place in the chronology. Initial mention of these features in historical sources is also included.

Section Three ~ Waterpower in the Nineteenth Century: Developing an Historical Context for the Waterpower System at the West Point Foundry

Waterpower played an integral part in the industrialization of the United States. Hydraulic power enabled mills, forges, and eventually large industrial complexes such as foundries to manufacture higher quality products in greater quantities than those produced with hand or horse power. Waterpower systems, which consisted of dams, reservoirs, canals, races, sluice gates, flumes, waterwheels, turbines, and tailraces, provided greater means of power production and regulation; the ability to regulate water flow and control its direction within the system provided security during times of low water levels and facilitated power generation at several areas of a site.²¹

Waterpower provided advantages to many industries, but the iron industry in particular reaped the benefits of water-powered processes. Water-powered bellows revolutionized the iron making process as early as 1214; larger and hotter furnaces, made possible by waterpower, facilitated smelting and impurity removal while cutting production costs.²² By the fifteenth century, water-powered blast furnaces were common

²¹ Reynolds, Terry. *Stronger than a Hundred Men: A History of the Vertical Water Wheel*. (Baltimore: The Johns Hopkins University Press, 1983), 7.

Approximate Date(s)	Feature(s)	Approximate Date(s) Modified	Sources
1817 - 1840	<ul style="list-style-type: none"> •Upper, Middle, Lower Dams •Blast Furnace •Battery Pond •Blacksmith Shop •Boring Mill •waterwheel, wheelpit, tailrace at boring mill. •subsurface drains at furnace and south of Battery Pond. •Waterwheel and steam engine in blacksmith shop. 		1840 Town map, 1853 Bevan map, Rutsch report, 1979, Archaeological evidence, Letter from Wylie, 1849.
1858-1867	<ul style="list-style-type: none"> •Fire suppression system installed. 		The <i>Highland Democrat</i> , 1864.
1867 - 1875	<ul style="list-style-type: none"> •Flume route. Began to the southeast of Battery Pond and ended at the blacksmith shop. •brick flume pillars constructed along Foundry Brook •iron pipe placed in dam #2 •Waterwheel pit at Boring Mill first depicted on map. 	1897 - 1900 Flume route changes to west side of Brook. Returns to position depicted on 1867 map.	1867 Beers map, 1897 Sanborn map, 1900 anonymous map, Archaeological evidence, 1872 Scofield map
1887	<ul style="list-style-type: none"> •Overhead flume route to the Boring mill from Battery Pond first depicted on map. •Flume route from northern end of machine shop to the rail line. 	1900 - flume route to rail line no longer depicted.	1887 Sanborn map, 1900 anonymous map
1897 - 1920	<ul style="list-style-type: none"> •Powerhouse first identified on map. 		1900 anonymous map
1912	<ul style="list-style-type: none"> •Drain from blacksmith Shop to Foundry Brook. 		1912 Sanborn map

Table 6-2: Provisional chronology of the development of the West Point Foundry waterpower system.

²² Reynolds 1983: 87.

in much of Europe, and by the seventeenth century they were utilized in America.²³ By 1770, the American colonies were the third largest iron producers in the world.²⁴

Low operating costs and abundant water sources throughout many areas of the United States extended the life of waterpower systems, despite the rising popularity of steam power in the latter half of the nineteenth century. The Hudson River (which fell approximately 4,322 feet over 300 miles from Lake Tear-of-the-Clouds in the Adirondack Mountains to its mouth in New York) and its many tributaries provided energy for different kinds of manufacture during the nineteenth century.²⁵ Probably because of this readily available source of power, many industrial sites did not switch entirely to steam power.

The West Point Foundry's partial reliance on waterpower throughout the nineteenth century was not unique. Wheel pits, waterwheels, pits from blowing engine cylinders, drainage ditches, and canals discovered during investigations of several iron sites in the United States demonstrate that waterpower systems remained in use until the end of the nineteenth century. Archaeological and historical studies of iron sites and features in the states of New York, Massachusetts, Pennsylvania, and Virginia provide comparisons for the waterpower system employed at the West Point Foundry.

The Adirondack Iron and Steel Company, New York

The Adirondack Iron and Steel Company, located forty-five miles west of Lake Champlain and 110 miles north of Albany, operated two charcoal furnaces from 1830 until 1855. A water system on the Hudson River powered both furnaces. One furnace relied upon four dams, while a later furnace relied upon a "timber-faced stone dam that

²³ Reynolds 1983: 87.

²⁴ Norris 2002: 41.

²⁵ Trowbridge, W. P. *Statistics of Power and Machinery Employed in Manufactures: Reports on the Water-Power of the United States*, Part I (Washington: Department of the Interior, 1885), 343.

stretched 180 feet across the Hudson and stood 25 feet high."²⁶ The furnaces were located close to their respective sources of waterpower, reducing the amount of power lost in transmission from the dam to the furnace.

The Burden Waterwheel, New York

Another example of a water-powered iron works comes from Troy, New York, on a small tributary of the Hudson River. Scottish ironmaster Henry Burden became the owner of the Troy Iron and Nail Factory in 1840, where he had worked as superintendent since 1822.²⁷ In 1838, Burden constructed a large waterwheel at the works, replacing five small wheels powered by a 50 foot waterfall. He rebuilt the wheel in 1851 due to operational difficulties.

The second wheel, constructed of wood and iron, was 62 feet in diameter, 22 feet wide, weighed 250 tons, and was capable of producing 280 horsepower.²⁸ A dam regulated flow from an upstream lake, from which water flowed along a canal on a hillside, through a brick conduit, into a wooden penstock (later replaced by a riveted iron pipe), and onto the overshot waterwheel.²⁹ The wheel pit was 20 feet deep and lined with brick. Discharge from the wheel pit went 200 feet through a tunnel cut in solid rock to a creek.³⁰ The wheel and ironworks ceased operations in 1896.

The Dover Union Iron Mill, Massachusetts

Between circa 1800 and 1840, Noanet Brook of Dover, Massachusetts, supplied power for the Dover Union Iron Company's blast furnace and iron and slitting mill. The mill utilized a waterpower system carefully designed to maximize flow from the brook. Archaeological investigation of this system suggested that a headrace directed water from

²⁶ Seely 1981: 29.

²⁷ Sweeny, F. R. I. *The Burden Water-Wheel*. Society for Industrial Archaeology. Occasional Publications, Number Two, April 1973: 6.

²⁸ Reynolds 1983: 316.

²⁹ Sweeny 1973: 7.

a millpond to a stone dam and into a flume that led to a penstock at the top of an overshot waterwheel inside the mill.³¹

Archaeologists excavated the wheelpit and the stone dam that held the water flume that led to the wheel pit. The stone-walled wheel pit was 40 feet long, 7 feet wide, and 20 feet deep.³² The east side of this pit held two large stones set with heavy bolts that once supported the waterwheel shaft.³³ The west side of the pit contained a recess and a stone foundation that outlined the rolling and cutting area.³⁴ Based upon remnants of the waterwheel, archaeologists calculated the wheel's dimensions as 36 feet in diameter and 5 feet wide, with 12 sets of spokes made of oak.³⁵ Pine boards formed the bottom of the wheel's buckets, and iron plates, bolts, nuts, and washers held the outer rim together.³⁶ The stone dam rose approximately six feet above the ground surface and was approximately eight feet wide at the bottom. Archaeologists also discovered a section of brook covered with stone that channeled water away from the wheelpit.

This set-up bears a striking resemblance to the waterpower system at the West Point Foundry boring mill. Historic documents suggest that the West Point Foundry's boring mill was also powered by a 36 foot waterwheel fed by a flume from a storage pond. Large stones on the surface of the wheel pit contained large holes, presumably from bolts that once supported parts of the wheel. Like the recessed wheelpit wall at the Dover Union Mill, the southern wheelpit wall at the West Point Foundry was much lower than the northern wall due to the need to transfer power from the wheel to the boring machinery via a shaft. The evidence from Dover suggests that further excavation in the

³⁰ Sweeny 1973: 9.

³¹ Vara, Richard Hart. *The Dover Union Iron Mill* (U.S.A.: Richard Hart Vara, 2003), 26.

³² Vara 2003: 14.

³³ Vara 2003: 13.

³⁴ Vara 2003: 14.

³⁵ Vara 2003: 15.

³⁶ Vara 2003: 15.

boring mill wheel pit at the West Point Foundry may reveal details pertaining to the wheel and gearing that drove the boring machinery.

The Hopewell Furnace, Pennsylvania

Constructed in 1770-71 and rebuilt in 1828, the Hopewell furnace operated continuously until 1883. This cold blast furnace also relied upon waterpower. Water from Hopewell Lake traveled along a headrace to a 22 foot diameter waterwheel that drove blast machinery for the furnace. A stone-lined tailrace, which went underground for approximately 400 feet south of the furnace, directed water away from the wheel pit and into a downstream creek.

Like the West Point Foundry, the Hopewell furnace did not switch to steam power. Hopewell relied upon a waterwheel, which drove double acting cylinders with pistons that compressed air. The compressed air then passed into a receiving box, and then into the furnace.

The Tredegar Iron Works, Virginia

The Tredegar Iron Works of Richmond, Virginia, operated from 1837 until 1957. Like the West Point Foundry, Tredegar did not convert to steam power; a system of races, flumes, penstocks, overshot waterwheels, and turbines fed by the James River and Kanauha Canal powered a cannon boring mill, rolling mill, several air furnaces, cupolas, and machine shops.³⁷ Four primary races drew from the river and canal, feeding waterwheels that most likely consisted of iron and wood composites.³⁸ Lists of waterwheels from Tredegar in 1843 indicate that the site had four wheels, one each for puddle rolls, a hammer, a machine shop, and for cannon boring.³⁹ A 1867 list indicates

³⁷ Raber, Michael S., Patrick M. Malone, and Robert B. Gordon. *Historical and Archaeological Assessment, Tredegar iron Works Site, Richmond, Virginia* (Connecticut: Raber Associates, 1992), 8, 14, 25, 43.

³⁸ Raber, Malone, and Gordon 1992: 44.

³⁹ Raber, Malone, and Gordon 1992: 45.

that the site had six overshot wheels and five turbines.⁴⁰ By 1927, Tredegar had 18 turbines.⁴¹

These examples indicate that the West Point Foundry was one of many ironworks that did not fully convert to steam power during their operation. By the Civil War, many iron sites used steam power, and many more had converted from water to steam by the 1870s.⁴² David Wylie's letter indicated that the West Point Foundry blacksmith shop contained a steam engine in 1849, and Blake's 1849 *The History of Putnam County, New York* suggested that the boring mill supplemented water with an auxiliary steam engine by 1839. Foundry boiler shops, present by 1840, may have provided steam for the engines at the blacksmith shop and boring mill. Yet the West Point Foundry, along with the aforementioned iron works, primarily powered their operations by maintaining a network of ponds, streams, dams, flumes, waterwheels, and turbines.

Exactly why the West Point Foundry did not fully convert operations to steam power is not known, but several possibilities exist. According to Louis Hunter, "waste heat and gasses from the new closed-top, hot-blast furnaces, combined often with puddling furnaces as an adjunct to rolling mills and nailworks, were used for steam raising and eliminated the traditional cost advantage of waterpower over steam power."⁴³

Using this information, Raber, Malone, and Gordon surmised that the Tredegar Iron Works, which did not have a blast furnace, did not switch to steam because its cupolas and heating furnaces did not provide enough waste heat to benefit converting to steam.⁴⁴ Perhaps proprietors of the West Point Foundry followed a similar course of reasoning.

⁴⁰ Raber, Malone, and Gordon 1992: 45.

⁴¹ Raber, Malone, and Gordon 1992: 43.

⁴² Raber, Malone, and Gordon 1992: 52.

⁴³ Hunter, Louis. *A History of Industrial Power in the United States, Vol. I, Waterpower in the Century of the Steam Engine* (Eleutherian Mills-Hagley Foundation, University Press of Virginia, Charlottesville, 1979), 493.

⁴⁴ Raber, Malone, and Gordon 1992: 52.

West Point's blast furnace ceased operation in 1844, eliminating the primary source of waste heat and therefore reducing the cost benefit from a steam conversion. It is also possible that the steel revolution in the latter half of the nineteenth century, which coincided with the rise of steam, inhibited foundry spending. The West Point Foundry already had capital invested in a waterpower system. The low costs of continuing this system probably discouraged commitment to a new power system.

Conclusion

Research and excavation during the 2003 field season constituted the first step in understanding how water from Foundry Brook powered operations at the West Point Foundry. Using information obtained during GPR surveys, as well as information from historical maps, illustrations, and documents, archaeologists mapped and excavated areas at the furnace, Battery Pond, blacksmith shop, boring mill, powerhouse, and boiler house. Archaeological excavation exposed the boring mill wheel pit, a tailrace inlet, a subsurface drain, a potential surface drain, and a possible tailrace outlet within Foundry Brook. Survey revealed subsurface drains and a tailrace at the furnace, and a possible machine base and wheel pit at the blacksmith shop.

Comparative studies of iron foundries in New York, Massachusetts, Pennsylvania, and Virginia demonstrated that the West Point Foundry was not unique in its continued reliance on waterpower during the second half of the nineteenth century; despite the growing popularity of steam power, several foundries continued to rely upon water, an affordable, renewable resource. The use of steam power in the blacksmith shop and the boring mill at the West Point Foundry requires further investigation. However, it remains clear that water was an important power source throughout the iron foundry's operation.

The information obtained during 2003 facilitated the development of a provisional overview of the development of the West Point Foundry's waterpower system. However,

the complexity of the West Point Foundry's waterpower system necessitates further archaeological and historical investigation.

Chapter 7 Conclusions

Research at the West Point Foundry during the summer of 2003 centered around two areas, 1) assessing the applicability of ground penetrating radar on industrial sites, and 2) identifying features of the foundry's waterpower system, including construction details and function.

Archaeologists tested the performance of a geophysical technique (ground penetrating radar) and gathered data useful for archaeological excavation during nine surveys performed across the foundry site. Despite problems created by uneven terrain and surface features such as fallen trees, brick scatters, and thick layers of leaves, the crew obtained useful data. Radar signals penetrated to a depth of approximately one meter in most areas and provided indications of the location of buried pipes, drains, and a possible tailrace. Archaeologists positioned three excavation units based upon ground penetrating radar data. Excavation in these units revealed a subsurface stone drain south of Battery Pond, a brick machine base at the boring mill, and a possible subsurface drain near the boiler house.

The West Point Foundry surveys demonstrated that with well designed field methods, ground penetrating radar is effective on industrial sites. Successful surveys depended on several variables, including clearing survey areas of surface debris to permit smooth operation of a radar cart, employing dense spacing between survey transects and dense data collection intervals to insure maximum data collection, and employing proper antenna strength. Archaeologists may obtain improved radar performance on industrial sites with the use of an antenna frequency lower than 250 MHz, which obscures small, near-surface objects and detects deeper features. Survey on sites such as the West Point

Foundry would also benefit from the use of a cart more suitable to uneven terrain or separate radar antennas to increase maneuverability and stability.

Archaeologists also gathered a substantial amount of data concerning the West Point Foundry's waterpower system. Examination of historic maps, paintings, and photographs, as well as surveys of visible features, GPR data, and archaeological excavation resulted in the development of a provisional summary of water flow throughout the foundry site (refer to map 6-2).

A storage pond and an upper and middle dam regulated water entering the foundry site. Water traveled from the middle dam to the blast furnace through an elevated flume. At the furnace, water turned an overshot waterwheel that provided the furnace blast. Water exited the wheel pit and traveled underneath the furnace and through a tailrace into Battery Pond. Subsurface stone drains guided tailrace overflow and ground water at the furnace into Foundry Brook. A subsurface stone drain south of Battery Pond directed waste water out of the pond. From Battery Pond, water traveled through an elevated flume to the boring mill, where it turned a 36 foot overshot waterwheel that powered cannon boring machinery. This flume also may have provided water for waterwheels in the blacksmith shop, but there is not enough evidence to support this hypothesis. At the boring mill, water entered a subsurface tailrace, traveled across the site, and exited into the southern end of Foundry Brook.

Around the turn of the twentieth century, an iron flume directed water from the middle dam to a powerhouse that straddled Foundry Brook just north of the machine shop complex. Water from this flume powered a turbine that, according to a man known as J.E.B., provided insufficient power for the foundry site. A letter from a foundry worker also indicated that auxiliary steam engines operated in the blacksmith shop and the boring mill by at least 1848.

Archaeological excavation, based upon anomalies identified during GPR surveys and features observed during pedestrian survey, provided detailed information about several water-related features at the foundry site. Excavation based upon GPR survey data revealed features such as a subsurface stone drain south of Battery Pond. This drain resembled drain outlets visible on the west bank of Foundry Brook near the furnace. Similar drains associated with water storage ponds and iron furnaces at sites in the United States and Europe suggested that the stone drains at the West Point Foundry prevented water from pooling under the furnace and facilitated removal of wastewater from Battery Pond.

GPR data also justified excavation east of the boiler house, where archaeologists uncovered a subsurface masonry wall and possible drain. This feature lay in the approximate location of a subsurface tailrace denoted by CRMSI on an historic base map created in 1979. It also aligned with a stone and masonry structure associated with an area of welling water in Foundry Brook. Although archaeologists must conduct further subsurface investigation to determine the nature of these features, it is possible that they are associated with the outlet of the tailrace that originated at the boring mill.

Through surface survey and excavation, archaeologists identified and recorded a tailrace between the furnace and Battery Pond and a tailrace inlet in the boring mill. A stone-lined tailrace south of the furnace directed water from the furnace waterwheel and into Battery Pond. A tailrace inlet at the boring mill once guided water away from the mill's 36 foot waterwheel and wheelpit through a subsurface tailrace to Foundry Brook. Unfortunately, archaeologists did not identify the path of this tailrace or details of its physical construction.

A survey of visible surface features also resulted in the identification of a depression that ran between the blacksmith shop and an area north of the foundry's power house. Archaeologists bisected this depression and revealed a possible drainage trench.

It is possible that the drain originated from a feature (Feature Three) that may have been part of a tilt hammer and waterwheel assembly in the southwestern part of the blacksmith shop.

Artifacts recovered during excavation did not provide pertinent information about the waterpower system. However, analysis of the 2003 assemblage enabled a comparison among assemblages from other site types, such as households and frontier encampments. Recovery of high percentages of architecture- and activities-related material reflected foundry activities such as boring and smelting and was consistent with structural decay evident at the site. Collection and analysis of these artifacts enabled the development of alternative catalog artifact groups that reflect material collected on industrial sites in contrast to material collected from household and frontier sites.

Conclusions concerning the development and function of the foundry's waterpower system could not be made from field data alone. A combination of field data, map data, and information gathered from past historical and archaeological research at nineteenth century iron foundries in the United States and Europe provided an historical context for the foundry's waterpower technology.

The West Point Foundry's continual reliance on waterpower throughout the nineteenth century was not unique. Several other sites in the United States, including the Tredegar Iron Works and the Hopewell furnace, also maintained a network of ponds, streams, dams, flumes, waterwheels, and turbines. Perhaps the foundry's declining prosperity that resulted from its failure to switch to steel production and/or its lack of furnace waste heat prevented investment in a new power system. However, the foundry had already invested in a water system that had low operational and maintenance costs, which was probably the major factor for the foundry's continued reliance on waterpower.

Recommendations for Future Research

Fieldwork and research conducted during the summer of 2003 represented initial efforts aimed at understanding the foundry's waterpower system. Archaeologists should direct attention to features associated with waterpower during future excavation in areas around the furnace, the blacksmith shop, and the boring mill. Research should focus upon identifying the paths and construction details of water flumes between the middle dam and the furnace and between Battery Pond and the boring mill. At the furnace, archaeologists should determine if a waterwheel provided power for the furnace blast and where it was located. At the blacksmith shop, archaeologists need to identify the location of the waterwheel(s) and their relation to the hammers. The source of water for these wheels and hammers must also be determined.

Archaeologists should also direct more attention to the boring mill waterwheel pit and associated tailrace. Excavation in the wheelpit could 1) define the pit and 2) identify elements of the waterwheel and the mechanisms that transferred power between the wheel and boring machinery. Obtaining a clearer understanding of the path of the tailrace between the boring mill and Foundry Brook also requires investigation. Further GPR survey at the site in areas between the boring mill and the boiler house might reveal more data related to this tailrace.

Components of the waterpower system identified in this thesis are provisional. The exact paths of the drains and tailraces, for example, are not known. Future archaeological excavation near water-related features, or efforts by property owners to redirect flow in flooded areas at the site, could compromise the historical and physical integrity of subsurface features. Care should therefore be taken to preserve these features for future research.

References

Books, Magazines, Journals, Theses, Letters, Presentations, and Site Reports

- Agricola, Georgius. *De Re Metallica*. Translated from the First Latin Edition of 1556 by Herbert Clark Hoover and Lou Henry Hoover. New York: Dover Publications, Inc., 1950.
- Aitken, M.J. *Physics and Archaeology*. Second Edition. Oxford: Clarendon Press, 1974.
- Bell, Edward L. "The O'Neal-Forshee Iron Mining Settlement." *In The Bulletin and Journal of Archaeology of New York State*. Spring 1983: 86. New York State Archaeological Association.
- Bennet, James R. *Tannehill and the Growth of the Alabama Iron Industry. Including the Civil War in West Alabama*. Alabama: Alabama Historic Ironworks Commission, 1999.
- Bevan, Bruce W. *Geophysical Exploration for Archaeology: An Introduction to Geophysical Exploration*. Midwest Archaeological Center Special Report No. 1. Lincoln, Nebraska: United States Department of the Interior, National Park Service, 1998.
- Bevan, Bruce W., Dennis Blanton and Audrey J. Horning. *Evaluation and Field Verification of Geophysical Data. Jamestown Archaeological Assessment 1992-1996*. Williamsburg, Virginia: Colonial Williamsburg Foundation, College of William and Mary, 2000.
- Clark, Anthony. *Seeing Beneath the Soil: Prospecting Methods in Archaeology*. London: Routledge, 2001.
- Conyers, Lawrence B., and Dean Goodman. *Ground Penetrating Radar: An Introduction for Archaeologists*. New York, New York: Altamira Press, 1997.
- Council, R. Bruce, Nicholas Honerkamp, and M. Elizabeth Will. *Industry and Technology in Antebellum Tennessee: The Archaeology of Bluff Furnace*. Knoxville, Tennessee: The University of Tennessee Press, 1992.
- Crossley, David. "The Conservation of Monuments Connected with the Iron and Steel Industry in the Sheffield Region" *In Ironworks and Iron Monuments; Study, Conservation and Adaptive Use*. Symposium at Coalbrookdale, UK, July 1984.

Danforth, G. W. *An Elementary Outline of Mechanical Processes. Giving a Brief Account of the Materials Used in Engineering Construction and of the Essential Features in the Methods of Producing Them, Also Describing Shop Processes and Equipment for the Shaping of Metals into Forms for Engineering and General Uses.* Annapolis, Maryland: The United States Naval Institute, 1920.

Diderot, Denis. *A Diderot Pictorial Encyclopedia of Trades and Industry, Manufacturing and Technical Arts in Plates Selected from "L'Encyclopedie, ou Dictionnaire Raisonne des Sciences, des Arts et des Metiers" of Denis Diderot.* Vol. I. New York: Dover Publications, Inc., 1959.

Eisenberg, Leonard A. "Physiography and Prehistory of the West Point Foundry Site." In Edward S. Rutsch, JoAnn Cotz, and Brian H. Morrell with Herbert J. Githens and Leonard A. Eisenberg, *The West Point Foundry Site Cold Spring, Putnam County, New York.* Newton, New Jersey: Cultural Resource Management Services, 1979.

French, J.H. *Gazetteer of the State of New York: Embracing A Comprehensive View of the Geography, Geology, and General History of the State and A Complete History and Description of Every County, City, Town, Village, and Locality. With Full Tables of Statistics.* Syracuse, New York: R. Pearsall Smith, 19860.

Frizell, Joseph P. *Water-Power, An Outline of the Development and Application of the Energy of Flowing Water.* New York: John Wiley & Sons, 1901.

Gordon, Robert B., and Patrick M. Malone. *The Texture of Industry: An Archaeological View of the Industrialization of North America.* New York: Oxford University Press, 1994

Gough, Monica, ed. *Fanny Kemble. Journal of a Young Actress.* New York: Columbia University Press, n.d.

Grossman, I.G. *The Ground Water Resources of Putnam County, New York.* Bulletin GW-37. Albany, New York: U.S. Geological Survey in Cooperation with the New York Water Power and Control Commission, 1957.

Grossman, Joel W. *The Archaeology and Economic History of the Civil War Era Worker's Housing Complex at West Point Foundry, Cold Spring, New York.* New York: Grossman and Associates, Inc., 1993.

- Heimmer, H.M.H., P.G., and Steven L. DeVore. *Near-Surface, High Resolution Geophysical Methods for Cultural Resource Management and Archaeological Investigations*. Revised edition. Denver, Colorado: National Park Service, 1995.
- Herz, Norman, and Ervan G. Garrison. *Geological Methods For Archaeology*. New York: Oxford University Press, 1998.
- Hunter, Louis C. *A History of Industrial Power in the United States, 1780-1930. Volume One: Waterpower in the Century of the Steam Engine*. Charlottesville, Virginia: University Press of Virginia, 1979.
- Keith, Herbert C. and Charles Rufus Harte. *The Early Iron Industry of Connecticut*. Reprinted from the 51st Annual Report of the Connecticut Society of Civil Engineers, Incorporated, February 20, 1935.
- Knight, Edward H. *Knight's American Mechanical Dictionary, Volume III*. Boston: Houghton, Mifflin and Company, 1884.
- Kvamme, Kenneth L. "Current Practices in Archaeogeophysics: Magnetism, Resistivity, Conductivity, and Ground Penetrating Radar." In Paul Goldberg, et al. *Earth Sciences and Archaeology*. New York: Kluwer Academic/Plenum Publishers, 2001.
- Mankowski, Len; Lemke, Seth; Young, C.T.; Hayes, D.H.; Martin, S.R.; and Martin, P.E. "A Geophysical Investigation of a Sugar Cane Plantation, St. Croix, U.S. Virgin Islands: Using Multiple Techniques to Assess a Complex Industrial Site." *Proceedings of the Symposium on the Application of Geophysics to Engineering and Environmental Problems*, compiled and edited by M.H. Powers, A.B. Ibrahim, and L. Cramer, pp. 369-378. The Annual Meeting of the Environmental and Engineering Geophysical Society, February 20-24, 2000, Arlington, Virginia.
- Memorials in Behalf of The South Boston Iron Co. and The West Point Foundry, With Data Showing the Necessity of Having at Least Two Foundries Kept in Perfect Working Order for Manufacturing Heavy Ordnance*. Washington, D.C.: Gibson Bros., 1878.
- Murphy, James L. "Tobacco Pipe Fragments from Schoenbrunn, Tuscarawas County, Ohio" in Byron Sudbury, ed. *Historic Clay Pipe Studies*, Volume 3. Oklahoma: Byron Sudbury, 1986.

- Norris, Elizabeth. "An Historical and Industrial Archaeology Strategy for the West Point Foundry Site, Cold Spring, New York." Master's thesis, Michigan Technological University, 2002.
- Pasquinucci, Marinella, and Frederick Terment, eds. *The Archaeology of Mediterranean Landscapes 4: Non-Destructive Techniques Applied to Landscape Archaeology*. Oxford: Oxbow Books, 2000.
- Phillips, J. Arthur. *Elements of Metallurgy: A Practical Treatise on the Art of Extracting Metals from Their Ores*. Third Edition. London: Charles Griffin and Company, 1891.
- Pollard, A.M., ed. "New Developments in Archaeological Science. A Joint Symposium of the Royal Society & the British Academy, February 1991." *Proceedings of the British Academy*: 77. Oxford: Oxford University Press, 1992.
- Rockwell, Cynthia and Monica Garcia, eds. *Ironworks and Iron Monuments; Study, Conservation and Adaptive Use*. Symposium at Coalbrookdale, UK, October 23-25, 1984. Rome: ICCROM 1985.
- Raber, Michael S., Patrick M. Malone, and Robert B. Gordon. *Historical and Archaeological Assessment, Tredegar iron Works Site, Richmond, Virginia*. Connecticut: Raber Associates, 1992.
- Reynolds, Terry. *Stronger than a Hundred Men: A History of the Vertical Water Wheel*. Baltimore: The Johns Hopkins University Press, 1983.
- Schmidt, Armin. *Geophysical Data in Archaeology: A Guide to Good Practice*. Oxford: Oxbow Books, 2001.
- Schools Council, Great Britain. *Industrial Archaeology of Watermills and Waterpower*. London: Heinemann Educational Books, 1975.
- Seely, Bruce E. "Blast Furnace Technology in the Mid-19th Century: A Case Study of the Adirondack Iron and Steel Company." In *Journal of the Society for Industrial Archaeology* Vol. 7(1):1981.
- Sexton, A. Humboldt. *An Elementary Text-Book of Metallurgy*. Sixth Edition. London: Charles Griffin and Company, Limited, 1922.

- Sweeny, F. R. I. *The Burden Water-Wheel*. Society for Industrial Archaeology. Occasional Publications, Number Two, April 1973.
- Tealby, Andres, and T. Campbell. "A Report on the Evaluation of Ground Penetrating Radar in Archaeology (1990/1991)." In Andres Vogel and Gregory N. Tsokas, eds. *Geophysical Exploration of Archaeological Sites*. Vieweg: Bertelsmann Publishing Group International, 1993.
- Thompson, John H. *Geography of New York State*. Syracuse, New York: Syracuse University Press, 1966.
- Tousard, Louis de. *American Artillerits' Companion or, Elements of Artillery, Treating All Kinds of Firearms in Detail, and of the Formation, Object, and Service of the Flying or Horse Artillery*. Philadelphia: C. & A. Conrad, 1809-1813.
- Trowbridge, W. P. *Statistics of Power and Machinery Employed in Manufactures: Reports on the Water-Power of the United States, Part I*. Washington: Department of the Interior, 1885.
- Valentino, Alicia. "Visualizing the Past at the West Point Foundry. Cold Spring, New York." Master's thesis, Michigan Technological University, 2003.
- Vara, Richard Hart. *The Dover Union Iron Mill*. U.S.A.: Richard Hart Vara, 2003.
- Vogel, Andreas and Gregory N. Tsokas, eds. *Geophysical Exploration of Archaeological Sites*. Vieweg: Bertelsmann Publishing Group International, 1993.
- Weitzman, David. *Traces of the Past: A Field Guide to Industrial Archaeology*. New York: Charles Scribner's Sons, 1980.
- Wylie, David. Letter to Andrew Wylie, 4 June 1849. Edited by Barbara Smith. From the personal collection of Barbara Smith. Transcript on file at Michigan Technological University.
- Wysor, Henry. *Metallurgy. A Condensed Treatise for the Use of College Students and Any Desiring a General Knowledge of the Subject*. Easton, Pennsylvania: The Chemical Publishing Company, 1908.

Internet Resources

Lossing, Benson J. *The Hudson from the Wilderness to the Sea* (1866). The New York Public Library Digital Library Collections <http://digilib.nypl.org/dynaweb/hudson/wwm9822/@Generic__BookTextView/3894;pt4263> (March, 2004).

Jockenhovel, Albrecht et al. *Archaeological Investigations of the Beginning of Blast Furnace-Technology in Central Europe*. <<http://www.uni-muenster.de/GeschichtePhilosophie/UrFruehGeschichte/kier1.htm>> (February, 2004).

Les Forges. <<http://www.xena.ad/viaferrata/forge/forge.htm>> (March, 2004).

Putnam Valley Master Plan, 1990.

<http://putnamvalley.com/archives/master_plan/1990/master_plan_natural.html> (September, 2003).

National Park Service. *Hopewell Village National Historic Site. Hopewell Furnace Handbook*. <http://www.cr.nps.gov/history/online_books/hh/8/hh81.htm> (March, 2004).

Tomas, Estanislau. "The Catalan Process for the Direct Production of Malleable Iron and its Spread to Europe and the Americas." In *Contributions to Science* Volume 1(2): 225-232. Barcelona: Institute d'Estudis Catalans, 1999. PDF available at <http://www.cat-science.com/admin/articles/pdf_99010217_The_Catalan.pdf> (March, 2004).

UAB Casting Engineering Laboratory. *The Catalan Furnace*.

<<http://www.eng.uab.edu/mse/labs/cel/sidebar/default.asp>> (March, 2004).

Wynn, Jeffery C. *A Review of Geophysical Methods Used in Archaeology*.

<<http://www.terraplus.com/papers/wynn.html>> (December, 2003).

Historic Maps, Photographs, and Paintings

1840s Town Map. Miller Lithographers, New York. Housed at the Putnam County Historical Society and Foundry School Museum.

1853 Bevan Map. Housed at the Putnam County Historical Society and Foundry School Museum.

1865 painting of the West Point Foundry Furnace by John Gadsby Chapman. Housed at the Putnam County Historical Society and Foundry School Museum.

1867 Beers Map. Housed at the Putnam County Historical Society and Foundry School Museum.

1872 Scofield Map. Housed at the Putnam County Historical Society and Foundry School Museum. Traced by K. Strong.

1887 Sanborn Fire Insurance Map. Housed at the Putnam County Historical Society and Foundry School Museum.

1897 Sanborn Fire Insurance Map. Housed at the Putnam County Historical Society and Foundry School Museum.

1912 Sanborn Fire Insurance Map. Housed at the Putnam County Historical Society and Foundry School Museum.

1979 Historic Base Map survey by Cultural Resource Management Services, Inc. Rutsch, Edward S., JoAnn Cotz, and Brian H. Morrell with Herbert J. Githens and Leonard A. Eisenberg. *The West Point Foundry Site Cold Spring, Putnam County, New York*. Newton, New Jersey: Cultural Resource Management Services, Inc., 1979.

1996 Property Survey by Badey and Watson Surveying and Engineering, P.C. Housed at the Putnam County Historical Society and Foundry School Museum.

2002 Survey Map. Alicia Valentino, Michigan Technological University.

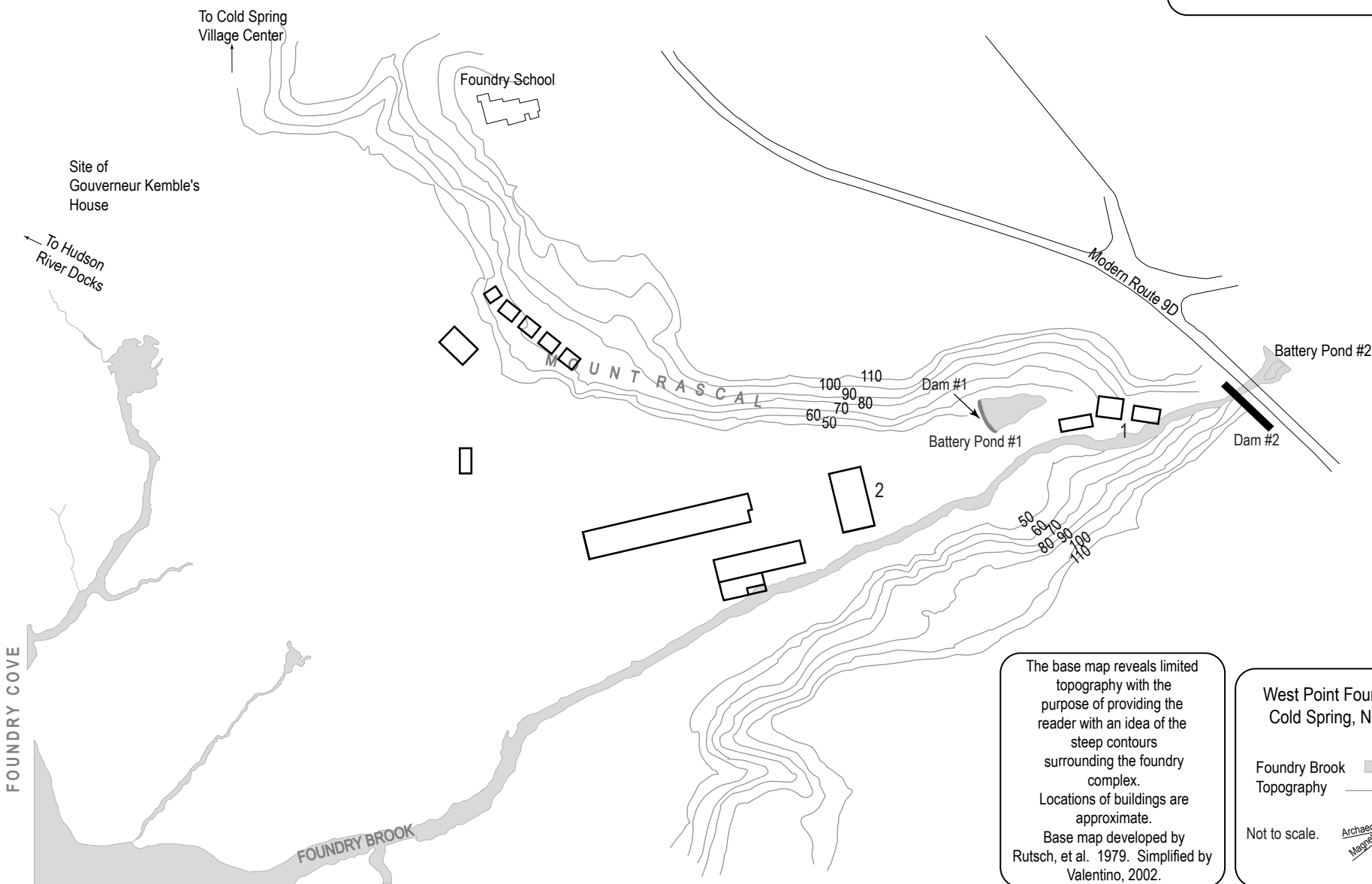
Undated, anonymous map from the Cornell Period. Housed at the Putnam County Historical Society and Foundry School Museum.

United States Geological Survey. USGS Topographic Map, New York Quadrangle. 1957, Photorevised 1981.

Appendix A
Maps Illustrating the Sequence
Of Development at the West
Point Foundry

West Point Foundry site circa 1840.

No.	Map Period Name
1	Furnace
2	Foundry Machine Shop



The base map reveals limited topography with the purpose of providing the reader with an idea of the steep contours surrounding the foundry complex. Locations of buildings are approximate. Base map developed by Rutsch, et al. 1979. Simplified by Valentino, 2002.

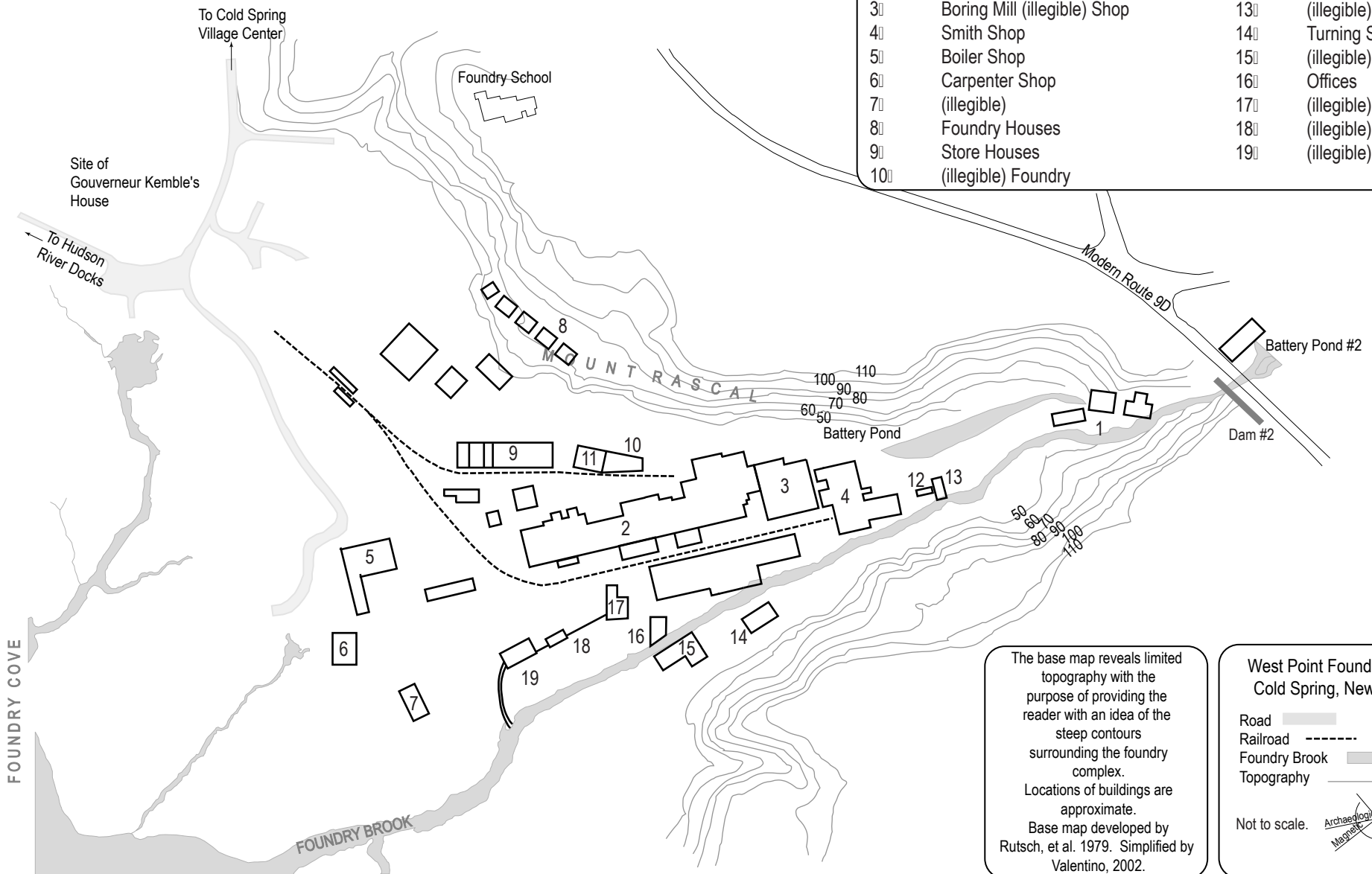
West Point Foundry Site
Cold Spring, New York

Foundry Brook
Topography

Not to scale.

Archaeological
Magnetic

West Point Foundry site circa 1853 according to Bevan Map



No.	Map Period Name	No.	Map Period Name
1	Furnace	11	(illegible) Shop
2	Molding House	12	(illegible) Houses
3	Boring Mill (illegible) Shop	13	(illegible) Houses
4	Smith Shop	14	Turning Shop
5	Boiler Shop	15	(illegible)
6	Carpenter Shop	16	Offices
7	(illegible)	17	(illegible)
8	Foundry Houses	18	(illegible)
9	Store Houses	19	(illegible)
10	(illegible) Foundry		

The base map reveals limited topography with the purpose of providing the reader with an idea of the steep contours surrounding the foundry complex. Locations of buildings are approximate. Base map developed by Rutsch, et al. 1979. Simplified by Valentino, 2002.

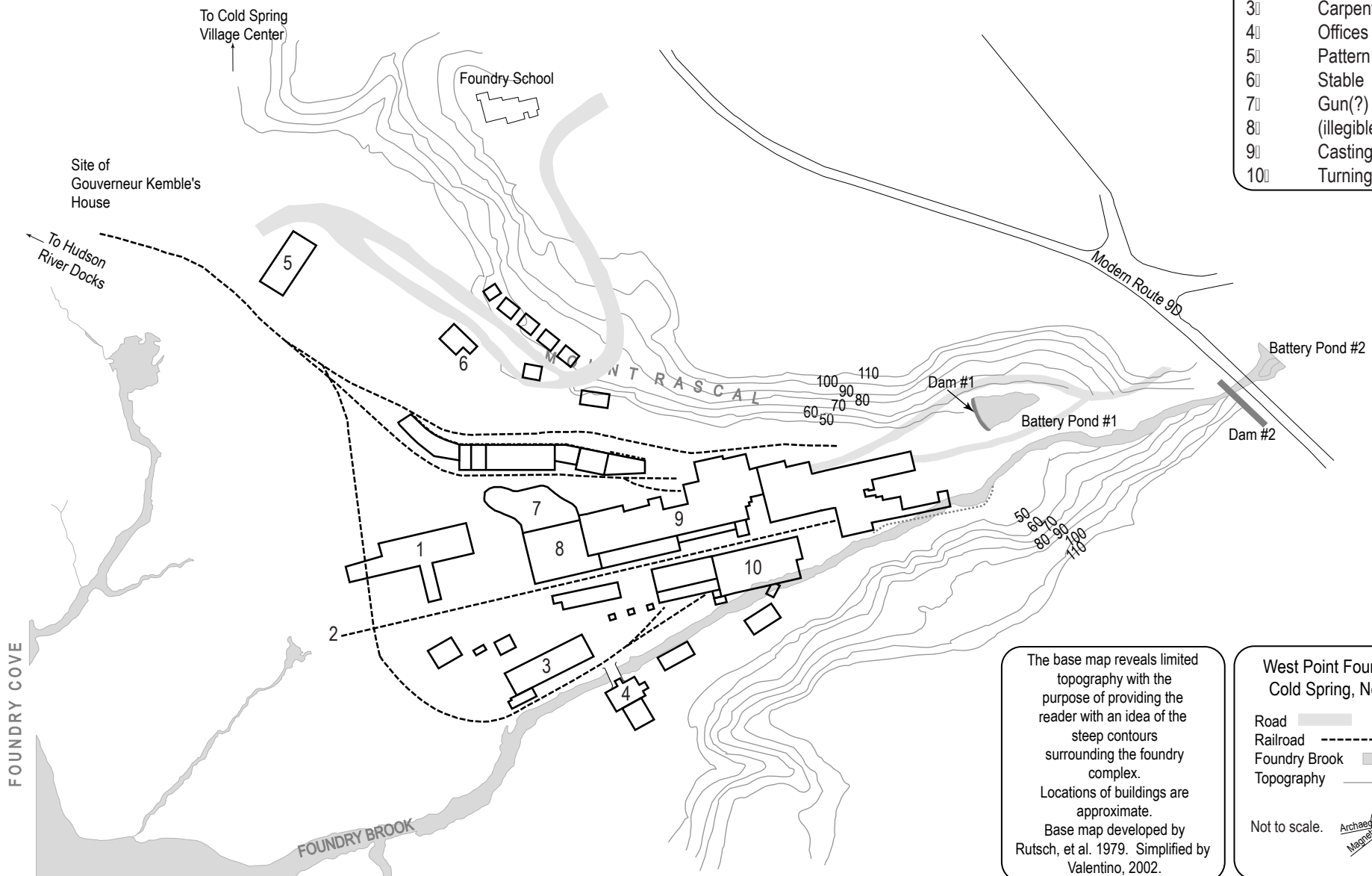
West Point Foundry Site
Cold Spring, New York

Road ———
Railroad - - - - -
Foundry Brook ———
Topography ———

Not to scale. Archaeological Magnet

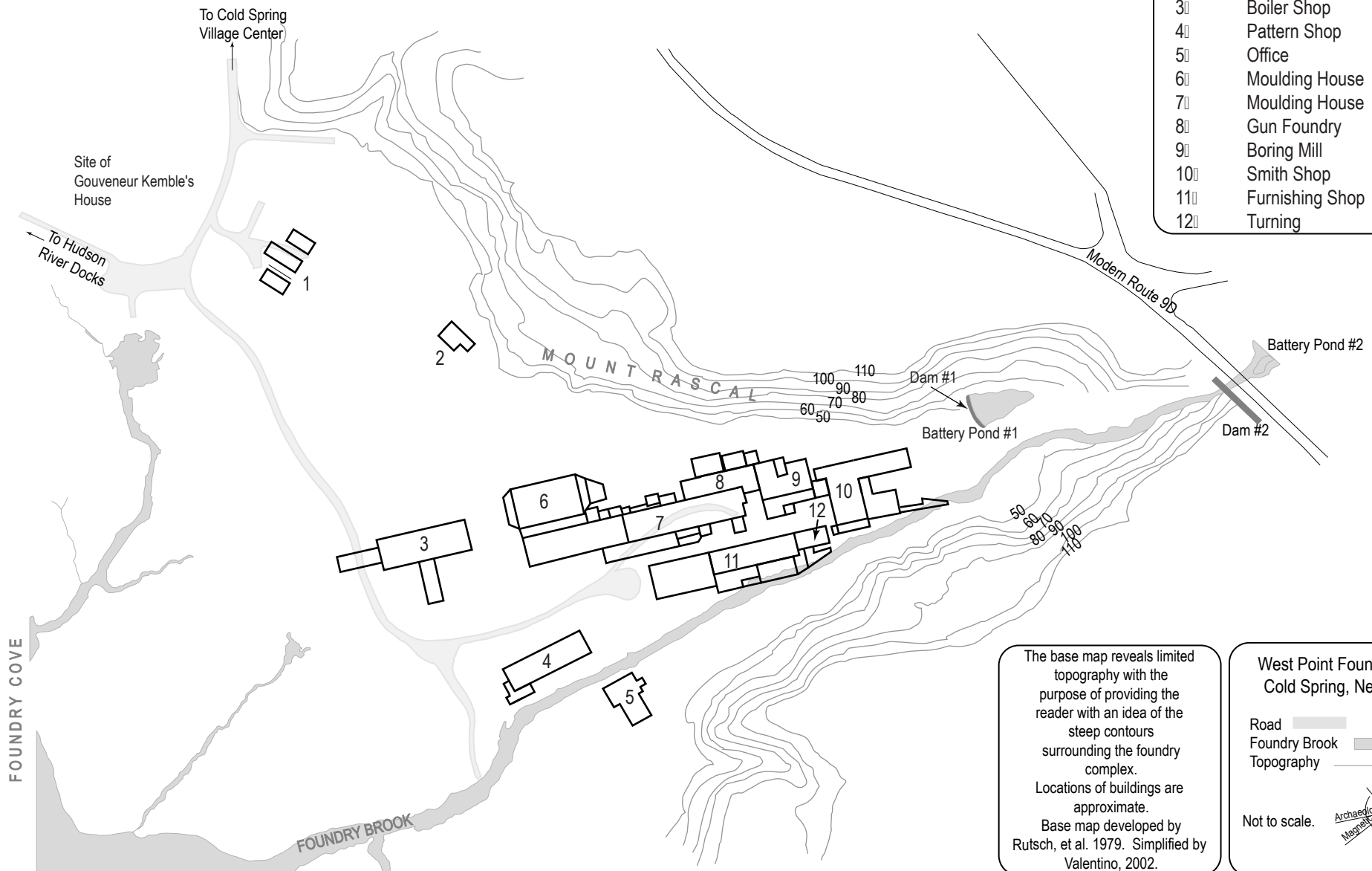
West Point Foundry site-1867 according to Beers map

No.	Map Period Name
1	Boiler Shop
2	Testing (illegible)
3	Carpenter Shop
4	Offices
5	Pattern Houses
6	Stable
7	Gun(?) Shop
8	(illegible)
9	Casting Shop
10	Turning Shop






West Point Foundry site-1872 according to Scofield map

No.	Map Period Name
1	Storage Houses for Pattern
2	Barn
3	Boiler Shop
4	Pattern Shop
5	Office
6	Moulding House
7	Moulding House
8	Gun Foundry
9	Boring Mill
10	Smith Shop
11	Furnishing Shop
12	Turning



The base map reveals limited topography with the purpose of providing the reader with an idea of the steep contours surrounding the foundry complex. Locations of buildings are approximate. Base map developed by Rutsch, et al. 1979. Simplified by Valentino, 2002.

West Point Foundry Site Cold Spring, New York

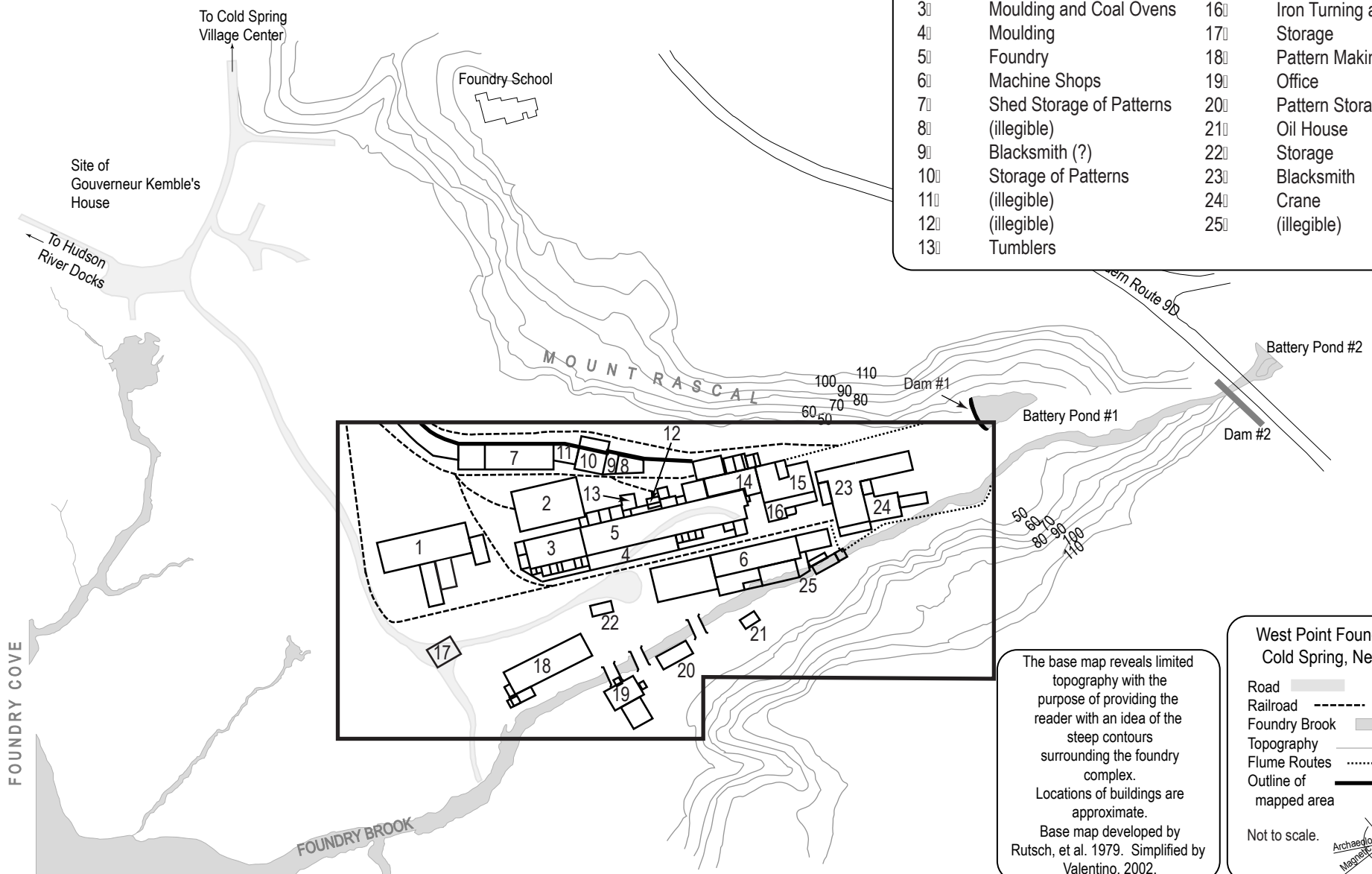
Road 
Foundry Brook 
Topography 

Not to scale.

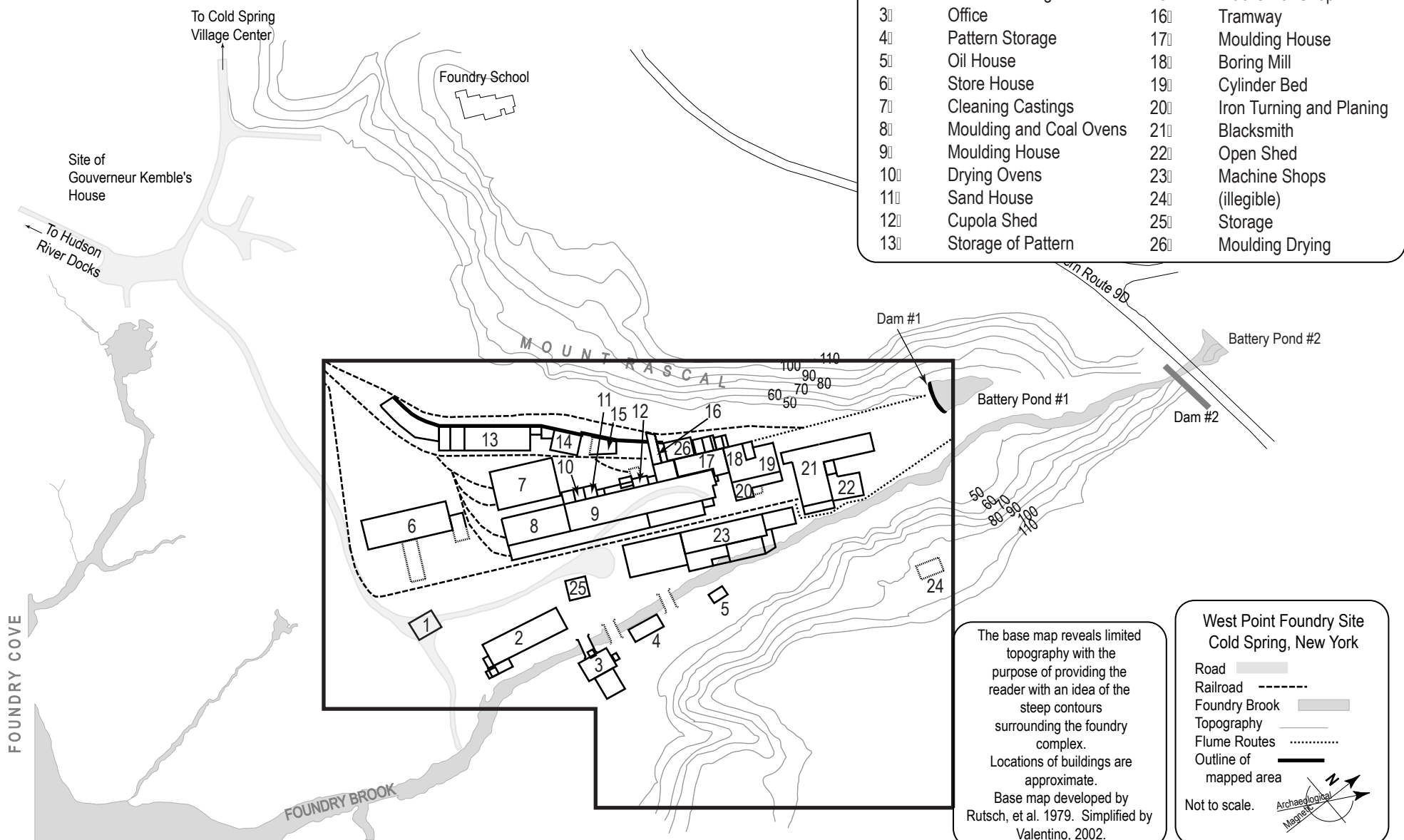


West Point Foundry site-1887 according to Sanborn map

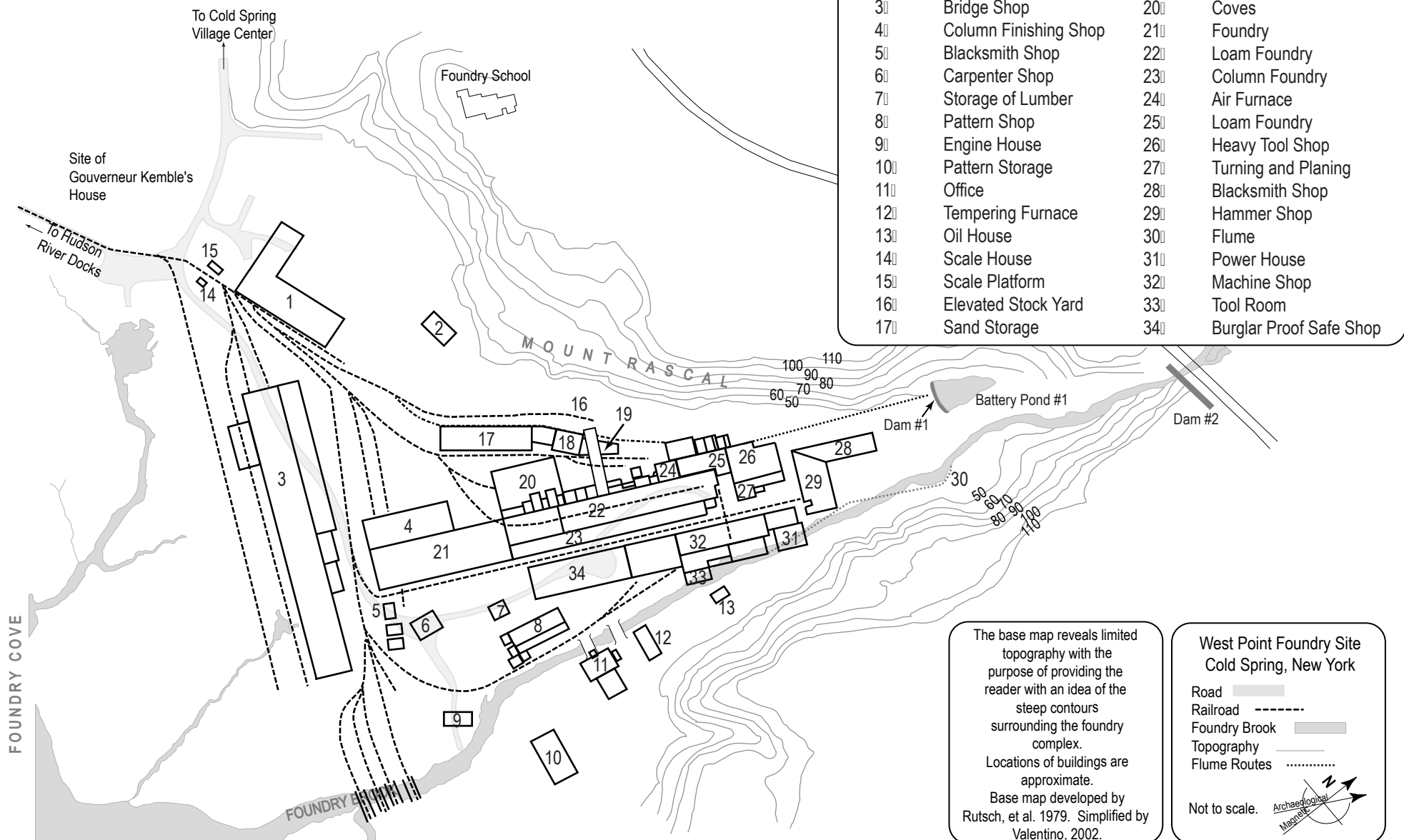
No.	Map Period Name	No.	Map Period Name
1	Boiler Shop	14	Cranes
2	Cleaning Castings	15	Gun Boring
3	Moulding and Coal Ovens	16	Iron Turning and Planing
4	Moulding	17	Storage
5	Foundry	18	Pattern Making
6	Machine Shops	19	Office
7	Shed Storage of Patterns	20	Pattern Storage
8	(illegible)	21	Oil House
9	Blacksmith (?)	22	Storage
10	Storage of Patterns	23	Blacksmith
11	(illegible)	24	Crane
12	(illegible)	25	(illegible)
13	Tumblers		



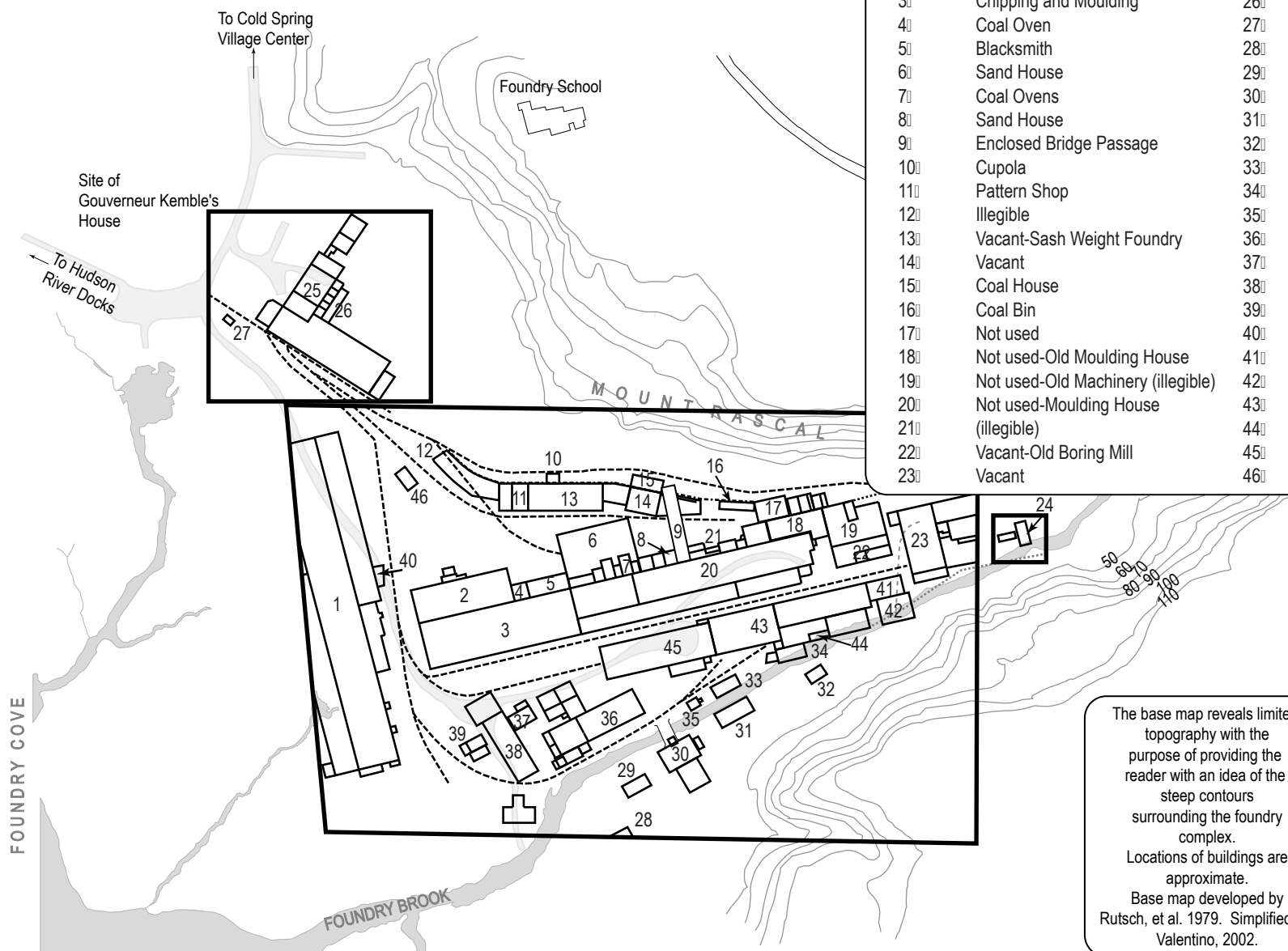
West Point Foundry site-1897 according to Sanborn map



West Point Foundry site circa 1900



West Point Foundry site-1912 according to Sanborn map



No.	Map Period Name	No.	Map Period Name
1	Bridge Shop	24	Coal Shed
2	Column House	25	Vacant-Dipping and Japanning Rooms
3	Chipping and Moulding	26	Vacant-Japan Ovens
4	Coal Oven	27	(illegible)
5	Blacksmith	28	Pattern Storage
6	Sand House	29	Laboratory
7	Coal Ovens	30	Office
8	Sand House	31	Pattern Storage
9	Enclosed Bridge Passage	32	Vacant
10	Cupola	33	Shed
11	Pattern Shop	34	Tool Room
12	Illegible	35	(illegible)
13	Vacant-Sash Weight Foundry	36	Not used-Pattern Storage
14	Vacant	37	Not used-Carpenter
15	Coal House	38	Not used-Template Shop
16	Coal Bin	39	Storage
17	Not used	40	Bolt Shop
18	Not used-Old Moulding House	41	Storage
19	Not used-Old Machinery (illegible)	42	Vacant
20	Not used-Moulding House	43	Machine Shop
21	(illegible)	44	Storage
22	Vacant-Old Boring Mill	45	Vacant
23	Vacant	46	Illegible

The base map reveals limited topography with the purpose of providing the reader with an idea of the steep contours surrounding the foundry complex. Locations of buildings are approximate. Base map developed by Rutsch, et al. 1979. Simplified by Valentino, 2002.

West Point Foundry Site Cold Spring, New York

Road

Railroad

Foundry Brook

Topography

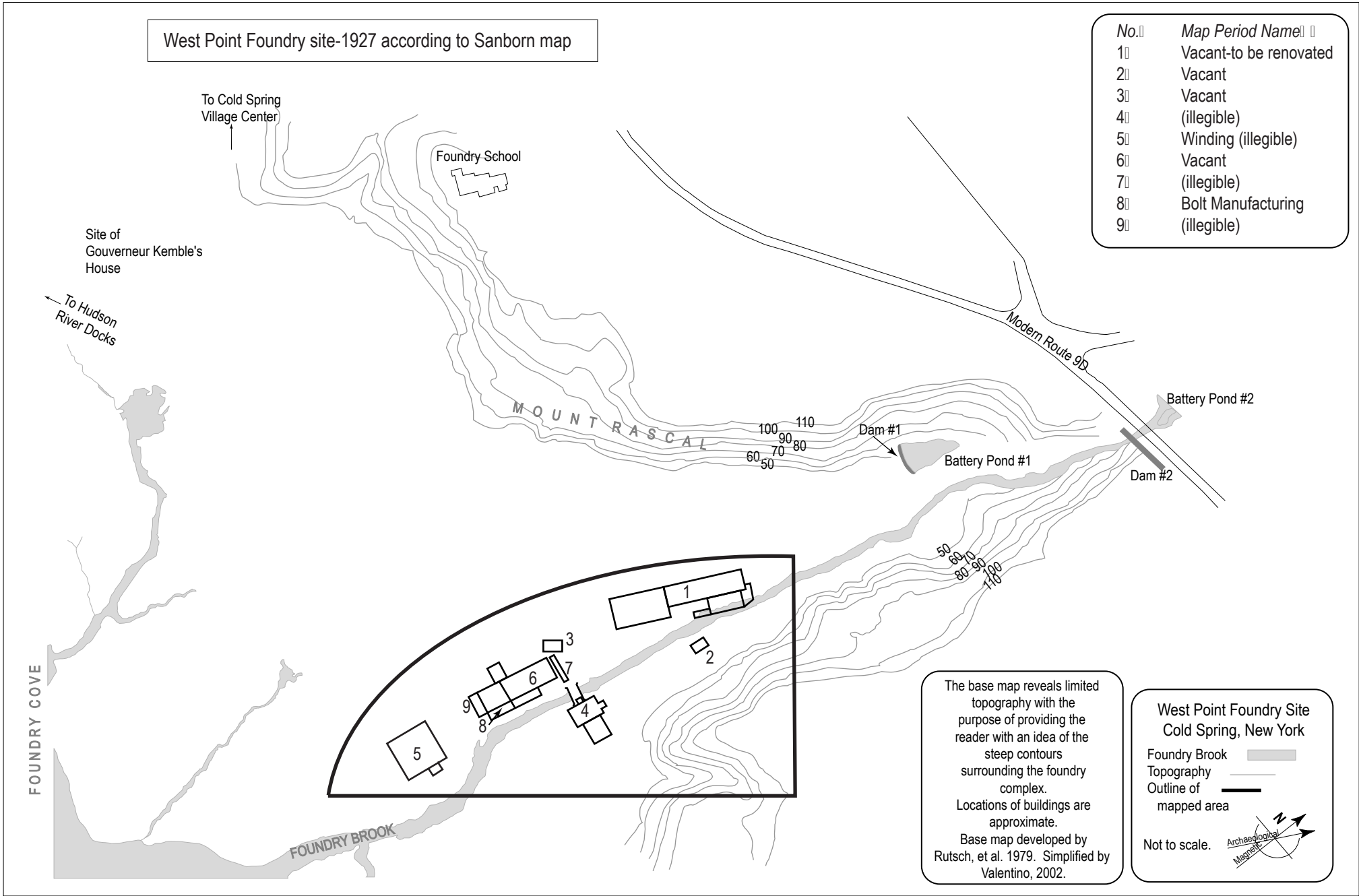
Flume Routes

Outline of mapped area

Not to scale.

West Point Foundry site-1927 according to Sanborn map

No.	Map Period Name
1	Vacant-to be renovated
2	Vacant
3	Vacant
4	(illegible)
5	Winding (illegible)
6	Vacant
7	(illegible)
8	Bolt Manufacturing
9	(illegible)



The base map reveals limited topography with the purpose of providing the reader with an idea of the steep contours surrounding the foundry complex. Locations of buildings are approximate. Base map developed by Rutsch, et al. 1979. Simplified by Valentino, 2002.

West Point Foundry Site
Cold Spring, New York

Foundry Brook
Topography
Outline of mapped area

Not to scale. Archaeological Magnetic

Appendix B
The 2003 Historic Artifact Catalog

WPF 2003 Historic Artifact Catalog - Unit 4A

Catalogue No.	Unit	Level	Artifact Group	Artifact Subgroup	No.	Artifact Characteristics
03-02-4A-1	4A	1	Kitchen	Bottle Glass	2	Clear fragments; 10grams
				Wine/Liquor Glass	1	<1gram
			Architecture	Window Glass	19	27grams
				Machine Cut Nails	5	3 large nails between 15-20cm long
				Wrought Nails	2	
				Slate	2	96grams; 1 saved
				Brick Fragments	1	
				Wood Samples	3	1 is a piece of board
			Activities	Coal/Charcoal	8	Coal fragments
				Other	26	1 iron washer
						1 iron coil
						18 iron shavings (8 saved)
						2 iron wedges; 1 is
						311 grams
						62 pieces iron conglomerate (wheel pit lining); 2090grams; 6 saved
						1 piece of copper
						Total Level 1: 69

Total Unit 4A: 69

WPF 2003 Historic Artifact Catalog - Unit 4B

Catalogue No.	Unit	Level	Artifact Group	Artifact Subgroup	No.	Artifact Characteristics
03-02-4B-1	4B	1	Kitchen	Ceramics	1	Fragment; 4grams. White, glazed. Probably electrical insulator fragment.
				Bottle	11	Clear fragments; 7 saved; 33 grams
			Architecture	Window Glass	284	Fragments; 558grams
				Modern Nails	6	
				Machine Cut Nails	11	
				Wrought Nails	16	
				Slate	7	Fragments; 6 saved
				Brick Fragments	13	7 saved
				Wood Samples	16	6 saved
				Mortar Fragments	7	1 saved
			Activities	Fishing/Hunting	1	Iron fish hook
				Coal/Charcoal	28	Coal fragments; 18 saved
				Sheet Iron	3	
				Iron Scrap	7	Fragments
				Other	86	1 Brazing Rod
						1 Iron Shaving
						73 iron conglomerate fragments
						2 iron washers
						1 wire
						1 iron spike
						3 electrical fittings
						2 lead fragments
						1 iron bolt fragment
						1 iron pipe connector; 2 male ends
						Total Level 1: 497

Catalogue No.	Unit	Level	Artifact Group	Artifact Subgroup	No.	Artifact Characteristics
03-02-4B-2	4B	2	Kitchen	Ceramics	1	Fragment; white glazed. Probably electrical insulator fragment.
				Wine/Liquor	1	Fragment
			Architecture	Window Glass	30	Fragments; 162grams
				Modern Nails	1	
				Machine Cut Nails	10	
				Wrought Nails	14	
				Slate	4	35 grams
				Brick Fragments	8	Not saved
				Wood Samples	5	
				Other	3	Granite fragments
			Tobacco	Bowls	1	Intact pipe bowl. No markings. 19th Century.
			Activities	Coal/Charcoal	17	Coal pieces
				Sheet Iron	3	
				Iron Scrap	3	
				Other	13	1 wire
						9 iron conglomerate fragments
						2 iron bolts (1 square, 1 round)
						1 iron spike
			Other	Bone/Shell	1	Bone fragment
						Total Level 2: 115

Catalogue No.	Unit	Level	Artifact Group	Artifact Subgroup	No.	Artifact Characteristics
03-02-4B-3	4B	3	Kitchen	Ceramics	2	Fragments; white glazed; 2 grams; possible insulator fragments
				Bottle Glass	1	Fragment; pinkish hue, slightly curved; c.4cm thick
			Architecture	Window Glass	33	175grams
				Modern Nails	3	1 is 5cm long; 2 are 7-8cm long
				Machine Cut Nails	14	3 are 15cm long; 3 are 11cm; 8 are 3-5cm long
				Wrought Nails	7	2 are 11cm long; 5 are 3-5cm long
				Unidentified Nails	15	
				Slate	7	23 grams; 5 pieces saved
				Brick Fragments	21	3 saved
				Wood Samples	33	12 saved
				Mortar Fragments	4	No samples saved
				Asphalt	2	Glob of melted asphalt
			Clothing	Other	1	Clothing snap
			Activities	Coal/Charcoal	12	Coal; 4 saved
				Iron Fragments	7	
				Sheet Iron	3	1 small piece discarded; 2 large sheets (32x26cm) saved
				Lead	3	178grams; 0.6cm thick
				Other	85	3 strips of leather
						2 pieces of brazing rod
						2 iron spikes
						2 threaded bolts
						70 fragments of iron conglomerate (4 saved)
						1 iron nut
						3 iron washers; 2 are round; 1 is square (8x9cm)
						1 piece of bar iron (346grams)
						1 skeleton key; teeth are missing (Tracing on artifact card)
			Other	Nut Shell	1	
						Total Level 3: 254

Catalogue No.	Unit	Level	Artifact Group	Artifact Subgroup	No.	Artifact Characteristics
03-02-4B-4	4B	4	Architecture	Window Glass	48	12 saved; 91 grams
				Modern Nails	1	
				Machine Cut Nails	9	1 is 21cm long; 1 is 18 cm; 3 are 15cm; 1 is 11cm; 1 is 12cm, 2 are 5cm long
				Wrought Nails	1	5cm long
				Unidentified Nails	3	Not saved
				Brick Fragments	9	Not saved
				Wood Samples	6	1 saved
			Activities	Coal/Charcoal	1	Coal fragment
				Other	22	1 metal spring
						1 lead splatter
						20 iron conglomerate fragments
			Total Level 4: 100			

Total Unit 4B: 966

WPF 2003 Historic Artifact Catalog - Unit 4C

Catalogue No.	Unit	Level	Artifact Group	Artifact Subgroup	No.	Artifact Characteristics
03-02-4C-1	4C	1	Architecture	Modern Nails	1	
				Machine Cut Nails	2	
				Wrought Nails	4	
				Unidentified Nails	4	Not saved
				Slate	4	318grams
				Brick Fragments	24	Not saved
				Mortar Fragments	7	
				Other	2	Asphalt Fragments
			Activities	Coal/Charcoal	8	Coal fragments
				Lead	1	
				Other	41	2 iron washers; 5.5cm and 5.9cm diameter
						14 coke fragments
						2 pieces bar iron;1 is 23x7cm and 1.2cm thick; 1 is 14.5x2.5cm and 9mm thick
					23 fragments of iron conglomerate (not saved)	
			Total Level One: 98			

Catalogue No.	Unit	Level	Artifact Group	Artifact Subgroup	No.	Artifact Characteristics
03-02-4C-2	4C	2	Architecture	Window Glass	7	7grams, 1 saved
				Modern Nails	12	
				Machine Cut Nails	3	
				Wrought Nails	6	
				Unidentified Nails	4	
				Slate	1	2 grams
				Brick Fragments	9	1 saved
				Mortar Fragments	6	Not saved
			Activities	Slag	2	
				Sheet Iron	2	
				Other	59	1 Iron washer 30 Iron conglomerate fragments (not saved) 28 pieces of coke
Total Level Two: 111						

Catalogue No.	Unit	Level	Artifact Group	Artifact Subgroup	No.	Artifact Characteristics
03-02-4C-3	4C	3	Architecture	Modern Nails	2	
				Slate	5	52grams
				Brick Fragments	4	Not saved
				Mortar Fragments	3	Not saved
			Activities	Coal/Charcoal	2	Coal fragments
				Sheet Iron	1	
				Iron Scrap	1	
				Other	11	2 coke fragments
						1 iron spike
						1 bolt
				6 iron conglomerate fragments		
				1 modern screw		
Total Level Three: 29						

Total Unit 4C: 238

WPF 2003 Historic Artifact Catalog - Unit 4D

Catalogue No.	Unit	Level	Artifact Group	Artifact Subgroup	No.	Artifact Characteristics
03-02-4D-1	4D	1	Architecture	Window Glass	2	4 grams
				Machine Cut Nails	3	
			Activities	Sheet Iron	1	46 grams
				Iron Scrap	5	Not saved
				Other	1	Iron Shaving (boring waste)
Total Level One: 12						

Catalogue No.	Unit	Level	Artifact Group	Artifact Subgroup	No.	Artifact Characteristics
03-02-4D-2	4D	2	Kitchen	Ceramics	1	12 grams; porcelain insulator fragment (round)
			Architecture	Window Glass	82	Size: 5x2cm to 1x1cm; 0.3 to 0.1cm thick; 106grams; 14 saved
				Modern Nails	1	
				Machine Cut Nails	6	
				Wrought Nails	9	
				Slate	1	5 grams
				Other	10	Asphalt fragments; 3 saved
			Activities	Slag	1	
				Sheet Iron	5	3 saved
				Other	42	1 piece coke
						1 iron wedge; 128grams
						1 piece bar iron; 100grams
					1 iron washer; 7x7cm	
					1 iron shaving (boring waste)	
		37 iron conglomerate fragments (none saved)				
Total Level Two: 158						

Catalogue No.	Unit	Level	Artifact Group	Artifact Subgroup	No.	Artifact Characteristics
03-02-4D-3	4D	3	Kitchen	Ceramics	4	13grams; insulator fragments; porcelain; round
			Architecture	Window Glass	99	117grams; 11 saved
			Modern Nails	14	2 are c.7cm long; 3 are c. 6cm long	
			Machine Cut Nails	20	7 are c.11cm long; 4 are c.8cm long	
			Wrought Nails	21	1 is c.8.5cm long with asphalt on head	
			Unidentified Nails	12	Not saved	
			Brick Fragments	1	Not saved	
			Wood Samples	5	2 saved	
			Other	10	Asphalt fragments	
			Activities	Coal/Charcoal	11	11 coal fragments
			Sheet Iron	10		
			Iron Scrap	5	1174grams; fragments range from 3x3cm to 9x5cm and 356grams to 34grams; 3 saved	
			Other	124	1 Iron screw	
					9 Coke fragments	
					60 iron shavings (boring waste); 8 saved	
					40 Iron conglomerate fragments (none saved)	
					1 piece of bar iron, 487grams	
					2 iron pipe fragments; 1cm diameter and 17cm long; other fragment is 3cm long	
					3 iron bolts	
					5 washers; 1 is 7.5x7.5cm; 1 is 5.5x5.5cm (both are cut on one side); 3 are 4.5x4.5cm	
					2 nuts	
					1 wrought iron ring; 5cm diameter, not threaded	
			Total Level Three: 336			

Catalogue No.	Unit	Level	Artifact Group	Artifact Subgroup	No.	Artifact Characteristics
03-02-4D-4	4D	4	Architecture	Window Glass	14	26grams; 4 saved
				Modern Nails	1	
				Machine Cut Nails	15	5 are 11.5cm long; 7 are 8cm long
				Wrought Nails	7	4 are 8cm long
				Wood Samples	3	
				Mortar Fragments	1	
			Tobacco	Stems	1	Pipe stem fragment
			Clothing	Other	1	Metal Snap
			Activities	Coal/Charcoal	7	Coal fragments, 1 saved
				Sheet Iron	1	
				Other	66	1 metal fragment (rim)
						1 iron spike/wedge
						6 iron washers
						2 iron nuts
				7 iron conglomerate fragments		
Total Level Four: 117						

Catalogue No.	Unit	Level	Artifact Group	Artifact Subgroup	No.	Artifact Characteristics
03-02-4D-5	4D	5	Architecture	Window Glass	19	17grams; not saved
				Modern Nails	1	
				Machine Cut Nails	28	
				Wrought Nails	2	
				Unidentified Nails	761	2383grams; 14 saved. These are from a dark stain in the west wall of 4D. The stain was surrounded by sand. The nails are approximately 3cm long and are very corroded
				Other	2	Asphalt fragments, not saved
			Clothing	Other	10	leather; 1 piece c.6.3cm wide, 7.2cm long on one side and 6.2cm long on the other. Two rivets at each corner and two more spaced c.2.3cm apart. Leather piece is c. 7mm thick.
			Activities	Coal/Charcoal	2	Coal fragments
				Slag	1	
				Sheet Iron	2	
				Iron Scrap	7	
				Other	85	1 iron nut 1 iron bolt 4 iron washers 40 iron conglomerate fragments; 1 saved 39 iron shavings (boring waste); 9 saved
						Total Level Five: 920

Catalogue No.	Unit	Level	Artifact Group	Artifact Subgroup	No.	Artifact Characteristics
03-02-4D-6	4D	6	Architecture	Window Glass	23	56grams; 6 saved
				Machine Cut Nails	3	
				Wrought Nails	3	
				Unidentified Nails	26	Not saved
				Brick Fragments	1	Not saved
				Mortar Fragments	6	Not saved
			Activities	Sheet Iron	3	
				Other	29	8 Metal shavings (boring waste); 3 saved 21 iron conglomerate fragments; not saved
			Other	Bone/Shell	1	Bone
						Total Level Six: 95

Catalogue No.	Unit	Level	Artifact Group	Artifact Subgroup	No.	Artifact Characteristics
03-02-4D-7	4D	7	Architecture	Window Glass	44	81grams; 10 saved
				Machine Cut Nails	1	
				Unidentified Nails	77	Not saved
				Slate	1	
			Activities	Coal/Charcoal	1	Charcoal fragment
				Sheet Iron	14	Fragments, not saved
				Other	21	1 piece of coke 18 iron conglomerate fragments 2 iron shavings (boring waste)
			Other	Bone/Shell	3	2 bone fragments and one shell fragment
						Total Level Seven: 162

Catalogue No.	Unit	Level	Artifact Group	Artifact Subgroup	No.	Artifact Characteristics
03-02-4D-F8	4D	Feature 8	Architecture	Window Glass	1	<1gram; not saved
				Unidentified Nails	4	Not saved
			Activities	Other	4	Metal shavings (boring waste); not saved
						Total Feature Eight: 9

Catalogue No.	Unit	Level	Artifact Group	Artifact Subgroup	No.	Artifact Characteristics
03-02-4D-Wall Scrape	4D	Wall Scrape	Architecture	Machine Cut Nails	1	
			Activities	Iron Scrap	1	
			Other		7	5 metal shavings (boring waste) 2 iron spikes
						Total Wall Scrape: 9

Total Unit 4D: 1818

WPF 2003 Historic Artifact Catalog - Unit 10A

Catalogue No.	Unit	Level	Artifact Group	Artifact Subgroup	No.	Artifact Characteristics
03-02-10A-1	10A	1	Kitchen	Ceramics	3	1 drain pipe fragment is brown, salt glazed, with a rounded lip that is 1.5cm wide. This fragment is 8.5x5cm long. 1 piece is a 6x4cm long and 0.5cm thick glazed earthenware fragment (orange peel texture on outside and smooth on inside) 1 piece is a ceramic insulator fragment; rounded white glazed
				Glassware	1	19grams; lip (rounded) with an aqua tint
			Architecture	Window Glass	7	
				Modern Nails	4	
				Machine Cut Nails	2	
				Wrought Nails	5	
			Clothing	Fabric	2	
			Activities	Tools	1	1 File; 32cm long
				Slag	4	2 saved; tap slag (glassy surface with bubbly interior)
				Sheet Iron	13	none saved
				Lead	1	
				Other	24	2 carbon brushes 12 metal wire pieces, range from 1mm to 4mm diameter 1 electrical wire fragment 2 brazing rod fragments 1 modern bolt (not saved) 2 iron spikes 2 nuts (one has a bowl on interior) 2 bolts
						Total Level One: 67

Catalogue No.	Unit	Level	Artifact Group	Artifact Subgroup	No.	Artifact Characteristics
03-02-10A-2	10A	2	Kitchen	Ceramics	3	2 fragments with blue glaze; 1 insulator fragment
			Architecture	Window Glass	6	26grams; 4 saved
				Modern Nails	3	
				Machine Cut Nails	1	
				Wrought Nails	2	
				Mortar Fragments	1	
			Clothing	Fabric	1	
				Other	1	Leather; 9.7cm long, 3.8cm wide, 1.8cm thick; has 3 puncture holes across the center (7cm diameter) and 2 round notches at the top.
			Activities	Sheet Iron	3	
				Iron Scrap	1	23.7 x 7 cm fragment
				Other	20	1 iron washer (7cm diameter)
						5 carbon brushes embedded in solidified tar
						3 iron shavings
						1 bolt
						1 brass electrical fitting
						1 large cast iron collar
						1 iron ring
						3 iron fragments (1 flat and sickle shaped)
						2 iron spikes
						2 pieces of wire (3mm and 2mm thick)
						Total Level Two: 42

Catalogue No.	Unit	Level	Artifact Group	Artifact Subgroup	No.	Artifact Characteristics
03-02-10A-3	10A	3	Kitchen	Ceramics	1	utility pipe fragment; brown, salt glazed.
			Architecture	Window Glass	1	8grams
				Modern Nails	2	
				Machine Cut Nails	3	
				Brick Fragments	1	Firebrick fragment
				Other	12	11 mica fragments
						1, 25.7cm long pipe with a spigot at one end
			Activities	Slag	1	
				Sheet Iron	1	
				Iron Scrap	7	
				Other	5	1 iron washer
						1 wire fragment
						1 iron wedge
		2 iron conglomerate fragments				
Total Level Three: 34						

Catalogue No.	Unit	Level	Artifact Group	Artifact Subgroup	No.	Artifact Characteristics
03-02-10A-4	10A	4	Kitchen	Ceramics	26	42grams; 25 late painted fragments; 1 insulator fragment
				Glassware	1	8grams; translucent blue with patenation
			Architecture	Window Glass	3	16grams
				Machine Cut Nails	1	
				Unidentified Nails	2	
				Other	3	1 asphalt fragment
					2	mica fragments
			Activities	Slag	2	
				Iron Scrap	4	1 saved
				Lead	1	
				Other	8	1 bolt
						1 nut
						2 carbon brushes
			Other		3	conglomerate fragments
						1 iron wedge; 473grams; nail embedded on one side, along with conglomerate
					3	Clay pieces; grey
					Total Level Four: 54	

Catalogue No.	Unit	Level	Artifact Group	Artifact Subgroup	No.	Artifact Characteristics
03-02-10A-Wall Scrape	10A	Wall Scrape	Kitchen	Bottle Glass	2	50grams; part of neck & body; blue tint; 0.04cm thick
			Architecture	Machine Cut Nails	2	
			Tobacco	Bowls	1	1/2 of pipe bowl with flute; T.D. with 13 stars
			Activities	Lead	1	275grams
				Other	10	1 iron shaving
						2 washers
						1lighting gas pipe fragment with brass cock
						1 wire
						1 electrical piece
						1 spigot
						1 iron hook; "s" shape, 28cm long
						1 iron gear tooth; 1018grams; 24cm long
1 iron spike, 31cm long						
Total 10A Wall Scrape: 16						

Total Unit 10A: 207

WPF 2003 Historic Artifact Catalog - Unit 15A

Catalogue No.	Unit	Level	Artifact Group	Artifact Subgroup	No.	Artifact Characteristics
03-02-15A-1	15A	1	Kitchen	Ceramics	5	12grams; 4 white, glazed insulator fragments. 1 fragment is creamwear.
				Glassware	1	30grams; baby-blue, translucent rim fragment that is 0.8cm thick;
				Bottle Glass	11	79grams; clear, 0.5cm thick fragments. Some contain red and white painted label "Cola". 1 fragment has a green tint (0.6cm thick)
				Beer Bottle Glass	8	10grams
			Architecture	Window Glass	60	113grams; 15 saved
				Modern Nails	12	
				Machine Cut Nails	2	
				Wrought Nails	3	
				Slate	3	81grams
				Brick Fragments	15	2 saved
				Door Hardware	1	Handle; 22x5cm, iron.
				Wood Samples	2	Doweling
				Mortar Fragments	18	2 saved
				Other	9	1 lightbulb filament (not saved)
						1 lightbulb base (not saved)
						2 fragments lightbulb glass (not saved)
						3 pieces of mica (semi-circle)
						1 asphalt fragment (not saved)
					1 masonry anchor (half of one)	
			Clothing	Fabric	6	
			Activities	Coal/Charcoal	15	Charcoal fragments
				Slag	44	4 saved
				Sheet Iron	8	
				Iron Scrap	10	
				Copper	2	
				Other	78	2 thermometer fragments
						1 rope fragment
						2 hinges
						4 wrought rings
						2 iron spike fragments
						4 washers; one is 20x20cm with 3cm diameter hole
						4 nuts
						8 bolts
						1 iron pin
						4 iron rods
						19 screws
						2 pipe fittings
						3 pieces of iron strapping
						2 iron handles
						1 electrical wire fragment with covering (not saved)
						1 iron fastener with bolt
						6 pipe fragments
						1 Coke Fragment
						1, 4cm diameter & 1cm thick carbon ring
						1 iron base for tie rod (20x20cm)
						1 small iron collar
						1 iron object with pin hole
						1 iron strap with an elaborate "u" shaped piece on one end. Artifact looks like an "h"
						1 cast iron washer for tie bolt/rod
						1 metal cap
						1 iron hanger
						3 unidentified fragments
			Other	Bone/Shell	1	Bone Fragment
				Modern	1	Plastic
						Total Level One: 315

Catalogue No.	Unit	Level	Artifact Group	Artifact Subgroup	No.	Artifact Characteristics
03-02-15A-F17	15A	F17	Architecture	Slate	1	125grams
				Brick Fragments	1	Not saved
				Mortar Fragments	4	Not saved
			Activities	Slag	2	
				Other	1	2.4cm long, threaded pipe fragment with a bolt going through the pipe at its bottom end (which is sealed)
Total Feature Seventeen: 9						

Total Unit 15A: 324

Catalogue No.	Unit	Level	Artifact Group	Artifact Subgroup	No.	Artifact Characteristics
03-02-STP1	STP1	n/a	Kitchen	Bottle Glass	1	2grams
			Architecture	Window Glass	2	
				Unidentified Nails	1	
				Mortar Fragments	1	
			Activities	Slag	2	
				Sheet Iron	9	None Saved
				Iron Scrap	24	None Saved
				Coal/Charcoal	1	Coal fragment
				Other	78	20 iron waste fragments; 2 pieces have a bolt with washer embedded (copper); all waste fragments are composed of iron with pebble inclusions; 3 saved
					6 iron straps	
					2 iron rods; 1 is c. 40cm long and 1.8cm diameter; other is c. 18cm long and 2.5cm diameter; other is c. 18cm long and 2.5cm diameter; 1 saved.	
				2 pieces of salt (8grams)		
				1 iron fragment (hammer head?)		
	47 coke pieces (21 saved)					
Total STP1: 119						

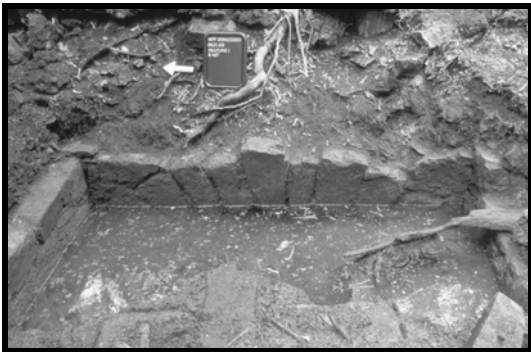
Appendix C

The 2003 Feature Database

2003 Feature Database

The following feature database illustrates and describes features recorded during the 2003 field season. Archaeologists identified Features Two, Five, Six, Seven, Seven-A, Nine, Ten, Eleven, Fourteen, and Fifteen during excavation at the 1865 office building, and as such are not included. Description of these features can be found in Finch 2003, "Excavation Report For The 1865 Office Building. West Point Foundry Archaeology Project."

Feature One



Catalogue Designation: 03-02-4A-F1

Description: Stone arch entrance to the tailrace, NE boring mill corner

Recorded by: Kim Finch, 06-03-03

Photographer: Mike Deegan

Feature Three



Catalogue Designation: 03-02-F3

Description: Trench, masonry base, & iron pipe, SW blacksmith shop corner

Recorded by: Kim Finch, 06-09-03

Photographer: Mike Deegan

Feature Four

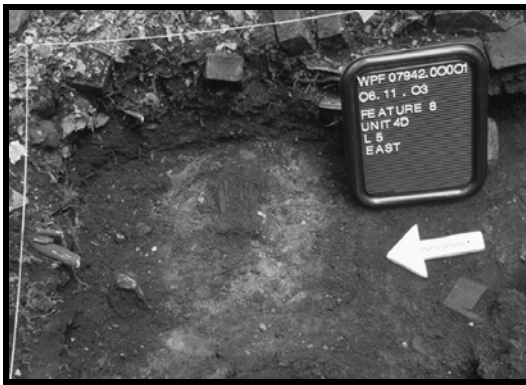


Catalogue Designation: 03-02-4D-F4

Description: Possible coursed brick machinebase. Unit 4D, turning and planing shop.

Recorded by: Kim Finch, 06-09-03

Feature Eight



Catalogue Designation: 03-02-4D-F8

Description: Sandy lens within Unit 4D, level 5.

Recorded by: Kim Finch, 06-11-03

Photographer: Mike Deegan

Feature Twelve



Catalogue Designation: 03-02-4B-F12

Description: Circular, stone-lined pit that incorporates unit 4B. Possible vertical boring pit.

Recorded by: Kim Finch, 06-15-03

Photographer: Joe Wilson

Feature Thirteen



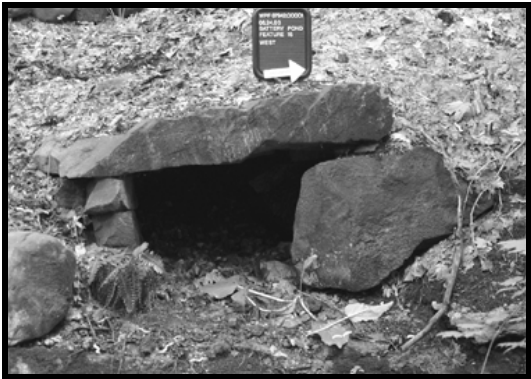
Catalogue Designation: 03-02-F13

Description: Square, stone-lined pit, E of site baseline within machine shop complex

Recorded by: Kim Finch, 03-17-03

Photographer: Steve Ftaclas

Feature Sixteen



Catalogue Designation: 03-02-F16

Description: Exit of stone drain, west bank Foundry Brook

Recorded by: Kim Finch, 06-20-03

Photographer: Rachel Herzberg

Feature Seventeen



Catalogue Designation: 03-02-15A-F17

Description: Sand-mortar lens and brick wall. North wall, unit 15A.

Recorded by: Kim Finch, 06-23-03

Photographer: Mike Deegan

Feature Eighteen



Catalogue Designation: 03-02-10A-F18

Description: Coal cinder lens. Northern 1/3 of unit 10A

Recorded by: Kim Finch, 06-24-03

Photographer: Pat Baird

Feature Nineteen

Photo not available. Refer to Figure 6-2.

Catalogue Designation: 03-02-F19

Description: Tailrace from furnace to Foundry Brook

Recorded by: Kim Finch, 06-25-03

Feature Twenty



Catalogue Designation: 03-02-F20

Description: Welling water and surrounding structure in Foundry Brook, E. of the boiler house. Photo: looking east, showing brick structure to the west.

Recorded by: Kim Finch, 06-25-03

Photographer: Kim Finch

Feature Twenty-One

Photo not available.

Catalogue Designation: 03-02-F21

Description: Subsurface stone drain N. of Feature 16. Similar construction as Feature 16, but slightly smaller. Chamber goes west for about 20-30 feet.

Recorded by: Kim Finch, 06-25-03

Feature Twenty-Two



Catalogue Designation: 03-02-F22

Description: Drain hole, STP1, iron pipe outlet S. of Battery Pond. Photo: planview of STP1.

Recorded by: Kim Finch, 06-19-03

Photographer: Kim Finch

Refer to Figure 6-5 for a planview of this entire area.
