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BRINGING VANISHED LANDSCAPES TO THE SURFACE:
A MULTI-TOOL APPROACH TO UNEARTHING
CHARLESTON'S WALLED CITY

A Thesis
Presented to
the Graduate School of
Clemson University

In Partial Fulfillment
of the Requirements for the Degree
Master of Science
Historic Preservation

by
Alexis Sue Allen
August 2023

Accepted by:
Dr. Jon Marcoux, Committee Chair
Katherine Pemberton
Craig Bennett
Martha Zierden

ABSTRACT

The early 18th century historic fortification system that surrounded the urban town of Charleston has been a focus of excavations and historical research within the past two decades. However, while the outline of early Charleston's walled city is hypothesized through the analysis of historic maps and plats, very few fortification locations have been visually confirmed. In order to determine their accuracy, this thesis georeferenced eleven historic maps and four plats to the modern landscape. As a result, possible locations of Charleston's walled city were predicted. These were surveyed as test sites and remote sensing methods were employed that helped confirm or deny each hypothesis. After an analysis of georeferencing and ground penetrating radar results, the surveys of portions of the historic fortification system that was once made of earth and entrenchments were unable to identify with confidence any remaining features. However, the location of the brick-made curtain line on East Bay Street near South Adger's Wharf and near South Market Street was identified, as well as a segment of the northern parapet wall of Craven's Bastion located today under the United States Custom House.

DEDICATION

This thesis is dedicated to my mother, Jennifer Allen, my fiancé, Jack Pashby, my best friend, Mackenzie Richards, and my classmate, Jacquelyn Nahman. These four individuals encouraged and supported me even during the toughest moments. I will forever be thankful they are in my life.

ACKNOWLEDGMENTS

It should be noted that this thesis would not have been possible without the previous work of the Mayor's Walled City Task Force. This includes years of research by Nic Butler, previous GPR surveys by Jon Marcoux, archaeology excavations by Martha Zierden, the leadership of Katherine Saunders Pemberton in her role as Chair of the Walled City Task Force since 2005, and the work of countless others provided a background for this thesis to even begin. Guidance and advice from these individuals allowed this thesis to flourish and be completed.

An additional thank you is warranted to Craig Bennett of Bennett Preservation Engineering, PC. Not only was he consistently positive, motivating, and inspiring, but he included me on his contracting work with the U.S. Custom House and General Service Administration. A confident analysis and conclusion of the location of Craven's Bastion would not have been possible without Craig Bennett and his company.

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CHAPTER ONE

INTRODUCTION

English colonists erected a fortification system around Charles Town¹ (now Charleston) through the work of slave labor beginning in the late 17th and continuing into the early 18th century as a defense mechanism against potential French and Spanish attacks. Now dubbed the walled city of Charleston, it has been a focus of recent excavations and historical research within the past two decades. However, while the outline of this colonial fortification is hypothesized through the analysis of historic maps and plats, very few locations have been confirmed. In order to determine their accuracy, this thesis georeferenced relevant historic maps and plats to the modern landscape. As a result, possible locations of Charleston's colonial fortifications were identified and tested using remote sensing methods that helped confirm or deny each hypothesis.

The construction of the city's earliest defenses was a consequence of the wars between England, France, and Spain. In response to their fears, South Carolina legislatures passed an act on December 23rd, 1703, to assemble a fortification wall that would function as an entire enclosure of the sixty-two acre town, an *enceinte* system. This protected urban Charles Town not only against future attacks, but consequently, it also prevented adequate growth of the town until it was removed.²

The assembly of much of the fortification system was an emergency response made of cheap and easily accessible materials that was not intended to last very long. On

¹ Depending on the map, it is written as Charles Town, Charlestown, or Charles-Town..

² Butler, Nic., 2022, "Creating a Walled City: The Charleston Enceinte of 1704".

the north, south, and west sides of the fortification system, the “wall” consisted of earthen entrenchments and ditches. In sharp contrast, the waterfront edge of the city located to the east consisted of a half-mile masonry brick structure providing a more permanent and sturdier naval defense.³ The entire enclosure consisted of the earthen entrenchments with bastions, redans, and a drawbridge and the masonry fortification line on the east, consisting of a curtain wall with bastions, redans, and a half-moon battery.⁴

Historical accounts found by historian Nic Butler describe the eastern brick wall as a “wharf wall” or “front wall” in relation to its location on the Cooper River waterfront, now called East Bay Street. It was eventually denoted as a “curtain line” in the 1720s; “that is, a linear feature forming a defensive link between a series of gun batteries”⁵. The eastern brick wall consisted of a total of six gun batteries which split the wharf wall into five individual curtain lines. This was important as an attack would most likely have come by sea instead of land. Butler hypothesizes the brick curtain line had a height of about six feet above street level, while the earthen walls were approximately eight feet tall.

Today, it is difficult to discover these fortification walls as the earthen walls were dismantled and the entrenchments were filled in in the early to mid-18th century, perhaps around the year 1732.⁶ This allowed the town’s urban center to be expanded, but other fortification methods still were implemented on the new north, south, and west boundaries until the end of the American Revolutionary War. The eastern brick wall was

³ Ibid.

⁴ Butler, Nic, 2015, “Johnson’s Ravelin: Charleston’s First Town Gate”.

⁵ Butler, Nic, 2023, “Searching for the Curtain Wall of Charleston’s Colonial Waterfront”.

⁶ Butler, Nic., 2022, “Creating a Walled City: The Charleston Enceinte of 1704”.

the last portion to be demolished and survived into the 1780s when it was then leveled to street level and the brick outworks auctioned off to the public.⁷ This was the result of Charleston's now goal to demilitarize the town's urban center. However, the lower half of the brick wall remained under the street surface⁸. Due to this later demolition, historic maps and plats included drawings of the eastern masonry fortifications up to the 1780's. Maps or plats with any portion of the walls depicted past this decade were also created after the destruction of the entire fortification system.

This thesis takes on the task of tracing this *enceinte* system through the use of historic map analysis in conjunction with ground truthing methods. Previous historical research conducted by historian Nic Butler with the Charleston County Library and research and archaeological investigations and documentation by the Mayor's Walled City Task Force (established in 2005) has resulted in a few known locations of the wall—mostly on the eastern side of the peninsula.

A portion of the Half-Moon Battery at the intersection of East Bay Street and Broad Street underneath the Old Exchange Building has been excavated and is open for visitors to view. Additional archeological excavations from 2008-2009 at East Bay Street and South Adger's Wharf resulted in the visual confirmation of the redan that once sat at that location. These sources will be referenced throughout this thesis using GIS, a database that uses geographical data to help conceptualize spatial information on subsequently created maps.⁹ Already known locations of the walled city were input into

⁷Butler, Nic, 2018, "Demilitarizing Urban Charleston, 1783–1789".

⁸Butler, Nic. 2023, "Searching for the Curtain Wall of Charleston's Colonial Waterfront".

⁹ "What is GIS?", Esri.

ArcGIS, a software that can visually place these points on the modern urban landscape of the Charleston peninsula.

Collected GIS locations of the colonial fortifications can be compared to maps without a known spatial reference system to determine the accuracy and validity of historic maps. Historic maps that include the outline of the fortification include: Charles “Blaskowitz Map” of 1780, Edward “Crisp Map” of 1711, the Sir Henry “Clinton Map” of 1780, the Albert “Halsey Map”, the John “Herbert Map” of 1721, *the Ichnography of Charles-Town at High Water* Map of 1739, the *Ichnography of Charleston at High Water* Map of 1788, *Investiture of Charleston* of 1780, the *Plan de la Ville de Charlestown* Map of 1780, the *Port of Charlestown Map* from 1764, and the George “Taylor Map” of 1780. The result of the analysis of these maps against known locations of the walled city fortifications allows for the forecast or prediction of other, unknown sites that can be tested through the employment of ground truthing methods. Ground truthing is a common practice of verifying hypotheses through visual inspection and remote-sensing data. For the purpose of this thesis, ground truthing will be conducted via Ground Penetrating Radar (GPR), a technology that sends high frequency radio waves to detect voids and irregularities underground¹⁰.

In summary, this thesis has two goals: one is that the utilization of all these tools will unearth locations of the destroyed walled city that once enveloped Charles Town in the early eighteenth century, and the second is developing and documenting a methodology for future investigation and analysis of historic maps using GIS data.

¹⁰ “What is GPR?”, GSSI Geophysical Survey System, Inc.

CHAPTER TWO

LITERATURE REVIEW

An integral part to georeferencing is using historic maps that have the greatest accuracy. Of course, this may not be known until the georeferencing process is undertaken but understanding the degree of error between historic maps without an established map coordinate system and modern, spatially referenced maps is a fundamental part of this thesis. Additionally, archival research including journals, newspaper articles, deeds, and plats can all aid in the mapping process. While digital technologies play integral roles in research methodologies today, it wasn't until 20 years ago that these systems started greatly aiding studies seeking to reconstruct historic landscapes. In this chapter, I characterize several recent studies that discuss different digital technologies, including Geographical Information Systems (GIS) and Ground Penetrating Radar (GPR). This discussion is divided into studies of historic cartography and studies that report on the use of remote sensing. I conclude with a discussion of past studies in Charleston to lay out how this thesis will help fill in unknown information regarding the accuracy of historic maps and locations of parts of the colonial-era walled city.

Historic Cartography and Georeferencing

There are many recent studies that utilize GIS software to conduct georeferencing analysis on historic maps. One of the greatest challenges of using this methodology to identify historic sites and features on the modern landscape is determining the degree of

error of both the software and the historic maps themselves. However, even with a certain degree of error, this research method can be essential to understanding vanished historic landscapes through its potential use as a predictive model.

There can be multiple sources of error in historic maps surveyed and published during this thesis' time frame of the 18th century. One study that endeavored to understand potential root causes of error in historic maps was conducted by Valerio Baiocchi and Keti Lelo and reported in their article "Georeferencing the Historical Maps of Rome between the Seventeenth and Eighteenth Centuries".¹¹ They undertook various projects that involved georeferencing historic maps of Rome and ultimately outlined five potential sources of error: deformations of the cartography either via their medium or problems with conservation, error of the historical survey, errors of aesthetic representations, contemporary error of interpretation, and contemporary mapping errors, since historic cartography often lacked a reference system. Even if a spatial reference system was included, it often will not correspond to modern coordinate systems.

Baiocchi and Lelo began by analyzing characteristics of each map, particularly focusing on iconographic two-dimensional representations. For the maps used in their study, corners of buildings that have not moved over time were used as control points. To measure the degree of observable error, they used first degree polynomial transformations of the control points¹². "[T]he mathematical equation used with a first-order transformation can exactly map each raster point to the target location"¹³. Therefore, a

¹¹ Baiocchi, V and Lelo, K, 2005, "Georeferencing the Historical Maps of Rome between the Seventeenth and Eighteenth Centuries", CIPA 2005 XX International Symposium.

¹² Ibid.

¹³ "Understanding Raster Georeferencing", 2018, Esri.

first degree polynomial transformation is commonly used to georeference a map as it results in straight lines, making it ideal to use when needing to scale, stretch, or rotate a map. Three control points must be used when doing a first order transformation, but an error occurs when more than three are used. However, the more control points used, the less influential possible inaccurate control points are. This means that while an error in the mathematical transformation may increase with the use of more control points, the overall accuracy of the transformation will increase as well¹⁴.

While there are limits to metric precision in georeferencing, these transformations are one of the few applicable methods for measuring error. Beyond the discussion of the found systematic errors listed above, they were able to conclude through georeferencing investigation that cartography products of different ages and scales can still have comparable metric precision to cartography of a modern age with an established reference system.¹⁵ This study helps advise this thesis by providing a background knowledge of how errors in the historic map and georeferencing process can affect results, while showing that the georeferencing process can accurately measure the degree of error in various historic maps.

There are different georeferencing approaches, and because georeferencing is used by a variety of disciplines and research fields, it is important to find the method that produces the most accurate result. Another study conducted by Valerio Baiocchi, et al.,

¹⁴ Ibid.

¹⁵ Baiocchi, V and Lelo, K, 2005, "Georeferencing the Historical Maps of Rome between the Seventeenth and Eighteenth Centuries", CIPA 2005 XX International Symposium.

“Accuracy of Different Georeferencing Strategies on Historical Maps of Rome”¹⁶, set out to find how an integral process to georeferencing-- control points-- can change the degree of error. The software they experimented with first was QGIS as it has more built-in transformation algorithms than most commercial software beyond the above mentioned polynomial transformation, including the adjust transformation that combines the former with additional techniques, similarity transformation that tries to preserve the shape of the image, and projection transformation that keeps lines straight by warping them.. Each transformation algorithm requires a different number of control points. In this study, they georeferenced historic maps using the minimal number of required control points and increased the number of control points in two-point increments. These results would be able to show how many control points were needed for each transformation to produce the most accurately georeferenced map.

Depending on the type of transformation, they found that the residual number peaked even after the minimum required number of control points was reached, around 30 to 34 control points for the second-order polynomial transformation and 24 control points for the third order. As this result could not be explained, they repeated the test in the ArcGIS software, where these results were not observed: there was little residual error in the georeferenced maps when the minimum number of control points were met. They concluded there was a bug in the QGIS software and ArcGIS, the software used in this

¹⁶ Baiocchi, Valerio, et al, 2013, “Accuracy of different georeferencing strategies on historical maps of Rome”, *Geographia Technica*, 10-16.

thesis, produced accuracy statistics with the smallest margin of error when using the polynomial transformation.¹⁷

While their focus was on recreating an accurate historic landscape of Rome before modern urbanization took place, their analysis of the required number of control points for the georeferencing process, investigation into residual error calculations in two different GIS programs, and type of transformation best suited for georeferencing historic maps can be applied to other maps and localities, including this thesis study of the walled city in Charleston.

Georeferencing and Remote Sensing Methods

Georeferencing is not the only digital technology that can be implemented to reconstruct parts of a vanished landscape. While it has the ability to produce a predictive model for locating landscape features that no longer remain above ground, additional methods are needed to help confirm these subterranean features' existence.

Archaeological field methods serve as the best tools to visually identify remnants underground. However, because archaeological excavations cannot always take place due to inaccessibility of locations, such as in the middle of a busy street or private property, nontraditional and non-invasive methods must be employed instead.

Geophysical surveying, "...a broad term covering the suite of detection methods used to map contrasts between the physical properties of buried archaeological remains

¹⁷ Ibid.

and the surrounding soil”¹⁸ has aided researchers and archaeologists in discovering underground features for years. It serves as an exploratory tool for archaeologists and as a professor of anthropology at the University of Denver, Lawrence Conyers, once wrote, this form of landscape surveying can be seen “...as a research method in its own right.”¹⁹ Conyers notes that geophysical surveying was rooted in scientific disciplines such as geology and physics but has recently gained popularity with archaeologists and anthropologists. Today, these academics are using geophysical imaging techniques beyond their initial purpose in the field. Instead of being used as purely an excavation tool, different techniques, including ground penetrating radar (GPR), now serve as primary data sources to study historic, vanished landscapes.²⁰

GPR, a remote sensing method, can map anomalies beneath the Earth’s surface by transmitting radar waves into the soil and measuring the time it takes for these signals to bounce back to the surface.²¹ The results of this process can be analyzed to show subterranean features such as utility work, earthen entrenchments and ditches, and underground masonry components, such as fortifications. Once predicted locations are identified using georeferencing and GIS, GPR can be implemented to help aid the determination of whether or not such features have accurately been located. As GPR can map underground in horizontal “slices”, researchers can create an image of what the subterrain looks like at different depths. GPR is not a substitute for “ground truthing”, or

¹⁸ “Geophysical Survey”, historicengland.org.uk, accessed January 8th, 2023.

¹⁹ Conyers, Lawrence B., 2010, “Ground-penetrating radar for anthropological research”, *Antiquity*, Cambridge University Press.

²⁰ Ibid.

²¹ Marcoux, Jon and Leifeste, Amalia, 2022, “Impact of Digital Technologies on Historic Preservation Research at Multiple Scales”, *Technology/Architecture + Design*.

archaeological digging, but it can be used as a tool to help support the identification of subterranean features when direct visual observation is not applicable or possible.²²

One study that exercised both georeferencing and remote sensing methods involved a team from the University of South Florida that “...used 3D terrestrial laser scanning (TLS) and imaging along with geophysical remote sensing tools to provide [an] accurate, precise and representative survey of the [Kosciuszko] mine and environs.²³ Located in Ninety-Six National Historic Site in South Carolina, this mine was the only military tunnel that existed during the American Revolution. During the American Revolution, more battles (approximately 200 battles) were fought in South Carolina than any of the other colonies. Historians suggest the first land battle of the American Revolution in South Carolina occurred in the town of Ninety-Six as it “was a commercial and transportation hub, and its control was considered logistically critical to the military, political, and economic power in the region.”

During 1780, the British military strengthened their Star Fort, but within a year was under siege from Patriot troops. In order to infiltrate the fort, they dug the Kosciuszko Tunnel or Mine that allowed them to attack from the fort’s interior. Today, the National Parks Service aims to stabilize and preserve the mine as it poses various dangers, but first the mine’s exact location needed to be found.

The University of South Florida team’s multicomponent spatial and geophysical proposition “...to accurately record and visualize the historic features and terrain...”

²² Ibid.

²³ Collins, Lori, Doering, Travis, and Gonzalez, Jorge, 2015, "Terrestrial and Airborne LiDAR Digital Documentation of Kosciuszko Mine, Ninety Six National Historic Site", Digital Heritage and Humanities Collections Faculty and Staff Publications, University of South Florida.

involved the use of not only remote sensing methods (LiDAR, GPR) and GPS surveying, but also dimensional imaging, videography, and three-dimensional laser scanning to help preservation engineers visualize the inside of the mine. They started by using GIS to georeference historic maps of the fort and mine location over the modern landscape, and then performed a GPR survey in the proposed area of the mine to look at construction episodes and subsurface objects.²⁴ By exercising these methods jointly, the authors were able to accurately map the mine's path and features. This strategy of combining digital technologies into one methodology is applied in this thesis.²⁵ Additionally, the results of the GPR survey showed areas of soil deposition that differed from the surrounding layer - suggesting a filled-in tunnel" While this project is not looking at a fortification wall, it is embarking on a study to map underground apertures and gaps in the soil, indicative of the entrenchments of Charleston's walled city.

GPR is not limited to small scale archaeological remnants. Remote sensing methods were explored in a study that investigated the historic site of Santa Elena on Parris Island, South Carolina, a Spanish colony in the 16th century, but a site with over 4,000 years of occupation.²⁶ Currently, the United States Marine Corps Recruit Depot is located on top of the former colony and most recently the landscape was used as a golf course before its important history was recognized. In 2014, the Santa Elena Landscape Project was implemented to use remote sensing methods to collaborate with 40 previous years of archaeological testing.

²⁴ Ibid.

²⁵ Ibid.

²⁶ Thompson, Victor D., et al, 2018, "The Archaeology and Remote Sensing of Santa Elena's Four Millennia of Occupation", *Remote Sensing*, 10:2: 248.

Thompson, et al. explains the importance of remote sensing in archaeological investigations as they "...suggest that remote sensing can be a valuable tool to aid in the visualization of the historic landscape as well as provide key information regarding the nature of relationships that bound people together within the built environment. In addition, in certain situations, the data from remote sensing itself can aid in the interpretation of documentary evidence."²⁷ This study acknowledges that while geophysical surveys and remote sensing of historic sites are increasing in the United States, few have been published in peer review articles and books.

The Santa Elena Landscapes Project involved mapping an entire colonial town through GPR, magnetic, and resistance surveys. The results of these methods were able to positively identify the location of an old fort, as well as possibly a few other features of the layout of the historic town, including two structures, a ditch relating to one fort (San Felipe II), and architectural features of the form and structure of another fort (San Marcos I).²⁸ This positive outcome suggests the same methods can be employed in other locales, although notably the urban landscape of Charleston presents a greater difficulty not only in conducting remote sensing methods, but also in analyzing the resulting data.

While GPR has been used to identify various subterranean features, its use in locating earthen or masonry walls has been limited. Few of these studies have been conducted inside the United States with even fewer having been implemented in Charleston. One of the largest undertakings of mapping fortification walls in the United

²⁷ Ibid.

²⁸ Ibid.

States was performed in 1999 by Robert K. Nickel and William J. Hunt, Jr. from the Midwest Archaeological Center.²⁹ Nickle and Hunt conducted geophysical surveys of the perimeter fortification structure at the Second Fort Smith in Arkansas. Two of their three methods include magnetic and soil resistance surveying. However, they concluded magnetic surveying was limiting in an urban setting. Ultimately, the study's application of ground-penetrating radar and soil resistance survey divulged locations of the perimeter wall alongside bastions that once completed its wall fortification system, a result that will be similarly looked for in this thesis. The project found soil resistance surveying was helpful in identifying those features, but the process is slower than GPR surveying. It is worth noting that other techniques besides remote sensing can be manipulated to locate underground archaeological features, and perhaps soil resistance surveying may be implemented in future studies beyond this thesis..³⁰

In the past, a significant number of georeferencing and remote sensing projects have been conducted in Charleston. These have largely been focused on the defenses used during the Revolutionary War period. As mentioned in the introduction, additional fortification methods were implemented after the entrenchments of the north, south, and west colonial-era city wall were filled in and the town expanded. Carl Borick and colleagues have tried since the 1980's to locate siege lines from the British capture of

²⁹ Nickel, Robert K. and Hunt, Jr., William J, 2002, "Geophysical Surveys of the Perimeter Fortification System at the Site of the Second Fort Smith, Fort Smith National Historic Site, Fort Smith, Arkansas", *Midwest Archaeological Center: Technical Report No. 85*, National Parks Service, United States Department of Interior.

³⁰ Ibid.

Charleston in May 1780, which led to the longest siege of the war at 42 days.³¹ Borick's decades of historical research and historic map analysis has suggested potential localities of these features, and subsequent research methodologies have involved geophysical surveying and archaeological excavations, as discussed in Borick, et al.'s "Searching for the 1780 Siege of Charleston: History, Archaeology and Remote Sensing".³² This paper discusses four previous research projects undertaken near the British siege lines.

In 1986, test excavations were conducted by the Charleston Museum in the center of Wragg Mall. Two more projects at the Aiken-Rhett house were carried out by the museum in 1985 and 2001. The fourth project involved the testing of the ground of Marion Square in 1998 by Natalie Adams of New South Associates. Adam's project worked in conjunction with a survey done by Eric Poplin of Brockington and Associates in 1997 to find nine trenches and the continuation of the above ground tabby horn work (the only portion of the wall that exists) below the soil surface.³³

Between 2012 and 2016, archaeologists from the Charleston Museum and Historic Charleston Foundation monitored construction works and dispatched remote sensing projects in locales through the neck of Charleston's peninsula: Wragg Mall, Wragg Square and the Aiken-Rhett House yard to discover pieces of the British approach trenches. A large trench feature discovered via remote sensing methods by Jon Marcoux led to an archaeology excavation at the Aiken-Rhett House's rear yard through an

³¹ Borick, Carl P, Jon Bernard Marcoux, Martha A Zierden, Ronald W Anthony, and Katherine Saunders Pemberton, 2020, "Searching for the 1780 Siege of Charleston: History, Archaeology and Remote Sensing", *Archaeological Contributions* 51, The Charleston Museum.

³² *Ibid.*

³³ *Ibid.*

archaeology field school with the College of Charleston. Ground penetrating radar was continued in 2018 again at portions of the Aiken- Rhett House, Elizabeth Street, and Wragg Mall.³⁴

Lisa Gardiner, a graduate of Clemson University and the College of Charleston's Master of Science in Historic Preservation program, expanded on Carl Borick's and his colleague's work with the Siege of 1780 for her 2021 graduate thesis.³⁵ By building upon past work in Wragg Square and Marion Square, she was able to explore four different methods and their effectiveness to locate battlefield features of the Siege of 1780. These methods involved research of historic accounts, georeferenced historical maps, LiDAR to determine changes to the land topography overtime, and GPR to locate any battlefield features.³⁶ A similar approach is undertaken in this thesis in regard to the use of georeferencing and GPR with key differences of this thesis focusing on wall fortification features from early colonial occupation in the early 18th century, providing a framework methodology for studying historic maps in a georeferencing context, and evaluating the accuracy of various historic maps of Charleston's peninsula.

This literature review section on georeferencing and ground penetrating radar suggests these two methods combined together provide a promising research methodology for locating vanished features of the historic built environment. Charleston's walled city is an excellent location to test the combination of these

³⁴ Ibid.

³⁵, Gardiner, Lisa, 2021, "Defending a Nation: Synthesizing Geographic Information System Analysis and Ground Penetrating Radar to Locate Battlefield Features Associated with the 1780 Siege of Charleston", All Theses, 3533.

³⁶ Ibid.

methodologies together, which will assist in current attempts to identify and preserve surviving portions of Charleston's historic colonial fortification system.

Study Setting: Identifying Charleston's Walled City

A majority of georeferencing and GPR work on the Charleston peninsula has revolved around the Siege of 1780. However, in the past decade, there has been a shift in interest to the walled city fortifications since the mayor's appointment of volunteers from various institutions and agencies to a Walled City Task Force in 2005. A collaborative effort among individuals from diverse backgrounds, the Task Force responds to opportunities that present potential investigations to the early 18th-century fortification system, often found through prospective construction projects or implementation of underground utilities.³⁷

The Task Force was a response to pursuits by Katherine Pemberton³⁸ and others to explain the importance of the only English fortification system in America that had been overlooked by a majority of historians and scholars. Pemberton, the Walled City Task Force Chairman, released an article in 2002 before the organization's creation describing how the colonial fortification system was not "an insignificant part of Charleston's story".³⁹ Instead, it "physically dominated the town for the first half of the

³⁷ Pemberton, Katherine, "Charleston's Walled City Project: Collaboration and Collegiality", Not published, Accessed October 5th, 2022.

³⁸ Pemberton is Katherine Saunders' married name.

³⁹ Saunders, Katherine 2002. "As Regular and Formidable as any such Woorke in America": The Walled City of Charles Town. *In Another's Country: Archaeological and Historical Perspectives on Cultural Interactions in the Southern Colonies.*

eighteenth century, providing defense and influencing the growth and subsequent architecture of the town”.⁴⁰

While not many projects were undertaken to discover the walled city history and locations of these fortifications before the establishment of the Walled City Task Force, and most have been conducted in the past decade, there were a few important discoveries beforehand. These include the uncovering of the brick foundation of the Granville Bastion during the renovation of the Missroon House at 40 East Bay Street in 1925; excavations by Charleston Museum archaeologist John D. Miller under the Old Exchange Building in the 1960s; Martha Zierden’s archaeological excavation of the Powder Magazine in the 1990s; and Dr. Joe Joseph’s archeological finds at the corner of Meeting Street and Broad Street, the site of the walled city’s drawbridge, including the discovery of four, hand hewn cedar posts in the historic County Courthouse basement in the late 1990s.⁴¹

In 2008, post the creation of the Task Force, an opportunity for archaeological excavation finally arose with needed drainage work and repaving of South Adger’s Wharf, a street off East Bay Street near the intersection of Tradd Street. Dr. Nic Butler, a historian with the Charleston County Public Library, found a plat which identified this area as the potential location of a redan of the historic fortification system.⁴² The excavation in 2008, followed by another in 2009, conducted by the Task Force,

⁴⁰ Ibid,

⁴¹ Pemberton, Katherine, “Charleston’s Walled City Project: Collaboration and Collegiality”, Not published, Accessed October 5th, 2022.

⁴² Butler, Nic, et al, 2012, “Archaeology at South Adger’s Wharf: A Study of the Redan at Tradd Street”, The Charleston Museum.

ultimately resulted in the visual observation of the north face of the redan, and the point and south face of the redan, respectively.⁴³

While these excavations at South Adger's Wharf yielded the largest physical evidence of the walled city known to-date, another archaeology excavation conducted by the Task Force in 2012 resulted in another visual observation of a brick wall. Property owners of 43 East Bay Street, a house located across from the Granville Bastion, allowed the Task Force to excavate on their property as their driveway was being replaced.⁴⁴

All of these excavations, and additional opportunistic documentation of walled city features, have produced known location points for portions of the historic fortification system, which can be used to definitively measure error in georeferenced maps, but the entire perimeter of the wall has yet to be found. This is where the use of predictive modeling comes into play. Jon Marcoux and Amalia Leifeste published an article in June of 2022 that discussed digital methods in preservation using case studies from Charleston, SC.⁴⁵ Digital technologies have become more widespread in preservation and documentation research methodologies. Specifically relating to this thesis, remote sensing methods can either work alongside or be more advantageous than traditional methods as they have "...an ability to record and document continuous subsurfaces with high accuracy...", while having lower production times and more detailed and complete datasets⁴⁶.

⁴³ Ibid.

⁴⁴ Pemberton, Katherine, "Charleston's Walled City Project: Collaboration and Collegiality", Not published, Accessed October 5th, 2022.

⁴⁵ Marcoux, Jon and Leifeste, Amalia, 2022, "Impact of Digital Technologies on Historic Preservation Research at Multiple Scales", *Technology/Architecture + Design*.

⁴⁶ Ibid.

The article describes work conducted by Marcoux working with the Mayor's Walled City Task Force, to find a section of the walled city's earthen wall and entrenchment that marked the southern boundary of the walled city. This wall was suspected to be on The First Baptist Church property just north of Water Street. By georeferencing a 1739 map⁴⁷ of Charleston, he was able to create a predictive model to suggest a path of where the earthen wall would have been located. Following this step, Marcoux used remote sensing methods to test for any potential archaeological features of the walled city (masonry walls or filled-in entrenchments). The results of GPR can support or discredit a hypothesis for the walled city's location based on georeferenced maps. The archaeology team for this project concluded there was a filled-in ditch feature measuring 15 feet wide and 4 feet deep on the First Baptist Church property. Although they suspected this to be part of the fortification system, "ground truthing" through archaeological excavation is needed to confirm the conclusion.⁴⁸

Conclusion

This literature review discussion summarizes how georeferencing and remote sensing methods can be implemented in the realm of archaeology and anthropology. Unfortunately, these digital technologies have not been employed on a large scale in Charleston, South Carolina, especially regarding the colonial-period walled city

⁴⁷ *The Ichnography of Charles Town at High Water* Map of 1739 is also used in this thesis.

⁴⁸ Marcoux, Jon and Leifeste, Amalia, 2022, "Impact of Digital Technologies on Historic Preservation Research at Multiple Scales", *Technology/Architecture + Design*.

fortifications. However, Charleston provides a great opportunity to apply this mixed method of georeferencing and remote sensing, as there are several historic maps and plats that show a change in the downtown landscape overtime. Because of previous archaeology, specific locations of segments of the fortifications are already known, which can be used to definitively measure error. Beyond the practical application of investigating the walled city, this thesis will add to the literature of using digital technologies and geophysical surveying in an archaeological setting. The next chapter details the characterizations and implementation of these methodologies.

CHAPTER THREE

METHODOLOGY

This thesis involves a two-part methodology with each utilizing different technology to perform data collection and analysis. Georeferencing historic maps entailed researching historic maps and plats that contain at least a portion of the early 18th century city wall and overlaying them with current maps of the same locality. After these historic maps were georeferenced, testable survey areas for ground truthing were identified and suggested by the author. Once selected, ground penetrating radar was operated to survey these targeted sites.

Georeferencing Historic Depictions of the Walled City

Data Collection for Historic Maps and Plats

There are only a handful of historic maps depicting the historic city fortification system in Charleston that are suitable for georeferencing. Most of these maps span the eighteenth century, as very few records remain from before. For this thesis, 11 maps were georeferenced and analyzed, alongside four plats that were created by surveyors to denote property parcels. Information found on plats can include the property owner, the surveyor, street, roads, structures on a property, and the length and width, along with directionality in degrees, of the parcel of land. Plats can be recordings of individual properties or can include multiple properties, although the scale limits how many can be drawn on a single document. It should be noted that there are many plats that show portions of Charleston's walled city. Due to time and emphasis on historic map analysis,

only four plats that give clear measurements, degrees of compass direction, and zoomed-in looks to testing site predictions on East Bay Street were used in this thesis.

The georeferencing process requires the highest resolution possible from each map. Most were able to be downloaded directly at high enough resolution from the Library of Congress Geography and Map Division website. Other repositories for the maps and plats used in this thesis are outlined in Tables 1 and 2, respectively. Listed on the tables are the full map title, surveyor (if known), and dates of each historic map, alongside a shortened name the maps are colloquially called. For the conciseness and consistency of this thesis, these maps will be referred to by their shortened title, located in the first column of the table. Information pertinent to each map is listed below.

The “Crisp Map”⁴⁹ (figure 1), surveyed by Edward Crisp in 1704 and published in London in 1711 is a large-format (82 x 99 cm) multi-image map. Crisp was tasked with publishing this map for which he would receive a land grant in Carolina in return⁵⁰. It is the only published map that shows the first walls and outworks surrounding the city, although not all the designed works were finished by this time. Through visual observation, this inset map appears to be a colorful approximation to narrate the historic landscape of town, while not focusing on direct precision and accuracy of the city streets and fortification layout.

⁴⁹ Referred to as the “Crisp Map”, the full title is *A Compleat Description of the Province of Carolina in 3 Parts. 1st. The Improved Part from the Surveys of Maurice Mathews & Mr. John Love. 2ly. The West Part by Capt. Tho. Nairn. 3ly: A Chart of the Coast from Virginia to Cape Florida.*” The map contains a small inset called *A Plan of the Town & Harbour of Charles-Town*. Taken from the Library of Congress. “Maps”, Library of Congress Online Catalog, <https://www.loc.gov/item/2004626926/>.

⁵⁰ Butler, Nic, “The ‘Crisp Map’ of 1711”.

The second oldest map employed in this thesis is the “Herbert Map” (figure 2) surveyed on October 27th, 1721, a decade before the city’s earthen walls were dismantled, “by His Excellency’s faithful and obedient Servt., John Herbert”. A 23 inch by 18-inch map, it shows the completed fortification system, including the Granville Bastion, Half Moon Battery, Craven’s Bastion, Carteret Bastion, Drawbridge, Colleton Bastion, and Ashley Bastion.⁵¹

One of the most popular and useful maps of the colonial-era Charles Town is the 1739 *The Ichnography of Charles-Town, At High Water*. Drawn by Cartographer George Hunter and published in London by Bishop Roberts and W. H. Toms. The Ichnography Map of 1739 shows the expansion of Charles Town after the threat of invasion was minimized, and the earthen entrenchment sections of the city wall were no longer needed. Still extant at this time was the masonry east curtain wall, and the fortifications along that side including Half Moon Battery and Craven’s Bastion as indexed in the key located on the bottom of the map⁵².

Jacques Nicolas Bellin, a notable French Maritime Atlas Cartographer, created the *Port Et Ville De Charles-Town dans la Caroline* map in 1764. As one of the earliest obtained maps depicting the original city of Charleston and its surrounding rivers and

⁵¹ The “Herbert Map” is named nicknamed after its surveyor and the full title is *Ichnography of Plann [sic] of the Fortification of Charlestown and the Streets, with the names of the Bastions, quantity of acres of land, number of Gunns and weight of their shott [sic]*. Ascertained by Nic Butler, The National Archives, Kew, UK.

⁵² The map is located at the British Library in the United Kingdom with a high resolution photographic copy held at the John Carter Brown Library at the University of South Carolina. “The ICHNOGRAPHY of CHARLES-TOWN, at High Water”, British Library, Main Catalogue, https://explore.bl.uk/primo_library/libweb/action/dlDisplay.do?vid=BLVU1&search_scope=LSCOP-ALL&docId=BLL01004818452&fn=permalink.

forts, the French language map does not provide a layout for city streets beyond the walled city parameters. However, the map outlines the city's curtain wall and its corner bastions, Half Moon battery, and redans.⁵³

In 1780, Joseph F. W. Des Barres drew *A Sketch of the Operations before Charlestown, the Capital of South Carolina*.⁵⁴ Named the "Clinton Map" by historians, it was created for Commander Sir Henry Clinton during the Siege of 1780 to show American and British positions. Previous georeferencing of the "Clinton Map" completed by Jon Marcoux suggests there is "a significant correlation between the topography and tidal creeks, on the LIDAR map, and the earthworks and creek crossings on the Sir Henry Clinton Map." This map was a suitable one to use for this thesis with background knowledge that suggested the map was fairly accurate and its outline of the eastern brick fortification of the walled city.⁵⁵

On May 12th, 1780, the key date of Charleston's surrender, Charles Blaskowitz, a British officer, dated his *Plan of the Siege of Charlestown in South Carolina*.⁵⁶ The map has a key that details features of the map from siege lines to churches to the old Beef Market, with an outline of the still standing eastern front wall of the historic fortification

⁵³ "Port et ville de Charles-Town dans la Caroline", Birmingham Public Library, Digital Collections. Birmingham, Alabama, <https://bplonline.contentdm.oclc.org/digital/collection/p15099coll3/id/42/>.

⁵⁴ "A sketch of the operations before Charlestown, the capital of South Carolina. [By] I. F. W. Des Barres." Library of Congress Online Catalog, <https://lccn.loc.gov/gm71000644>.

⁵⁵ Borick, Carl P, Jon Bernard Marcoux, Martha A Zierden, Ronald W Anthony, and Katherine Saunders Pemberton, 2020, "Searching for the 1780 Siege of Charleston: History, Archaeology and Remote Sensing", *Archaeological Contributions* 51, p. 30, The Charleston Museum.

⁵⁶ *The Plan of the Siege of Charlestown in South Carolina*'s full description is written as "A Plan of the Siege & Surrender of Charlestown South Carolina to his Majesty's Fleet and Army Commanded by their Excellencies Sir Henry Clinton Knight of the Bath, General and Commander in Chief and Mariot Arbuthnot, Esqr. Vice Admiral of the White, and Commander in Chief of His Majesty's Ships and Vessels in North America, &c. &c. &c. May 12th, 1780. Surveyed during & after the Siege by Charles Blaskowitz Capt. Guides & Pioneers." Ascertained by Nic Butler, The National Archives, Kew, UK.

system. The “Blaskowitz Map” has been used by historian Carl Borrick and archaeologist Jon Marcoux to locate features from the Siege of Charleston, including a linear line discovered in the yard of the Aiken-Rhett house. While this map has proved successful in discovering features from the American Revolution period, it has not been employed to try to identify locations of the colonial-era fortifications of Charles Town.⁵⁷ The map is included in this thesis because of its suggested accuracy and its inclusion of the eastern brick wall of the walled city.

In 1780, a French officer in the American Revolution, Louis Antoine Jean Baptiste de Cambray-Digny drew a pen-and-ink and watercolor manuscript called *Plan de la ville de Charlestown, de ses retranchements et du siege faits par les Anglois en 1780*. This French map’s purpose was to summarize both the British Siege of 1780 and the subsequent built fortifications. It is useful for this thesis as it has a depiction of the brick eastern wall alongside East Bay Street of the colonial walled city.⁵⁸

A hand-colored manuscript map named *The Investiture of Charleston, S.C. by the English Army, in 1780 with the Position of Each Corps*, and measuring 70 x 51 cm was published in 1780 by an unknown surveyor and publisher⁵⁹. Similar to the *Plan de ville*

⁵⁷ Borick, Carl P, Jon Bernard Marcoux, Martha A Zierden, Ronald W Anthony, and Katherine Saunders Pemberton, 2020, “Searching for the 1780 Siege of Charleston: History, Archaeology and Remote Sensing”, *Archaeological Contributions* 51, The Charleston Museum.

⁵⁸ *Plan de la ville de Charlestown, de ses retranchements et du siege faits par les Anglois en 1780*. Library of Congress Geography and Map Division, Rochambeau Collection, No. 46, <https://lccn.loc.gov/gm71002163>.

⁵⁹ *The Investiture of Charleston, S.C. by the English army, in 1780. With the position of each corps*, Library of Congress Geography and Map Division, <http://hdl.loc.gov/loc.gmd/g3914c.ar155900>.

de Charlestown, the Blaskowitz Map and the Clinton Map with the purpose to depict American Revolution events in Charleston, it includes an outline of the brick eastern wall of the colonial-era fortification system.

A “Pencil, pen, ink and watercolour on six sheets of paper, joined; laid down on two pieces of coarse linen, stitched together; edged with purple silk ribbon”⁶⁰ map depicted Britain’s Sir Henry Clinton’s military operation in Charlestown. The *Plan of the Town and Neck of Charlestown* was surveyed in 1780 by George Taylor, a Scottish appointed assistant engineering who was sent to Charleston by the British military. This map also includes the walled city of Charleston, making the map a suitable candidate for this thesis project.

The earliest believed fire insurance map was requested by Adam Tunno for the use of the Phoenix Fire Company of London in the late 1780s. Published in 1790, Edmund Petrie took this survey of Charleston on August 2nd, 1788, titling it *Ichnography of Charleston, South-Carolina*. While very little of the early fortification wall is depicted on this map, the still-standing Craven’s Bastion is drawn in the lower right-hand corner. It includes a Street index that describes the width of some streets, which can then be used as a comparison to modern streets to suggest if modern streets are similar representations to the streetscape of the early 18th century.⁶¹

⁶⁰ “Charlestown, 1780”. Royal Collection Trust. Accessed February 16th, 2023.
<https://militarymaps.rct.uk/american-war-of-independence-1775-83/charlestown-1780-plan-of-the-town-and-neck-of>

⁶¹ “ICHTNOGRAPHY OF CHARLESTON, South Carolina”, Leventhal Map and education Center, Boston Public Library, Boston, Massachusetts,
<https://collections.leventhalmap.org/search/commonwealth:hx11z451r>

The “Halsey Map”, officially titled *Historic Charleston on a Map*, shows the historic layout of Charleston since its early colonial days over a City Engineers Map drawn by Joseph Needle in 1946. Drawn by Alfred O. Halsey in 1949, this map describes and locates buildings, sites, events, natural disasters, fires, epidemics, battles, and the walled city.⁶² While this map is a 20th century representation of the colonial era fortification system, visual observation suggests there may be some accuracy to its depiction.

⁶² “Halsey Map”, Preservation Society of Charleston, <http://halseymap.com/Flash/map.asp>

Table 1: List of historic maps used for georeferencing including surveyor, date, and depository.

Map	Full Map Name	Surveyor	Date	Depository
Crisp Map	A Plan of the Town & Harbour of Charles-Town	Edward Crisp	1711	Library of Congress
Herbert Map	The Ichnography or Plan of the Fortifications of Charlestown, and the Streets, with the names of the Bastions quantity of acres of Land, number of Gunns and weight of their Shott	John Herbert	1721	The National Archives, Kew, UK.
The Ichongraphy of Charles-Town at High Water	The Ichongraphy of Charles-Town at High Water	George Hunter (cartographer); Bishop Roberts (publisher)	1739	John Carter Brown Library Map Collection
Port of Charles Town	Port Et Ville De Charles-Town dans la Caroline	Bellin	1764	Birmingham Public Library, Birmingham
Blaskowitz Map	Plan of the Siege of Charlestown in South Carolina	Charles Blaskowitz	1780	National Archives in the UK
Clinton Map	Sir Henry Clinton's Map of Charles Town	Joseph Des Barres	1780	Library of Congress
Plan de la Ville de Charlestown	Plan de la Ville de Charlestown de ses retranchements et du siege faits par les Anglois en 1780.	Louis Antoine Jean Baptiste de Cambray-Digny	1780	Library of Congress
The Investiture of Charleston	The Investiture of Charleston, S.C. by the English army	Anonymous	1780	Library of Congress
Taylor Map	Plan of the Town and Neck of Charlestown	George Taylor	1781	Royal Collection Trust
Ichnography of Charleston	Ichnography of Charleston, South-Carolina: at the request of Adam Tunno, Esq., for the use of the Phœnix Fire-Company of London	Edmund Petrie	1788	Leventhal Map and Education Center, Boston Public Library
Halsey Map	Historic Charleston on a Map	Alfred O. Halsey	1949	Preservation Society of Charleston

McCrary Plat, number 1197 used in this thesis comes from the John McCrary Plat collection that contains over two hundreds eighteenth and nineteenth century plats of Lowcountry properties. McCrary was a civil engineer who collected plats, deeds, and other documents. This collection is now held by the South Carolina Historical Society and can be viewed on microfilm at the Charleston County Records of Deeds office or via their website as the plats have been digitized.⁶³ This plat was surveyed in 1787 and has the following description: “plat showing continuation of East Bay Street past various streets, city hall, various decks and Craven’s Bastion”.⁶⁴

A plat that was commissioned by the order of City Council and submitted on May 15, 1787 by Surveyor Bernard Beekman “illustrates the landscape following the partial demolition of the curtain wall and widening of the street over the foundations of the wall”.⁶⁵ The digitized image of this plat was provided by historian Nic Butler who retrieved it from the Charleston County Public Library. Due to no clear title, this plat will be referred to as the “East Bay Street Plat” throughout this thesis.

The Charleston County Record of Deeds office also houses another plat that details Craven’s Bastion in July of 1789. It was created due to a land dispute after the widening of East Bay Street. It still depicts the bridge that went over the creek that once ran where today’s Market Street lays, the building that once stood inside the bastion, and the parapet walls. The measurements and details in the shape of this plat make it an

⁶³ “John McCrary Plat Collection, 1696-1924”, South Carolina Historical Society, Lowcountry Digital Library.

⁶⁴ “Plats: McCrary 1197”, Record of Deeds, Charleston County, South Carolina.

⁶⁵ Butler, Nic. 2023, “Searching for the Curtain Wall of Charleston’s Colonial Waterfront, Charleston County Public Library.

excellent source for predicting Craven’s Bastion’s location under today’s modern surface. This map is referred to throughout this thesis as “Craven’s Bastion Plat”.

The fourth plat used in this thesis was one that laid the groundwork for the Walled City Task Force’s excavation at South Adger’s Wharf. This plat of the area, drawn in 1785 by Joseph Purcell, a famous surveyor of South Carolina, depicts a plan of a water lot and wharf belonging to Mrs. Rebecca Motte. This plat includes a close-up drawing of the redan that was once located here at the intersection of Tradd Street and East Bay Street, alongside where it meets the curtain wall line.⁶⁶ For conciseness, this plat is referred to as the “Tradd Street Redan Plat” throughout this thesis.

Table 2: List of 18th century plats used for georeferencing including surveyor, date, and depository.

Plat	Full Name	Surveyor	Date	Depository
Tradd Street Redan Plat	"A Plan of a Water Lot and Wharf"	Joseph Purcell	1785	Charleston County Public Library
East Bay Street Plat	"Plan of East Bay Street in the City of Charleston"	Bernard Beekman	1787	Charleston County Public Library
McCrary Plat 1197		Unknown	1787	Charleston County Record of Deeds
Craven’s Bastion Plat		Unknown	1789	Charleston County Record of Deeds

⁶⁶ Butler, Nic, et al. 2012. “Archaeology at South Adger’s Wharf: A Study of the Redan at Tradd Street”. The Charleston Museum.

Georeferencing Analysis of Historic Maps and Plats

To complete part one of the thesis and discern which of the historic maps are the most accurate, each map was georeferenced with modern maps in ArcGIS, an Esri developed software. Historic maps usually lack a spatial reference or coordinate system that utilizes map projecting. Therefore, it is required that they be aligned, overlaid, and georeferenced with modern maps to establish a map coordinate system. For the georeferencing process, two maps were downloaded from the National Oceanic and Atmospheric Administration Aerial Imagery database: 2015 NOAA NGS DSS Natural Color 8 Bit Imagery: Charleston, SC and 2022 NOAA NGS Emergency Response Imagery: Hurricane Ian. The 2015 imagery contains the following attributes: cell size of 0.50m, a radiometric resolution (bit) of 8, three bands, and the sensor used was the digital sensor system RGB.⁶⁷ The 2022 Hurricane Ian imagery has the same attributes as the 2015 imagery with a difference in cell size: 0.30m instead of 0.50m⁶⁸.

ArcGIS's desktop software, ArcMap (10.8.1), was used as it was provided by Clemson University and because the literature review suggests ArcGIS is one of the more simple, consistent, and reliable georeferencing programs⁶⁹. To start the georeferencing process, the modern and historic maps were opened in ArcGIS and the coordinate system of the reference maps was assigned to the historic maps. Using the Georeferencing tab, the historic map was connected to the reference map using "control points". Control

⁶⁷ "Digital Coast: Data Access Viewer: 2015 NOAA NGS NGS DSS Natural Color 8 Bit Imagery: Charleston, SC". NOAA National Geodetic Survey.

⁶⁸ "Digital Coast: Data Access Viewer: 2022 NOAA NGS Emergency Response Imagery: Hurricane Ian". NOAA National Geodetic Survey.

⁶⁹ Baiocchi, Valerio, et al, 2013, "Accuracy of different georeferencing strategies on historical maps of Rome", *Geographia Technica*, 10-16.

points are known locations (x,y coordinates) that link locations on the historic map with the same locations on the reference map. These points must be easily and accurately identified in both maps. For the purpose of this thesis, Charleston's street-grid was used for control points by using street intersections, and in some cases, street corners.

While some streets in Charleston have been widened or slightly realigned, enough of the layout of the roads in the walled city section (Meeting Street to East Bay Street and Market Street to Water Street) has remained relatively the same since the 18th century. Historic plats and deeds, alongside building ages, were researched to confirm the streetscape today follows the same grid that it once did three hundred years ago. In the instances where there has been change, those locations were not used for control points, including the east edge of East Bay Street and all of Meeting Street.

There are three streets that have had "alignments" since the time most of these maps were created: Cumberland Street, Chalmers Street, and State Street (once Union Street). Therefore, depending on the map, intersections, or street corners along parts of these three streets were omitted from control points. Additionally, Meeting Street and East Bay Street have both been widened from 33 feet to 66 feet over the years. While East Bay Street widened 33 feet to the east, it is unknown exactly which parts of Meeting Street were widened. Therefore, Meeting Street was omitted from serving as control points. Although it is known what direction East Bay Street expanded, it is uncertain when this change exactly occurred, and if this change was reflected on a map. Therefore, the width of East Bay Street on all the historic maps was ignored. As a result, control

points were taken at the intersection (or street corners) of each cross street when it runs into East Bay Street, instead of the center of the full intersection (Figure 1).



Figure 1: This map shows examples of control points: the red dot was taken at the center of intersections; the blue dot represents where a cross street runs into East Bay Street; and the yellow dots portray street corners.

Control points allow for the historic map without a map coordinate system to undergo transformations to accurately align with the spatially correct modern map. While ArcGIS software offers multiple polynomial transformation algorithms, the first-order polynomial transformation is the most often used for georeferencing⁷⁰. It shifts, scales, and stretches the historic map while minimizing the complexity of the distortion and

⁷⁰ “What is GIS?”. Esri. <https://www.esri.com/en-us/what-is-gis/overview>

maintaining straight lines instead of bending or curving the map like other available transformations. This transformation produces residual errors, a measure of model fit or accuracy, or root mean square (RMS) errors, a measure of the difference between the control point on the historic map and its pair on the modern reference map⁷¹. Large residuals suggest there is a poor model fit and the greater the residual, the less the historic map accurately correlates with the modern map. The RMS error value “is derived by squaring the differences between known and unknown points, adding those together, dividing that by the number of test points, and then taking the square root of that result.”⁷²

These residual numbers were compared to one another to answer the first question of this thesis regarding which historic maps display more accurate depictions of Charleston than others. Once determined, the overlays of those maps can be closely examined against the modern landscape to suggest where parts of the historic fortification system may lie today. This method of predictive modeling was used in conjunction with already known locations of the walled city from previous archaeology and GPR work conducted by the Mayor’s Walled City Task Force. Once potential areas were narrowed down, GPR was conducted to help confirm or deny the hypothesis that the city wall lies beneath that locale.

⁷¹ “Overview of Georeferencing”, ArcGIS Pro 3.0.

⁷² “GIS Dictionary: RMS Error”, Esri.

Ground Penetrating Radar Collection

GPR data collection occurred on four separate days with the help of Dr. Jon Marcoux on three occasions and peer Jacquelyn Nahman on another. Locations chosen were in public areas of Charleston, including streets and sidewalks, and on the grounds of the United States Custom House with permission from General Service Administration. The GPR instrument used was a Utility Scan system manufactured by GSSI, Inc. with a 350-megahertz antenna that shared all collected data onto a tablet via its own Wi-Fi connection. Rectangular survey grids were laid out strategically to avoid trees, flowers, cars, curbs, and other aboveground objects and features. Then, the machine was pushed along the surface in linear transects spaced two feet apart. Depending on the survey area, the transects were oriented North-South or East-West, and in some areas, both directions were surveyed. Transects were taken perpendicularly to the orientation of the historic wall, but in an instance in which there are multiple orientations, like with sections of a bastion, both directions may be needed.

The GPR results were analyzed using the GSSI, Inc. computer software RADAN 7, which allows the data to be viewed through vertical profiles or horizontal plans. These can be combined to present a three-dimensional model of any underground feature. Anomalies in the soil can be analyzed as each reflection will have its own amplitude with dark gray showing low amplitude and white showing high amplitude. Additionally, these reflections should have their own “shape” either as a hyperbola, or U-shape, or as a flat, planar line (Figures).

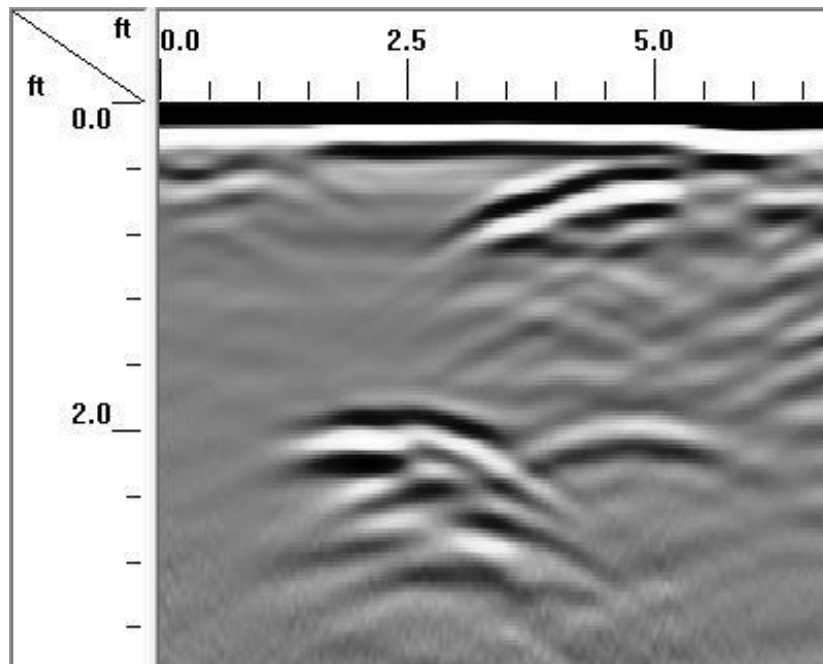


Figure 2: A zoomed in photo of a GPR profile showing a hyperbola.

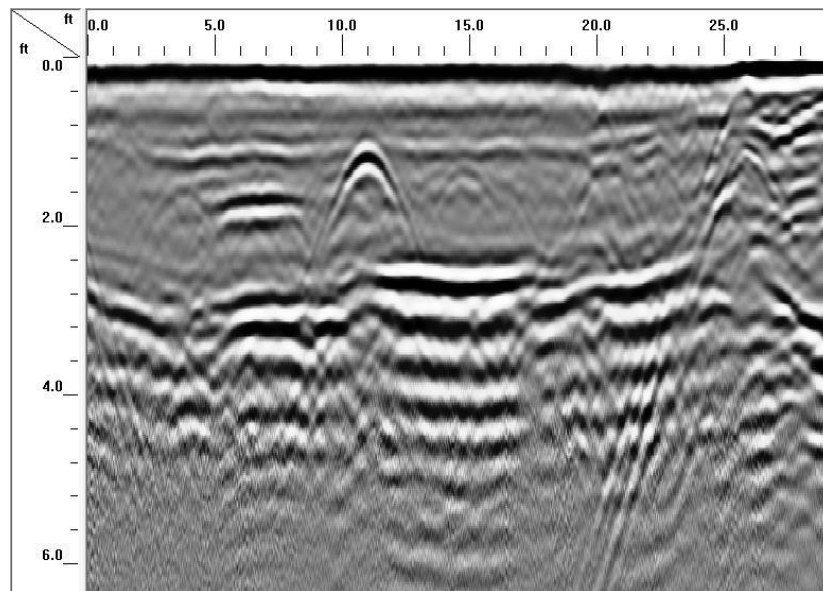


Figure 3: A photo of a GPR profile showing hyperbolas around one to two feet in depth and a flat, planar object starting at a depth of three feet.

Based on historic records and previous archaeology work conducted by Martha Zierden and the Walled City Task Force, it is known that the colonial-era fortification system consisted of both a masonry line of outworks connected by a curtain wall on its east front and earthen entrenchments on its other three sides. Therefore, depending on the survey location, the GPR results should result in a highly reflective display that is either planar in shape alone, indicating a masonry underground component, or in conjunction with highly reflective hyperbolas, suggesting an area of “fill”, such as with entrenchments.

Looking at the amplitude of the reflections and their shape, as well as placing the plan view on top of the georeferenced maps, can help identify feature types, helping to confirm whether the walled city is located where hypothesized. This thesis does not allow for the time nor has the permission to undertake a “ground truthing” archaeological investigation to support any findings, but the GPR results will guide archaeological digs in the future, as well as lay out a basic understanding of what is located underneath the surface of Charleston’s modern urban landscape.

CHAPTER FOUR

RESULTS AND DATA ANALYSIS

This section is divided into two parts: georeferencing and GPR, each having their own subsections. First is a discussion of the visual observations and accuracy of each georeferenced historic map and plat. Then, the GPR results of the four testing locations are analyzed. Due to the large volume of maps produced, most are placed in the Appendices at the end of this thesis with a few examples incorporated in this section. All historic plat images are included here as there are only a select few.

Georeferencing

Below, the results of georeferencing are presented for each historic map and plat in the study. As mentioned in the methodology, two methods of control point placement were implemented (intersections and corners) for each reference map. However, it became apparent after analyzing the first few maps that corners provided a smaller RMS measurement. Maps were georeferenced in no particular order as some maps were immediately available and some needed to be requested.

Due to the limited time available for this thesis, it was decided that after the first maps, Street corners were no longer necessary to include as they produced a georeferenced map that would be less useful for choosing possible locations to conduct GPR. Street corners were less reliable as it is possible the modern streetscape changed through time. Intersections provided more of an approximation that could be similarly obtained from both the historic map and reference map. This is why some maps have

comparisons between intersections and corners, while others only have results of intersection control points. It was deemed after the first few maps that the street corners produced a larger RMS value, especially when used outside of the walled city boundaries.

Some of these historic maps present streets that visual observation shows are either in a different location or with a directionality that does not align with today's modern street grid. Results are presented in this section that include those streets in order to analyze error values for the entire map. In addition, the maps were also georeferenced without using those streets in order to provide a more accurate visual account for pinpointing GPR survey locations.

The maps that had one or more streets visually different than today's modern street grid layout would only be georeferenced with the reference map that had the clearest intersections for those specific streets. For instance, because each map's aerial imagery was taken at a different angle, some street corners and intersections have tree or house coverage. This made the control point location more of a guess than others, and thus, were deemed unusable for control points. This can be seen in the variation of control points taken; different streets would be shown on each map, adjusting the amount of control points available, but if those streets were obscured, they were omitted from being a control point, as well. Therefore, the reference map that had the least coverage of the street intersections in question for each map was only used.

Charleston's street grid and urban expansion beyond the walled city grew with time. Subsequently, each map produced at different years had varying numbers of streets

drawn. The goal of the georeferencing part of this thesis was to analyze the accuracy of each map, but also produce map overlays that could be used to predict the walls location under the modern landscape today. It is assumed that the smaller the size of the map, the more accurate the georeferencing process is. Therefore, regardless of whether or not there is urban expansion drawn on a map, it was necessary to take control points only within the walled city boundaries itself. While this is sufficient and gives the most accuracy for the position of the fortifications today, it does not represent the entire accuracy of the map. In order to produce results for both georeferencing goals, separate control point sets were taken for both only within walled city boundaries, as well as for the entirety of the map if urban expansion beyond the walled city section was drawn.

For each map, there is a table listing the residual error (as RMS) measures for differing methods of control point placement (intersection and corners), in or out of walled city boundaries, and street omission or inclusion respective to each reference map. The RMS measure is presented in feet. Maps are presented in this results section in ascending order dependent on date of production.

Historic Maps

“Crisp Map”

The “Crisp Map” is an interesting map with which to start this thesis. It is the earliest surviving depiction of the *enceinte* system in Charles-Town, though it was clearly drawn without great care for precision. Using 10 control points at intersections within the boundaries of the early walled city, the first order polynomial transformation produced a residual of 12.46 for the IOCM imagery and 12.63 for the Hurricane Ian imagery. With 24 control points at identifiable street corners, the same transformation resulted in a residual of 14.70 for the IOCM imagery and 14.84 for the Hurricane Ian imagery. When comparing the differences of each reference map, the IOCM map has a smaller residual error by 0.17 for intersections and 0.13 for Street corners. While the locations for the street intersections appear to be approximately placed, the width of the streets are not to scale. This can be seen in the greater residual error for street corner control points, as well as visually in Figure where the blue lines show the discrepancies between locations of the control points on the historic map (green) and reference map (red).

Table 3: Residual error in feet for the “Crisp Map” for two types of imagery with both intersection and streets corner control points within the walled city boundaries.

	Intersection	Points	Street Corners	Points
IOCM 2015 Imagery	12.46	10	14.70	24
Hurricane Ian 2022 Imagery	12.63	10	14.84	24
Average RMS	12.54		14.77	

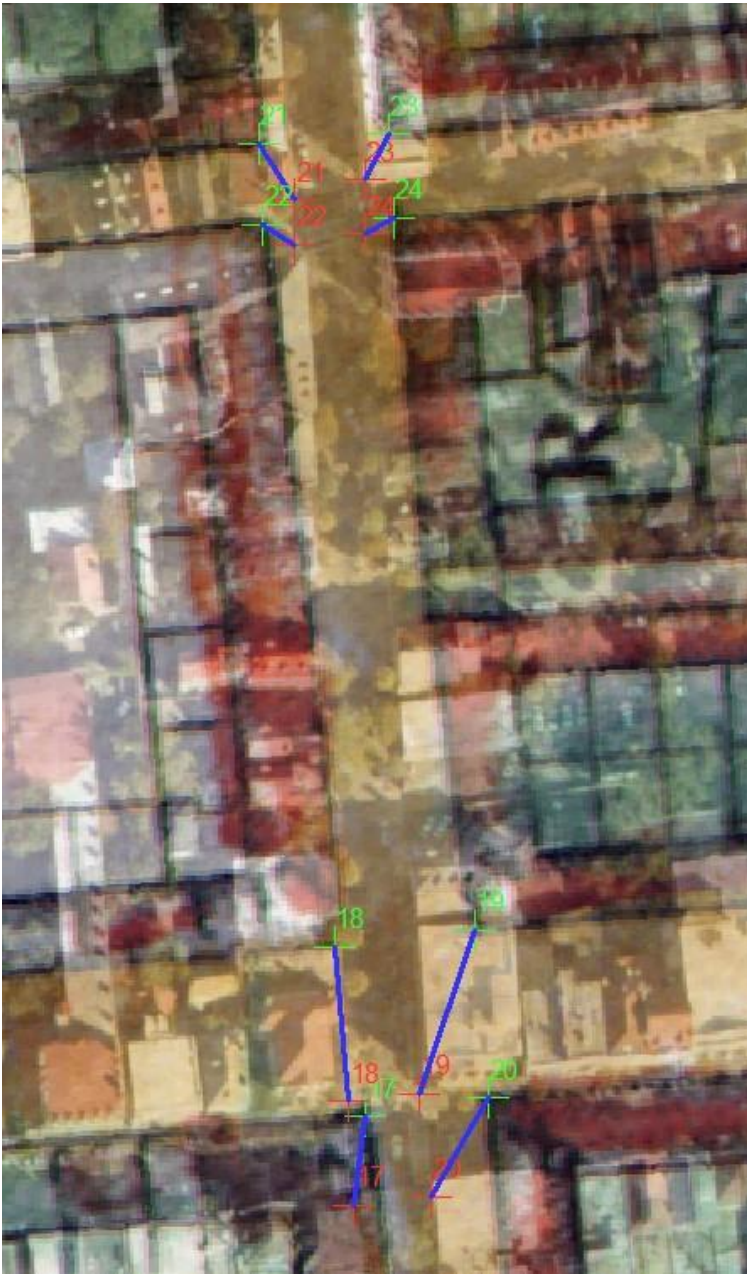


Figure 4: Zoomed in georeferenced “Crisp Map” overlaid on the modern streetscape of downtown Charleston showing links between control points.

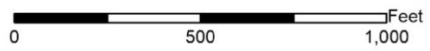


Figure 5: Georeferenced “Crisp Map” overlaid on the modern streetscape of downtown Charleston.

“Herbert Map”

The Herbert map was surveyed less than two decades after the “Crisp Map” and before the *enceinte* system was dismantled and trenches filled in with dirt and debris. In order to analyze the accuracy of the street layout, as well as the proportions of the streets and features on the map, the map was georeferenced twice, once with intersections and the second with street corners serving as control points. Because both Cumberland Street⁷³ and State Street⁷⁴ have been realigned since this map was produced, those streets were avoided for control point locations. Because of its early production date, only the streets within the historic walled city are presented on this map as this map predates Charleston’s urban expansion. Therefore, the streets represented on this map that were used for control points include Queen Street, Broad Street, Tradd Street Elliott Street, Church Street, Meeting Street, East Bay Street, Unions Alley, and Bedons Alley⁷⁵.

Visually, Bedons Alley appears to have a different orientation, angle, and slightly different location than Bedons Alley’s true trajectory and position (Figure). This is supported mathematically by the greater residual error produced for the maps georeferenced with Bedons Alley for control points versus excluding the alley.

The “Herbert Map” was georeferenced using intersection control points with both the IOCM imagery and Hurricane Ian imagery. The latter reference map resulted in a

⁷³ Formerly known as Wraggs Alley

⁷⁴ Note State Street, formerly Union Street (not to be confused with Union Alley), is not included as control points for georeferencing for any of the maps in this thesis.

⁷⁵ Bedons Alley has been referred to as Bedons Alley and Bedon’s Alley.. Because the Ichnography of 1788 Map has Bedons Alley written without an apostrophe, it is referred to as Bedons Alley in this thesis.

significantly lower residual error (by -2.38) when including Bedons Alley, but with an insignificant difference when Bedons Alley was excluded (Table 4).

The width and proportions of the streets on the historic maps appear to be relatively like the modern landscape today as seen by the results in Table . However, the features of the walled city on the “Herbert Map” are scaled greater than they were actually created. The location of a redan at Tradd Street and East Bay Street directly correlates with known GPR coordinates of the redan taken during the archaeological excavation of South Adger’s Wharf⁷⁶. Figure _ shows the drawing of the redan on that map is of a greater scale than it was constructed.

⁷⁶ Zierden, Martha and Reitz, Elizabeth, 2002, “Excavations on Charleston’s Waterfront: The Atlantic Wharf Garage Site”, The Charleston Museum, Archaeological Contributions 30.

Table 4: Residual error in feet for the “Herbert Map” with both intersection and street corner control points within the walled city boundaries that include or exclude Bedons Alley.

	Intersections including Bedons Alley	Street corners including Bedons Alley	Intersections excluding Bedons Alley	Street corners excluding Bedons Alley
IOCM 2015 Imagery	11.45	10.75	6.58	6.65

Table 5: Residual error in feet error for the “Herbert Map” for two types of imagery with intersection control points within the walled city boundaries that include and exclude Bedons Alley.

	Intersections including Bedons Alley	Points	Intersections excluding Bedons Alley	Points
IOCM 2015 Imagery	11.45	10	6.58	8
Hurricane Ian 2022 Imagery	9.07	10	6.73	8
Average RMS	10.26		6.65	

Ichnography of Charles-Town at High Water

The *Ichnography of Charles-Town at High Water* Map of 1739 appears to be one of the most accurate depictions of both the walled city's layout of streets, as well as the sizes, shapes, and scale of the fortifications. As mentioned above, while the overlay of the georeferenced historic maps is an integral process for this thesis for predicting locations of the walled city itself, and emphasis is then focused on the boundaries of the walled city, it is worth noting the accuracy of not just the *enceinte* system, but the map as a representation of the entire Charleston peninsula, as well. Therefore, the map was georeferenced using control points only within the walled city boundaries and using control points both within and beyond the walled city boundaries. Since this map was one of the later analyzed and it was already deemed that street corner control points were less useful for this thesis, intersections of streets were used as control points. There were 13 used within the boundary and 11 more beyond.

The results of the residual error calculations show the layout of the streets only within the walled city boundaries are lower than those calculated using control points across the peninsula without set boundaries. The map with only the 13 control points was used for a predicting locations of the walled city fortification system as the lower residual suggests the map is more accurately georeferenced with the modern landscape of the walled city when within its boundaries. Additionally, there does not appear to be a significant difference in the residuals between either reference map.

Table 6: Residual error in feet for the *Ichnography of Charles-Town at High Water* for two types of imagery with intersection control points within the walled city boundaries and without boundaries.

	Intersections within the walled city boundaries	Points	Intersections without boundaries	Points
IOCM 2015 Imagery	4.67	13	5.29	24
Hurricane Ian 2022 Imagery	4.84	13	5.20	24
Average RMS	4.76		5.23	

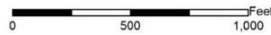
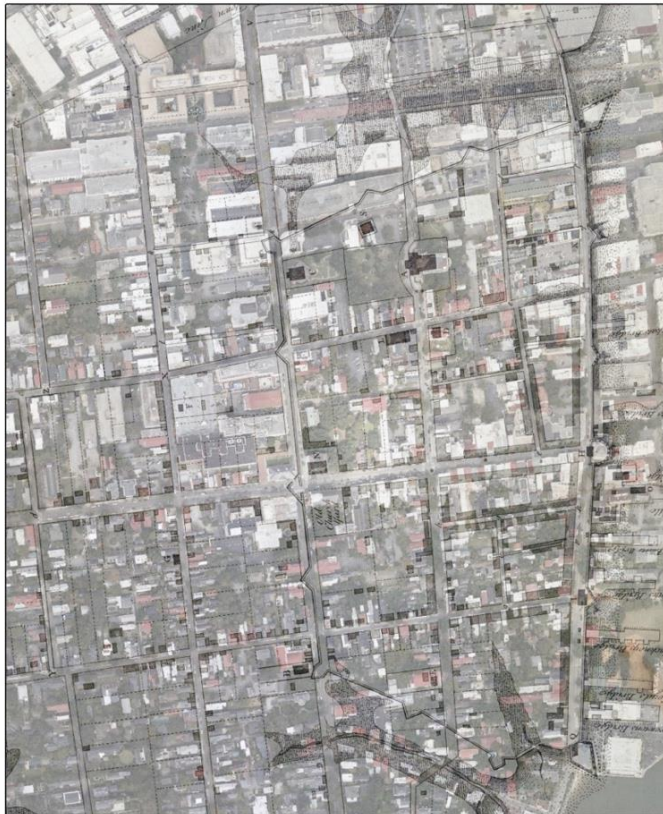


Figure 6: Georeferenced *Ichnography of Charles-Town at High Water* overlaid on the modern streetscape of downtown Charleston.

Port of Charles-Town

The *Port of Charles-Town* Map of 1764 visually looks similar to the “Crisp Map”. There is a lack of street detail, full use of color, and large, exaggerated features of the earlier fortification system. However, while this map was surveyed before dismantlement of the eastern brick wall was completed, it was after the three earthen walls and entrenchment sections were filled and the town began expansion. Like the “Herbert Map”, Bedons Alley is incorrectly depicted. This map was georeferenced using both intersections and street corners as control points with and without the use of Bedons Alley. When including and excluding Bedons Alley, residual errors are approximately 33% and 19% higher for intersection and street corner control points, respectively. Specifically, the use of street corners for control points produced residuals 24% and 52% greater than intersections when including and excluding Bedons Alley, respectively. These measurements support the visual observations that Bedons Alley is incorrectly drawn and the streetscape and features of the walled system are not proportionally depicted to scale. Residual error calculation also suggest there is no significant difference between using the two imagery sources for georeferencing.

Table 7: Residual error in feet for the *Port of Charles-Town* with both intersection control points and streets corner control points within the walled city boundaries that include or exclude Bedons Alley.

	Intersections including Bedons Alley	Street corners including Bedons Alley	Intersections excluding Bedons Alley	Street corners excluding Bedons Alley
IOCM 2015 Imagery	14.98	18.58	9.93	15.08

Table 8: Residual error in feet for the *Port of Charles-Town* for two types of imagery with intersection control points within the walled city boundaries that include or exclude Bedons Alley.

	Intersections including Bedons Alley	Points	Intersections excluding Bedons Alley	Points
IOCM 2015 Imagery	14.98	10	9.93	8
Hurricane Ian 2022 Imagery	14.87	10	9.76	8
Average RMS	14.93		9.84	

“Blaskowitz Map”

The “Blaskowitz Map” was created in 1780 for Sir Henry Clinton during his Siege of Charleston. The map includes a large portion of the Charleston peninsula shortly before the eastern line of the fortification system was completely dismantled. Even though the three former earthen entrenchments are not represented on this map, the “Blaskowitz Map” was deemed useful for its depiction of the eastern line of fortifications. It was georeferenced using intersection control points both only within and beyond the walled city boundaries (Figures 51 and 52, respectively). When using points only within the boundaries, Church Street served as the western line because of Meeting Street’s eventual width expansion, Queen Street served as the northern line as Cumberland Street was not aligned by this period (similar to State Street), the western side of East Bay Street was the east boundary line, and Stolls Alley was used for the southern border as Water Street today was still something of a creek in 1780.⁷⁷

Intersections that could be used for control points beyond the walled city boundaries include fifteen control points: five points on King Street and ten west of King Street. Residual error calculations suggest streets beyond the walled city boundaries are less accurately drawn as the residuals are over 100% greater than those calculated for the control points only within set boundaries. A visual analysis of the control point pairs on the “Blaskowitz Map” supports this conclusion as the links between the pairs are further apart for these intersections. There was not a significant difference in residual errors for both inside and beyond the boundaries when comparing the two reference maps.

⁷⁷ This boundary outline for the walled city is the same for all the maps in this thesis.

Unlike earlier maps where Bedons Alley has been inaccurately depicted, this alley appears approximate on the “Blaskowitz Map”, although Gadsden’s Alley⁷⁸ does not. This map is the earliest depiction of this alley on maps used in this thesis. Located south of Broad Street, north of Elliott Street east of Church Street, and west of East Bay Sreet, Gadsden’s Alley has been closed off since 1919. To support this visual observation, residual errors were calculated when the map was georeferenced using the walled city boundaries with and without the intersections of Gadsden’s Alley at Broad Street and Elliott Street as control point locations. The Hurricane Ian 2022 reference map served as the clearest map with least visual obstruction regarding the intersections of Gadsden’s Alley.

Table 9: Residual error in feet for the “Blaskowitz Map” for two types of imagery with intersection control points within the walled city boundaries and without boundaries.

	Intersections within the walled ctiy boundaries	Points	Intersections without boundaries	Points
IOCM 2015 Imagery	8.23	17	16.74	30
Hurricane Ian 2022 Imagery	8.36	17	17.14	30
Difference in Residual	8.29		16.94	

⁷⁸ Also historically referred to as “Four Post Alley”.

Table 10: Residual error in feet for the “Blaskowitz Map” with intersection control points within the walled city boundaries that include or exclude Gadsden’s Alley.

	Intersections including Gadsden’s Alley	Points	Intersections excluding Gadsden’s Alley	Points
Hurricane Ian 2022 Imagery	8.36	15	7.79	17

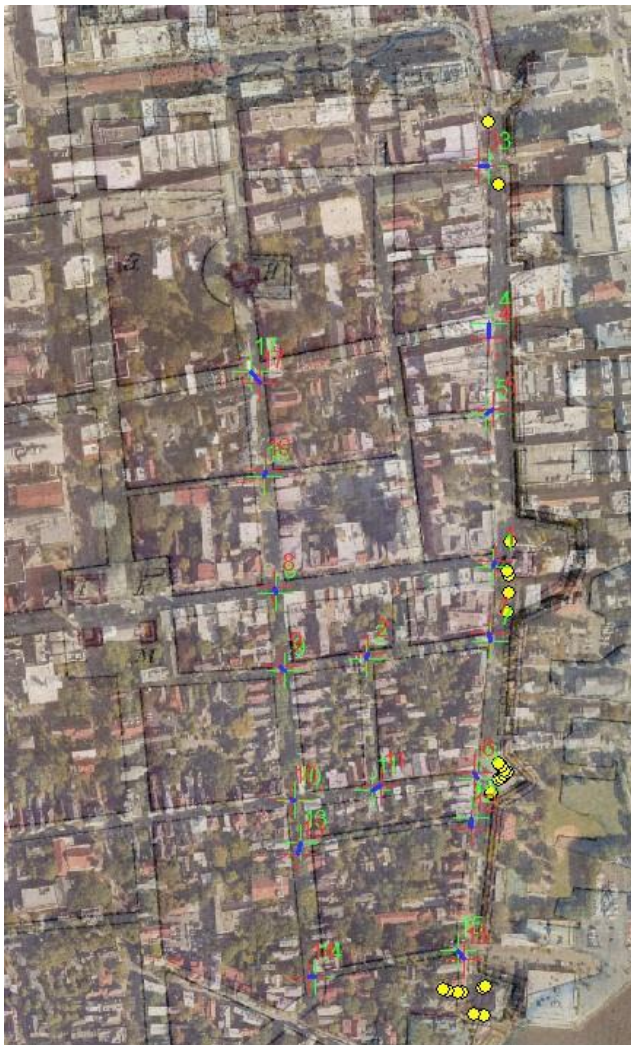


Figure 7: Control point pairs for intersections within the walled city boundaries on the overlay of the georeferenced “Blaskowitz Map”.



Figure 8: Control point pairs for intersections beyond the walled city boundaries on the overlay of the georeferenced “Blaskowitz Map”.

“Clinton Map”

The “Clinton Map” was created in 1780 during the Siege of Charleston. The map includes a large portion of the Charleston peninsula shortly before the eastern line of the fortification system was dismantled. Even though the three former earthen entrenchments are not represented on this map, the “Clinton Map” was deemed useful for its depiction of the eastern wall. It was georeferenced using intersection control points both only within and also beyond the walled city boundaries. The boundaries for the streets used within the walled city were the same as those used for the “Blaskowitz Map”.

Residual error calculations of control points within the walled city boundaries and beyond the boundaries result in the same conclusion as the “Blaskowitz Map”:
Streets beyond the walled city boundaries are less accurately drawn than those within the boundaries. Enough maps had been analyzed by this point and the inclusion of street corners for control points was deemed unnecessary. Also, visual observation suggested the street corners were not to scale nor were approximately located (Figure 31). While the residual error for the Hurricane Ian aerial image is less than the IOCM image, the difference is concluded as insignificant.

Table 11: Residual error in feet for the “Clinton Map” for two types of imagery with intersection control points within the walled city boundaries and without boundaries.

	Intersections within the walled city boundaries	Points	Intersections without boundaries	Points
IOCM 2015 Imagery	17.01	14	21.73	23
Hurricane Ian 2022 Imagery	16.64	14	19.95	23
Average RMS	16.83		20.84	

Plan de la Ville de Charlestown

The *Plan de la Ville de Charlestown* was created in 1780 during the Siege of Charleston. The map includes a large portion of the Charleston peninsula shortly before the eastern line of the fortification system was completely dismantled. Even though the three former earthen entrenchments are not represented on this map, the *Plan de la Ville de Charlestown* was deemed useful for its depiction of the eastern wall. It was georeferenced using intersection control points both only within and beyond the walled city boundaries. The boundaries for the Streets used within the walled city were the same as those used for the other maps.

Residual error calculations of control points within the walled city boundaries and beyond the boundaries result in the same conclusion as the “Blaskowitz Map” and “Clinton Map”: streets beyond the walled city boundaries are less accurately drawn than those within the boundaries. However, a different finding for the *Plan de la Ville de Charlestown* compared to the other maps is that residual error for the Hurricane Ian aerial image is significantly lower compared to the IOCM aerial image (36% and 22.4% difference within and beyond the walled city boundaries, respectively).

A visual analysis of *Plan de la Ville de Charlestown* concluded State Street was drawn with an incorrect diagonal trajectory, the street between Church Street and East Bay Street south of Tradd Street could not decisively be determined to be either Longitudinal Lane or Stolls Alley (thus, it could not be used as a control point), and streets west of King Street were inaccurately named. Two streets on this map, Orange Street and Friends Street, appear to be today’s Legare Street. Additionally, the 1872 *Birds*

Eye View of the City of Charleston shows Friends Street as north and Orange Street as east of these streets on the *Plan de la Ville de Charlestown*.⁷⁹ Due to this complexity, these street intersections were not included for control points.

Table 12: Residual error in feet for the *Plan de la Ville de Charlestown* for two types of imagery with intersection control points within the walled city boundaries and without boundaries.

	Intersections within the walled city boundaries	Points	without boundaries	Points
IOCM 2015 Imagery	18.70	10	24.03	15
Hurricane Ian 2022 Imagery	13.76	10	19.63	15
Average RMS	16.23		21.83	

⁷⁹ “Bird’s Eye View of the City of Charleston, South Carolina 1872”. Drie, Camille Noel. Library of Congress. <https://lccn.loc.gov/75696567>

Investiture of Charleston

The *Investiture of Charleston* Map was created in 1780 during the Siege of Charleston. The map includes a large portion of the Charleston peninsula shortly before the eastern line of the walled city was dismantled. Even though the three former earthen entrenchments are not represented on this map, the “*Investiture of Charleston* Map” was deemed useful for its depiction of the eastern fortification line. It was georeferenced using intersection control points both only within and beyond the walled city boundaries. The boundaries for the streets used within the walled city were the same as those used for the other maps.

Residual error calculations of control points within the walled city boundaries and beyond the boundaries suggest the streets beyond the walled city boundaries are less accurately drawn than those within the boundaries. Although this map used less control points as there are fewer streets drawn (9 points and 12 points for intersections within and beyond the boundaries, respectively, compared to 17 and 30 for the “Blaskowitz Map”), this is the same result concluded for the previous maps. The residual error for the Hurricane Ian aerial image is significantly lower compared to the IOCM aerial image (38.7% and 7.67% difference within and beyond the walled city boundaries, respectively).

A mathematical calculation for the accuracy of street corners was deemed unnecessary. Visual observation suggested the street corners were not to scale nor were approximately located (Figure 35). Further visual analysis concluded some streets were inaccurately named: Johnson Street is actually Legare Street, Friends Street is a part of

Archibald Street, and Union Street on the map is actually Queen Street (Union Street was the former name of State Street). Additionally, this map does not depict the jag in Legare Street at Tradd Street.

Table 13: Residual error in feet for the *Investiture of Charleston* for two types of imagery with intersection control points within the walled city boundaries and without boundaries.

	Intersections within the walled city boundaries	Points	Intersections without boundaries	Points
IOCM 2015 Imagery	12.29	9	16.52	12
Hurricane Ian 2022 Imagery	8.86	9	15.34	12
Average RMS	10.58		15.93	

“Taylor Map”

The “Taylor Map” was created in 1780 during the Siege of Charleston. The map includes a large portion of the Charleston peninsula shortly before the eastern line of the fortification system was dismantled. Even though the three former earthen entrenchments are not represented on this map, the “Taylor Map” was deemed useful for its depiction of the eastern line of fortifications. It was georeferenced using intersection control points both only within and beyond the walled city boundaries. The boundaries for the streets used within the walled city were the same as those used for the other maps.

Residual error calculations of control points within the walled city boundaries and beyond the boundaries suggest the streets beyond the walled city boundaries are less accurately drawn than those within the boundaries. These residual errors are lower than most of the other maps in this thesis, suggesting it is one of the more accurate depictions of the historic landscape of Charleston. However, visual analysis concluded there are some inaccuracies with the street layout. First, the “Taylor Map” does not depict Bedons Alley or Longitude Lane. Second, Chalmers Street has an inaccurate trajectory. Chalmers Street is not included in this thesis as it was realigned after the turn of the 19th century. However, when looking at the overlay of the georeferenced “Taylor Map”, it lies north of today’s Chalmers Street. This is an inconsistency in this map as other streets appear to layout accurately. The residual error supports this observation: with the inclusion of control points at the intersections of Chalmers Street, the residual error increases from 3.16 to 6.88. The residual error for the Hurricane Ian aerial image is significantly lower compared to the IOCM aerial image when control points were taken within and beyond

the walled city boundaries but is not for control points taken only within the boundaries (0.5% and 31%, respectively).

Table 14: Residual error in feet for the “Taylor Map” for two types of imagery with intersection control points within the walled city boundaries and without boundaries.

	Intersections within the walled city boundaries	Points	Intersections without boundaries	Points
IOCM 2015 Imagery	3.16	12	5.60	19
Hurricane Ian 2022 Imagery	3.18	12	4.28	19
Average RMS	3.17		4.94	

Ichnography of Charleston

The *Ichnography of Charleston* was created in 1788 after the Siege of Charleston and the eastern line of the fortification system was dismantled (although this segment of the wall was still drawn on this map). It was georeferenced using intersection control points both only within and beyond the walled city boundaries. The boundaries for the Streets used within the walled city were the same as those used for the other maps.

Residual error calculations of control points within the walled city boundaries and beyond the boundaries result in the same conclusion as the previous maps: streets beyond the walled city boundaries are less accurately drawn than those within the boundaries. The residual error for the Hurricane Ian aerial image is significantly lower compared to the IOCM aerial image when control points were taken within and beyond the walled city boundaries, but is not for control points taken only within the boundaries (0.5% and 11.4%, respectively).

Table 15: Residual error in feet for the *Ichnography of Charleston* for two types of imagery with intersection control points within the walled city boundaries and without boundaries.

	Intersections within the walled city boundaries	Points	Intersections without boundaries	Points
IOCM 2015 Imagery	4.90	17	5.42	33
Hurricane Ian 2022 Imagery	4.92	17	6.04	33
Average RMS	4.91		5.73	

“Halsey Map”

The “Halsey Map” is the latest map used in this thesis with a survey year of 1946. However, the “Halsey Map” includes a drawing of the entire colonial-era fortification system, making it a viable map for this thesis. It was georeferenced using intersection control points both only within and beyond the walled city boundaries. The boundaries for the streets used within the walled city were the same as those used for the other maps.

Residual error calculations of control points within the walled city boundaries and beyond the boundaries do not significantly differ. The layout of the streets on the “Halsey Map” line up accurately with the modern landscape, but the outline of the fortification system is just an approximate depiction. The fortifications appear to be thicker than they were built, the north entrenchment is drawn over the Powder Magazine, which was within the walled city, Craven’s Bastion is drawn further south than on the other maps and plats, and while the Tradd Street redan is placed accurately in location and position, it is not proportionally to scale. These are not surprising observations as while the map most accurately reflects the modern landscape due to its late production, it was the furthest produced from when the walled city was extant.

Additionally, the residual error for the Hurricane Ian aerial image is significantly lower compared to the IOCM aerial image when control points were taken within and beyond the walled city boundaries, but is not for control points taken only within the boundaries (0.69% and 12.3%, respectively).

Table 16: Residual error in feet for the “Halsey Map” for two types of imagery with intersection control points within the walled city boundaries and without boundaries.

	Intersections within the walled city boundaries	Points	Intersections without boundaries	Points
IOCM 2015 Imagery	3.23	14	3.78	30
Hurricane Ian 2022 Imagery	3.21	14	3.36	30
Average RMS	3.22		3.57	

Historic Plats

McCrary Plat 1197

Plat 1197 in the John McCrary Collection from 1787 was created to provide a visual representation and survey for lots and wharves along East Bay Street spanning from Wraggs Alley (today's Cumberland Street) to south of Stoll's Alley. This plat is useful for predicting the location of Craven's Bastion, as the bastion was the last remaining part of the walled city and is drawn on this plat.

Although this plat shows a smaller area than the maps, comparing georeferencing methodologies was applicable and tested by using both street intersections and corners for control points. Residual errors were lower for intersections control points than street corners, suggesting where streets intersect with one another is more accurate on this plat than the drawn lines of the streets. This is again supported when using the entirety of East Bay Street for intersections control points. Intersections chosen for plat include the middle of streets where they meet East Bay Street as it is unknown if East Bay Street is drawn at 33ft or its eventual widening of 66 ft for the maps. However, the McCrary Plat 1197 includes the 66 feet dimension. While the difference in residual error between street corners and intersection control points appears very minimal (0.22), the error of this plat is so low that using intersection control points results in a 22.8% lower residual error than street corners.

Overall, compared to the maps, the residual errors calculated for this plat are very low regardless of method. This was expected as the plat shows great surveying details including measurements and coordinates. Additionally, residual errors show that the

intersection control points were comparable between the aerial images used (3% difference), while the Hurricane Ian aerial image is 49% more accurate than the IOCM aerial image when streets corners were used for control points instead.

Table 17: Residual error in feet for the “McCrary 1197 Plat” for two types of imagery with both intersection and streets corner control points within the walled city boundaries.

	Intersections	Points	Street Corners	Points
IOCM 2015 Imagery	1.20	12	2.02	22
Hurricane Ian 2022 Imagery	1.24	12	1.35	22
Difference in Residual	1.22		1.69	

Table 18: Residual error in feet for the “McCrary 1197 Plat” for intersection control points within the walled city boundaries using the edge or middle of East Bay Street.

	Intersections including edge of East Bay Street	Intersections including middle of East Bay Street	Points
IOCM 2015 Imagery	1.20	0.98	12

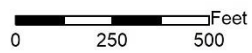


Figure 9: Georeferenced *McCrary Plat 1197* overlaid on the modern streetscape of downtown Charleston.

East Bay Street Plat

Another East Bay Street Plat from 1787 was created to provide a visual representation and survey for lots and wharves along East Bay Street spanning from Wraggs Alley (today's Cumberland St) to south of Stolls Alley. This plat is useful for predicting the location of Craven's Bastion, as the bastion was the last remaining part of the city wall and is drawn on this plat.

Although this plat shows a smaller area than the maps, comparing georeferencing methodologies was applicable and tested by using both street intersections and corners for control points. There was a greater difference in the residuals errors when using intersections for control points between the two imageries than when using Street corners. Additionally, the residual errors were smaller when using the middle of East Bay Street. This plat was made to reflect the widening of East Bay Street, so it is not surprising how low the error is in this case compared to earlier maps.

Table 19: Residual error in feet for the “East Bay Street Plat” for two types of imagery with both intersection and streets corner control points within the walled city boundaries.

	Intersections	Points	Street Corners	Points
IOCM 2015 Imagery	2.92	12	1.84	32
Hurricane Ian 2022 Imagery	1.39	12	1.95	32
Difference in Residual	2.16		1.90	

Table 20: Residual error in feet for the “East Bay Street Plat” for intersection control points within the walled city boundaries using the edge or middle of East Bay Street.

	Intersections including edge of East Bay Street	Intersections including middle of East Bay Street	Points
IOCM 2015 Imagery	1.39	1.17	12

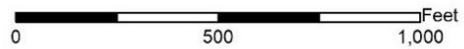
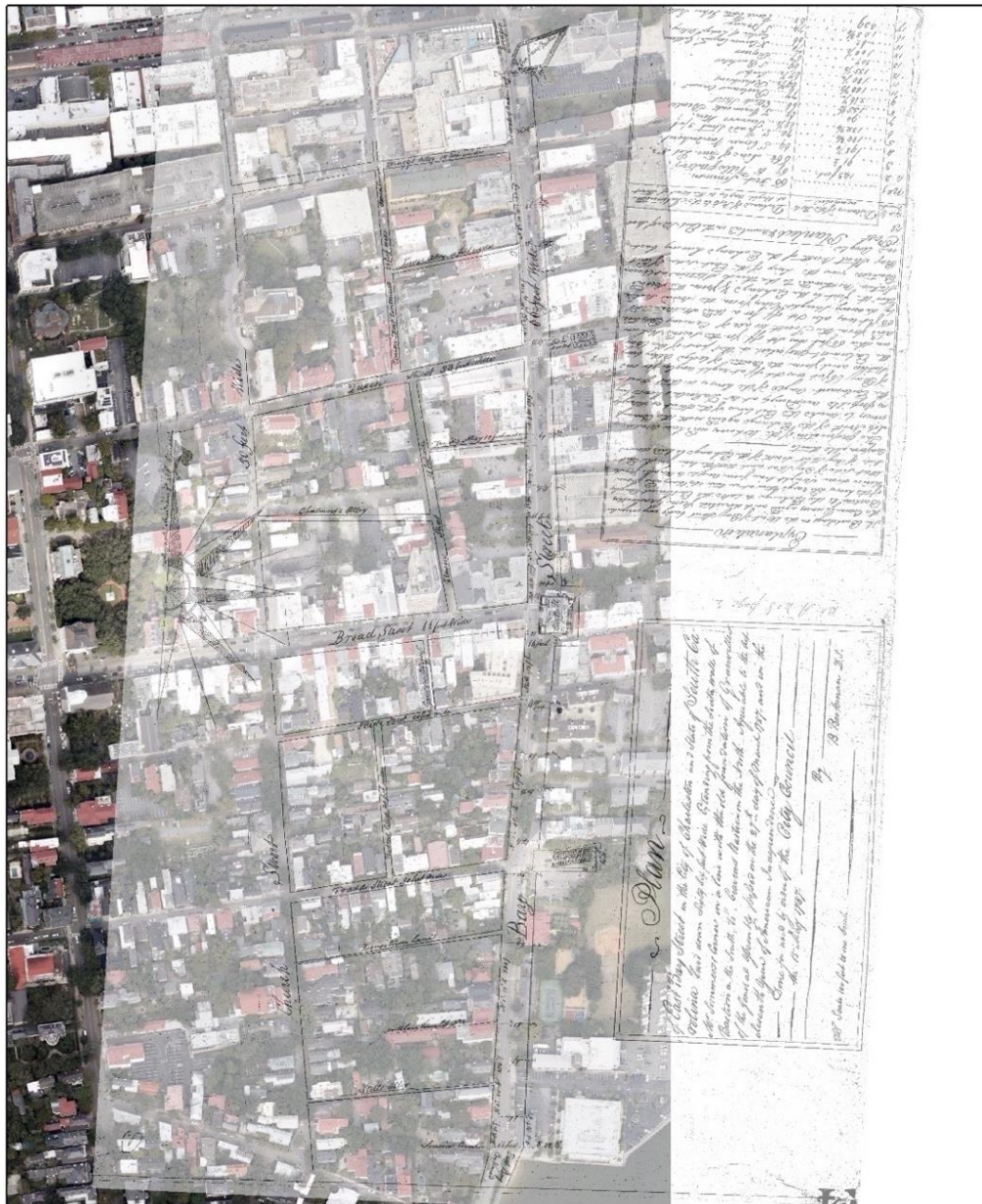


Figure 10: Georeferenced *East Bay Street Plat* overlaid on the modern streetscape of downtown Charleston.

Tradd Street Redan Plat

Due to the *Tradd Street Redan Plat* being limited in size, and GIS needing a minimum of three points to accurately georeferenced the plat, georeferencing was done in conjunction with known archaeology points (three in total). The first order polynomial residual error was 1.35.



Figure 11: Georeferenced Tradd Street Redan Plat overlaid on the modern streetscape of downtown Charleston at South Adger's Wharf.

Craven's Bastion Plat

Similarly, to the Tradd Street Redan Plat, the Craven's Bastion Plat is limited in size, resulting in few control points (total three) The first order polynomial residual error was 0.18. This low error value makes this plat an excellent option for use in making a prediction of a test site location for GPR.



Figure 12: Georeferenced Craven's Bastion Plat overlaid on the modern streetscape of downtown Charleston.

Table 21: Summary table with the average residual error in feet for each historic map and plat.

Map	Intersections within walled city boundaries	Intersections without boundaries	Street Corners within walled city boundaries
"Crisp Map"	12.46		14.7
"Herbert Map"	6.65		6.65
<i>Ichnography of Charles-Town at High Water</i>	4.76	5.25	
<i>Port of Charles-Town</i>	9.84		15.08
"Blaskowitz Map"	8.29	16.94	
"Clinton Map"	16.83	20.84	
<i>Plan de la ville de Charlestown</i>	16.23	21.83	
<i>Investiture of Charleston</i>	10.58	15.93	
"Taylor Map"	3.17	4.94	
<i>Ichnography of Charleston</i>	4.91	5.73	
"Halsey Map"	3.22	3.56	
East Bay Street Plat	1.21		1.69
McCrary Plat	2.16		1.90
Craven's Bastion Plat	0.18		
Tradd Street Plat	1.35		

Summary

In summary, the residual errors calculated for each historic map accurately reflect visual observations for each map. The "Crisp Map" is not drawn to scale, nor does it have a detailed streetscape, explaining why its error is so high. For the maps created in the 1780s during the Siege of Charleston where only the eastern line of fortification was drawn and focus was on the fortification methods further north on the peninsula, residual errors were also reportedly high (with the exception of the "Taylor Map"). The low

residual error for the “Halsey Map” is also explained by its later creation date and its closer match with the modern landscape. However, this map does not have the most detailed walled city drawing as it was created over a century and a half after its demolition. The *Ichnography of Charleston* was the map that was drawn the closest to the period while the eastern fortification line was still standing with the lowest residual error. Therefore, this map served as an excellent template for predicting test site locations for GPR.

The plats had the lowest calculated residual error, the result of the detail placed on taking accurate measurements and the small surface area recorded. The Craven’s Bastion plat had the lowest residual error of all as there were only three control point links possible. This plat, showing the bastion in great detail, was the main guide for predicting test site locations near today’s US Custom House. The Tradd Street plat was also georeferenced with only three control point links, using street corners and the location of the corner point of the redan determined by archaeological excavation. This plat, alongside results for that previous excavation, was used to predict the location for where the curtain line meets the redan.

Georeferenced Overlays And Ground Penetrating Radar

This section discusses the accuracy of the historic maps and plats depiction of Craven’s Bastion, the northern entrenchment wall at Cumberland Street and Church Street, Colleton’s Bastion and western entrenchment wall at Meeting Street south of Tradd Street, and the Tradd Street Redan at Tradd Street and South Adger’s Wharf,

followed by a review of the GPR results conducted at each location (figure). Included in this section are the GPR images produced from surveys at the predicted test sites., as well as a description of the image and the identification of the most probable features discovered.

The figures below present a plan view map of the survey area at approximately six feet below the surface. The arrows mark high-amplitude features that are possibly located under the surface, seen as oblong green, red, and white features oriented roughly East-West. Each of these features is connected to a black and white profile of the feature. In these profiles, horizontal distance is portrayed along the top of each readout and depth is measured along vertical axis on the left side. Features are depicted as high amplitude reflections (color-coded as high-contrast white and black) that represent significant differences in the soil encountered by the radar waves. Each blue-dotted line denotes the location of the transect associated with the connected black and white profile in the figure margins.

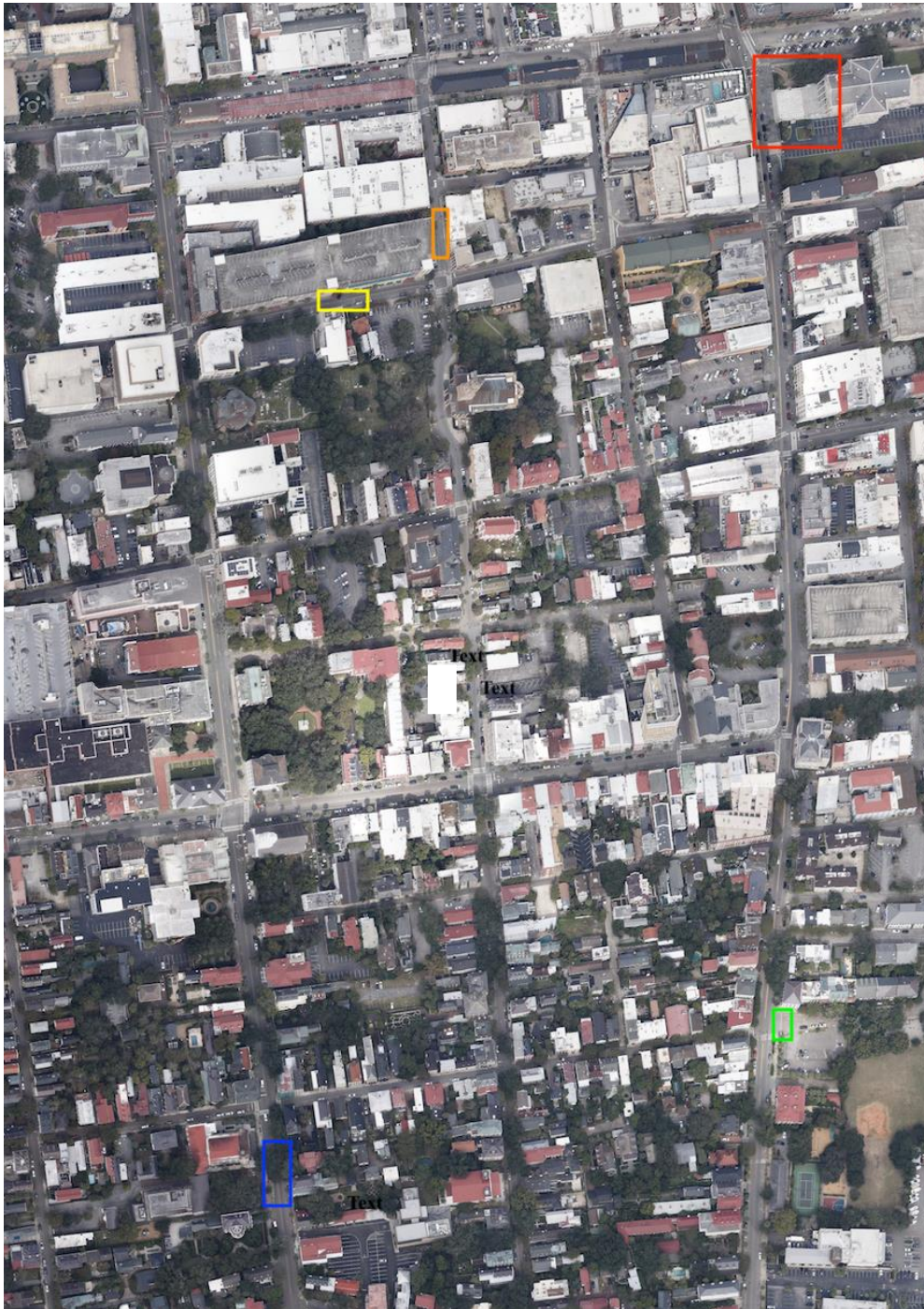


Figure 13: Map of GPR survey locations outlined by boxes (Craven's Bastion in red, northern entrenchment line at Cumberland Street in yellow, northern entrenchment line at Church Street in orange, Colleton's Bastion in blue, and Tradd Street Redan in green).

Craven's Bastion

Four test locations were employed in this study using GPR to locate walled city features. The greatest emphasis was placed on Craven's Bastion, the northeast cornerbastion that remained standing longer than any other walled city feature. After georeferencing and discerning which combination of methods created the lowest residual error (intersections vs street corner control points, inside vs outside the walled city boundaries, inclusion or exclusion of anomaly streets), all of the maps and plats applicable (not the Tradd Street Plat) were overlaid on the Hurricane Ian 2022 reference map to pinpoint potential testing sites. The Hurricane Ian imagery provided the clearest view of the corner of South Market Street and East Bay Street where Craven's Bastion is predicted to have once stood. Below is a summary of the visual observations for each map and plat, including example figures that shows the drawing of Craven's Bastion on the *Ichnography of Charles-Town at High Water Map* and all three historic plats overlaid on the modern landscape. See Appendix B for the overlaid images for all other historic maps.

Overlay of Historic Maps

The "Crisp Map" depiction of Craven's Bastion is accurately placed in respects to being approximately at the corner of South Market Street and East Bay Street where today's US Custom House now stands. However, Craven's Bastion, as well as the walls of the fortification system, are drawn proportionately out of scale, and thus, makes this map unsuitable for making a test site prediction.

The “Herbert Map” depiction of Craven’s Bastion is accurately placed in respects to being approximately at the corner of South Market Street and East Bay Street where today’s US Custom House now stands. However, Craven’s Bastion, as well as the walls of the fortification system, are drawn proportionately out of scale, although less so than the “Crisp Map”. Additionally, the bastion is depicted as having a steeper upward triangular shape than the other maps. Altogether, this map was deemed unsuitable for making a test site prediction.

The *Ichnography of Charles-Town at High Water* Map of 1739 drawing of Craven’s Bastion more accurately aligns with the Walled City Task Force suggestion that the bastion was located directly under the steps of today’s US Custom House. The width of the walls and size of the bastion visually appear more to scale than the two previously mentioned maps. The *Ichnography of Charles-Town at High Water* Map was deemed suitable for predicting potential test sites for GPR.

The map of the *Port of Charles-Town* has the fortification system shifted further east than the other maps and has the redans drawn more closely to the bastions than they were probably actually designed. Visual observation deemed this map unsuitable for making a test site prediction.

The drawing of Craven’s Bastion on the “Blaskowitz Map” has steep upward triangle direction similar to the “Herbert Map” and is placed too far to the east under the US Custom House itself instead of the stairs. Its inaccuracy can be seen based on the bridge shown attached to the bastion. Since East Bay Street was widened 33 ft, the bridge would have had to connect to that street. Instead, this map depicts the bridge as traversing

the east side of the street, meaning the bridge would have been either in the water or over the site where Craven's Bastion has once stood suggested by the Walled City Task Force. This conclusion deemed this map unsuitable for making a test site prediction.

The "Clinton Map" depicts the bastion being much larger and with thicker walls than any other map used in this thesis. It suggests Craven's Bastion stood approximately near the US Custom House, although its scale and direction (it depicts the northern edge of the bastion as being completely horizontal instead of trending at an upward angle) are visually inconsistent with other hypotheses. This map deemed was unsuitable for making a test site prediction.

The *Investiture of Charleston* Map has Craven's Bastion drawn with the same shape and proportions as the "Clinton Map". Both maps have the curtain wall south of the bastion beyond the eastern side of East Bay Street. Since East Bay Street was the eastern edge of the land with the harbor beyond it, if these two maps were accurate, it would suggest the curtain wall was placed out in the water. This could not have been possible as there were wharves that connected to East Bay Street. Therefore, this map was also deemed unsuitable for making a test site prediction.

Similar to the previous two maps, the *Plan de la Ville de Charlestown* has the curtain wall drawn east of East Bay Street where the harbor once abutted the wharves. Additionally, the bastion is drawn with less of a shape than others and the overlay shows it aligns underneath the US Custom House itself, beyond the suggested location of the under the west stair case. The *Plan de la Ville de Charlestown* was also deemed unsuitable for making a test site prediction.

The “Taylor Map” appears to have Craven’s Bastion drawn closer to its actual size than any of the previous maps, although the walls seem to be proportionally too wide. This map lines up with the prediction of the curtain wall running along East Bay Street and the center of the bastion having been located underneath today’s west staircase of the US Custom House. Visual observation suggests while clearly not an exactly accurate depiction of the bastion, the “Taylor Map” may be used in conjunction with other more accurate maps to narrow down potential GPR testing sites.

The *Ichnography of Charleston* Map has a similar shape and size as the “Taylor Map”. It shows the bridge having been on the western half of East Bay Street (the original 33 feet) and the curtain wall running down the eastern edge of the sidewalk to the east of East Bay Street. The bastion is depicted about 100 feet south of the “Taylor Map’s” drawing, but similarly provides enough of an approximation that it may be used in conjunction with other more precise maps to narrow down potential GPR testing sites.

The Halsey’s Map depicted Craven’s Bastion as being located where today’s US Custom House’s south parking lot is currently located. The bastion was not drawn very clearly and without much of a definitive shape. This might be expected as it was created in 1946, over 160 years after it was dismantled and based solely on earlier maps and descriptions. The “Halsey Map” was deemed unsuitable for making a test site prediction.

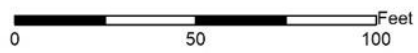


Figure 14: Georeferenced *Ichnography of Charles-Town at High Water* Map overlaid on the modern streetscape of downtown Charleston zoomed in to the intersection of East Bay Street and South Market Street.

Overlays of Historic Plats

McCrary Plat 1197 included the outline of Craven's Bastion, the curtain wall, and the bridge that traversed over the creek where today's Market Street lays. Once georeferenced and overlaid, the bastion was suggested to be located under the US Custom House's west staircase, stepping a few feet into the sidewalk. Based on background knowledge collected by the Walled City Task Force, this appears to align with the hypothesis of where the bastion was once located. However, other features in this plat do not correlate as precisely. The plat lists the width of East Bay Street as 66 feet, which is the measurement for the width of the street today. However, while the overlaid map's western edge aligns with the modern edge of East Bay Street, the eastern curtain line on the map overlays the opposite side of the eastern sidewalk. The bridge was drawn to be the modern width of East Bay Street (66 feet), although it would only have been the width of the 33 feet original street. Therefore, the plat was drawn slightly too large to scale. While still a successful plat for predicting testing site possibilities, the bridge and curtain line overlay suggests the bastion was truly built to the west of its depicted location on the plat.

The East Bay Street Plat has Craven's Bastion, the bridge and the curtain line drawn incredibly similar to *McCrary Plat 1197*. Craven's Bastion and the curtain wall were drawn in the same shape and scale and located at the same point in the georeferenced overlay. The differences regarding the bridge between the two plats are very slight. The bridge on the *McCrary Plat 1197* spans the entire width of modern East Bay Street, including the current parking lanes, while the East Bay Street Plat's drawing

shows a bridge with a smaller width. Additionally, the East Bay Plat states the width of the street to the curtain wall is 68 feet instead of 66 feet. Both plats do denote the length of the eastern curtain wall being 181 feet from the furthest north to furthest south bastions.

The Craven's Bastion Plat includes the most detail about the bastion, including measurements, scale, and trajectory. It describes the curtain wall as running along the edge of East Bay Street, instead of on the other side of the sidewalk like the two previous plats. The western bastion wall overlays the eastern parking lane of East Bay Street, which makes sense considering the eventual 66 feet expansion. This plat also depicts the keeper's house that is not included on the other two plats. It was concluded that this plat would serve as the base for the predicting the GPR testing site locations.



Figure 15: Georeferenced *McCrary Plat 1197* overlaid on the modern streetscape of downtown Charleston zoomed in to the intersection of East Bay Street and South Market Street.



Figure 16: Georeferenced *East Bay Street Plat* overlaid on the modern streetscape of downtown Charleston zoomed in to the intersection of East Bay Street and South Market Street.

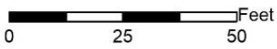


Figure 17: Georeferenced *Craven's Bastion Plat* overlaid on the modern streetscape of downtown Charleston zoomed in to the intersection of East Bay Street and South Market Street.

GPR of Craven's Bastion

The results of the GPR conducted at Craven's Bastion suggest features of Craven's Bastion have been located. GPR taken at two separate segments of the hypothesized location of the northern parapet wall yielded images with high amplitude reflections in flat, rectangular shapes at an approximate depth (two to six feet) and width (approximately six-to-eight feet) acceptable for a masonry parapet wall. These anomalies were detected inside the US Custom's House grounds just north of the west staircase, as well as on the eastern sidewalk of East Bay near the first steps of the west staircase. The overlaid georeferenced Craven's Bastion plat used to hypothesize potential wall locations aligns its drawing of the parapet wall directly over the GPR results.

GPR also showed anomalies in the subterrain where the western wall of the bastion was predicted to have been located. A reflective, shallow parabola shape located at about a depth of two feet to at least five feet (image starts dissipating at this depth) and about three feet in width was detected in the eastern parking lane of East Bay Street against the curb of the sidewalk. The contrast in the amplitude of the image, along with the shape, depth and width of the parabola, are all attributes indicative of a masonry curtain wall component.

There were other anomalies that the GPR machine picked up that are not suggested to be related to the historic fortification system. A high contrast amplitude feature with a width thicker than what a typical utility metal pipe would be was found to correlate with the fire hydrant located on the eastern sidewalk of East Bay Street. Another high contrast image with a thin and prominent parabola shape was detected next to a

possible walled city location. However, the shape is indicative of a pipe and the high contrast in the reflection suggests the feature is made out of metal.

The southeast corner of the bastion, predicted to be located south of the US Custom House's west staircase in the parking lot was the last area to be surveyed with GPR. The GPR did not detect any features where the bastion was predicted to be located. However, an image produced by the machine shows a flat rectangular feature. This anomaly correlates with the square patch of grass located in the parking lot. The GPR result was compared to another project at the College of Charleston's campus where a similar image was produced by a GPR machine surveying a cistern. The reason for the location of the green patch of grass in the parking lot of the Custom House is not clear as it takes away potential prime parking spaces. However, the location of a cistern, even if filled in, would explain why this square section is not available for parking. Therefore, it is suggested this detected feature is not related to the walled city system.

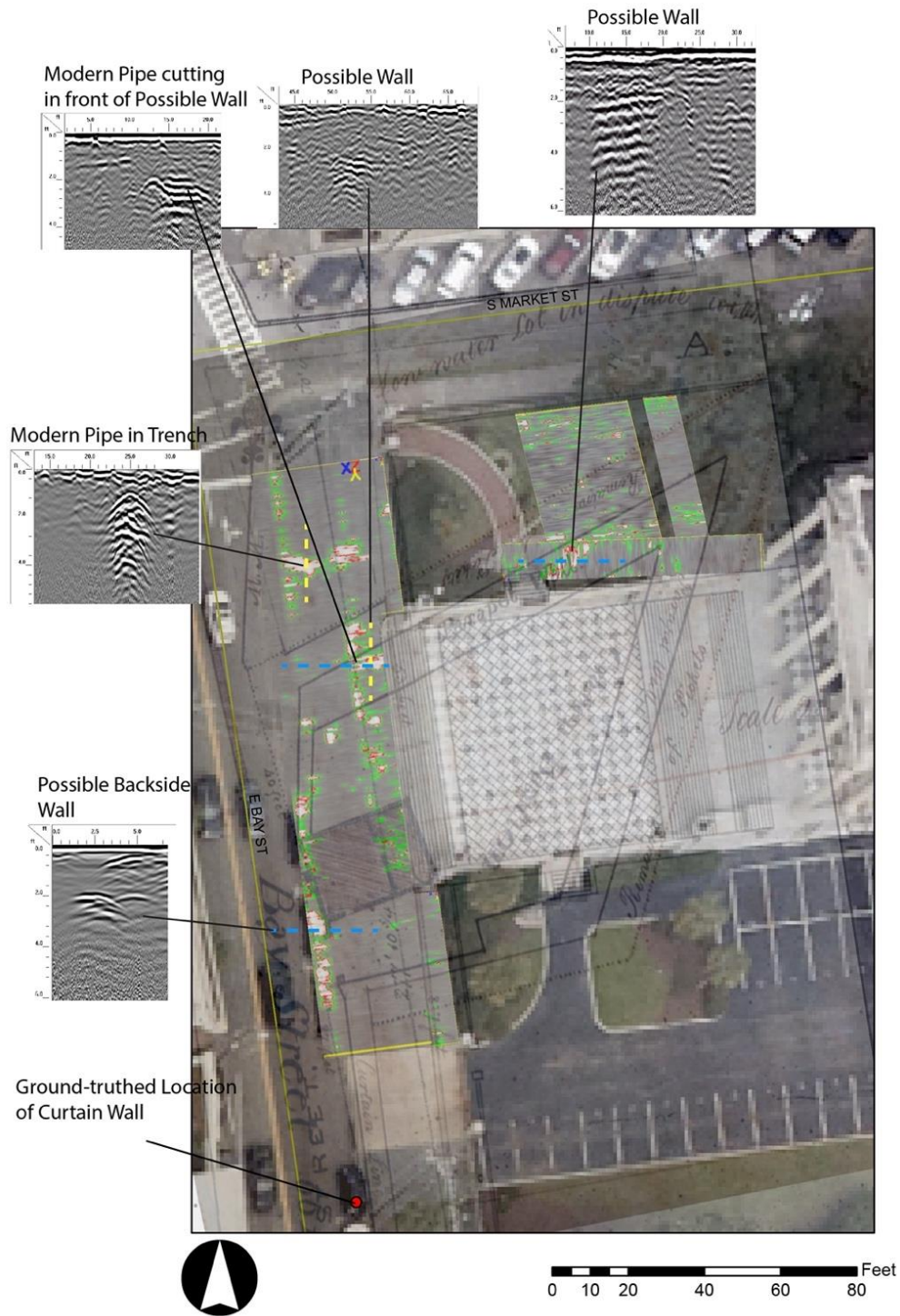


Figure 18: GPR results of Craven's Bastion at East Bay Street and South Market Street.

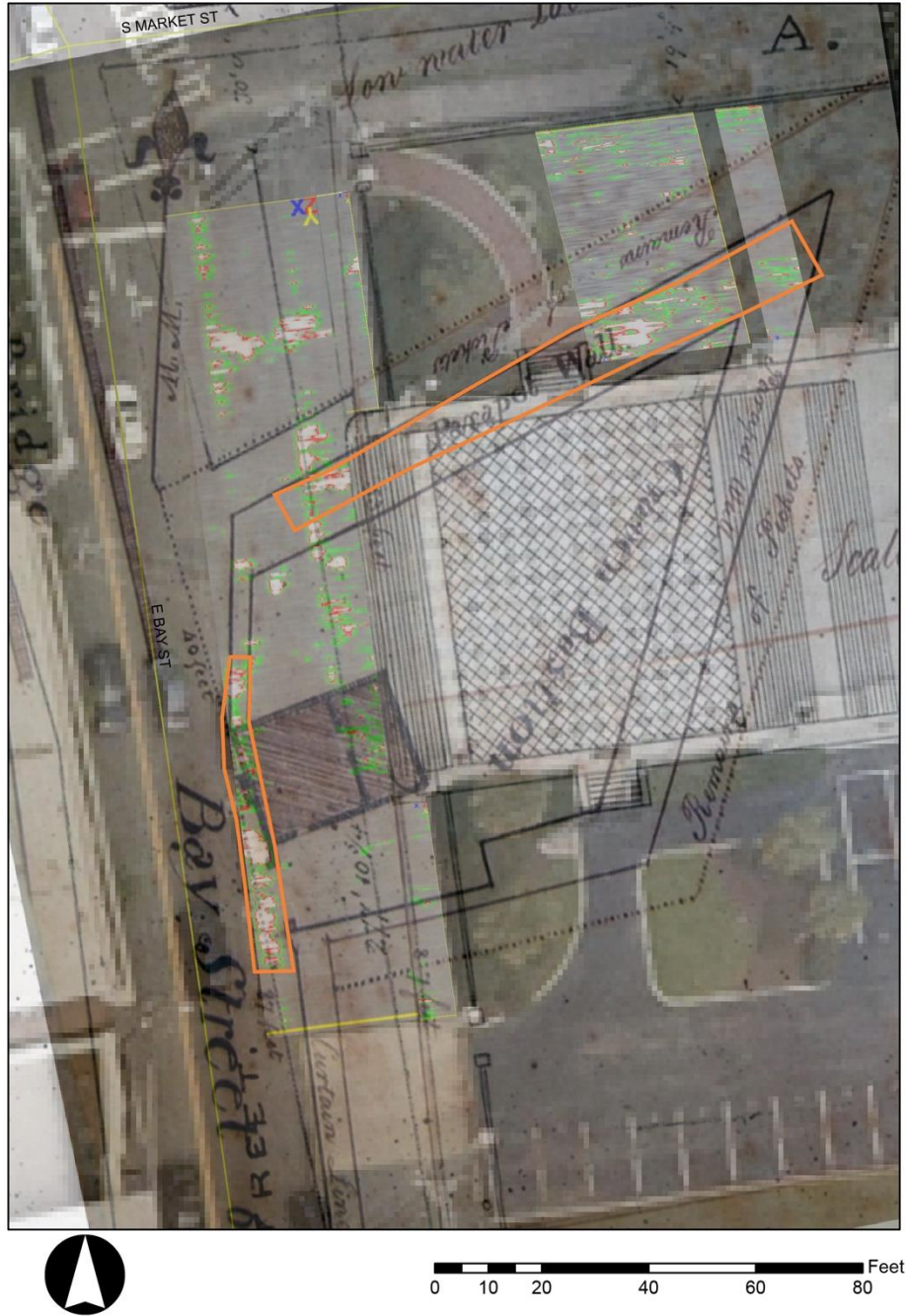


Figure 19: GPR results of Craven's Bastion at East Bay Street and South Market Street with suspected found wall features boxed in orange.

Northern Entrenchment Wall at Cumberland Street and Church Street

Overlay for Northern Entrenchment Wall at Cumberland Street and Church Street

Another of the four test locations employed in this study is a segment of the northern entrenchment wall that ran just north of the Powder Magazine at Cumberland Street and Church Street. After georeferencing and discerning which combination of methods created the lowest residual error (intersections vs street corner control points, inside vs outside the city wall boundaries, inclusion or exclusion of anomaly streets) it was deemed the *Ichnography of Charles-Town at High Water* Map of 1739 was best suited for predicting testing sites. This map agreed with the Walled City Task Force's hypothesis that part of the northern entrenchment line was located under the current parking garage at the northwest corner of Cumberland Street and Church Street.⁸⁰

Additional information concluded by historian Nic Butler was utilized to create a "projection line". Using Craven's Bastion plat (the most accurate of all analyzed), a line was drawn along the parapet wall at an angle of 62 degrees West of South. During his research endeavors, Butler came across a plat that suggests the northern entrenchment line extends from Craven's Bastion at this angle. However, because the "positions of the north and south magnetic poles gradually change over time", a projection line was placed with an angle one degree greater to account for historical declination. At the time this map was created, declination, that is "the angle between the direction of force and the direction of the geographic north pole", was between zero and one degree East of true

⁸⁰ Cite source that says wall was _ feet above the powder mag- <https://www.ccpl.org/charleston-time-machine/creating-walled-city-charleston-enceinte-1704>

North. This is important because the true positions of the north and south magnetic poles can change over time. Figure 19 shows the overlay of this map on modern streetscape and its predicted possible wall trajectory lines following the northern edge of the bastion, red representing 62 degrees and blue representing 63 degrees. Visual observation shows the red line of 62 degrees corresponds to the orientation of the powder magazine.

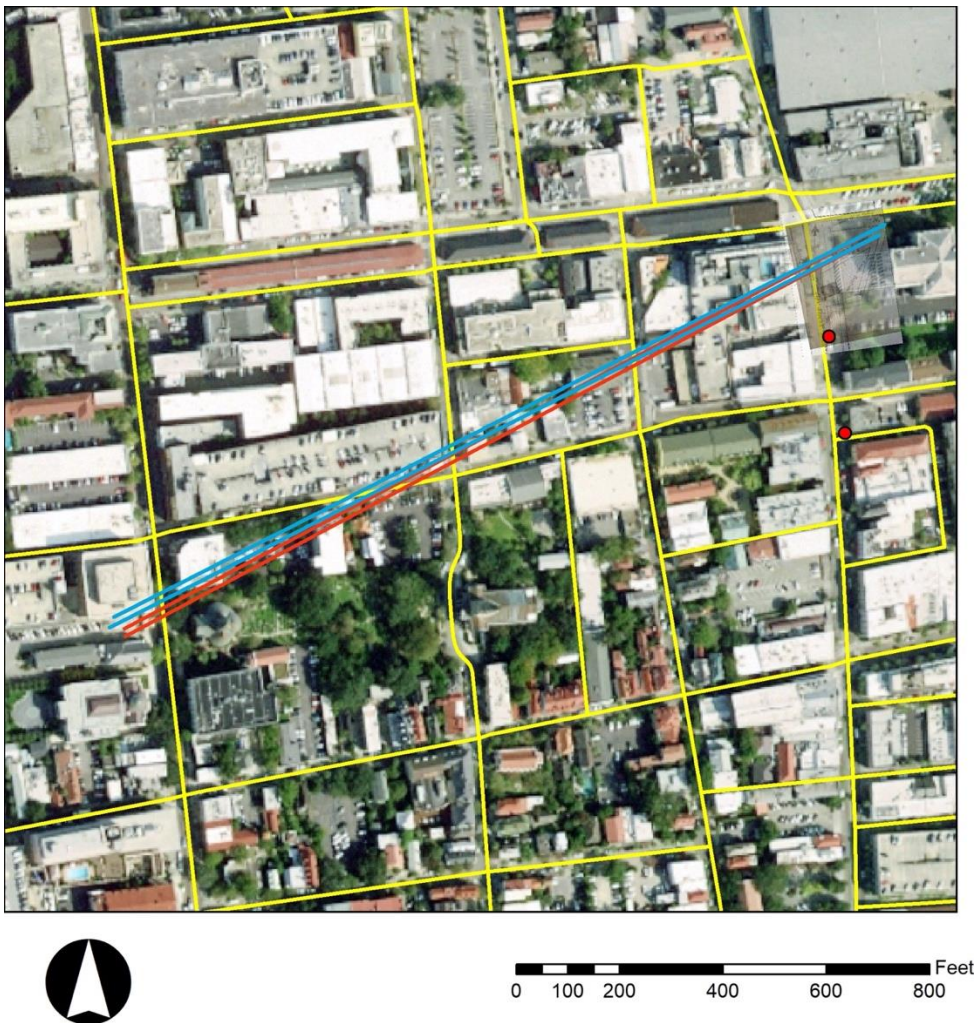


Figure 20: Georeferenced Craven's Bastion Plat overlaid on the modern streetscape of Charleston and its predicted possible northern entrenchment wall trajectory lines.

GPR of Northern Entrenchment Wall at Cumberland Street

Although Cumberland Street is known to have had utility work underneath it, a section of it above The Powder Magazine was surveyed where the northern entrenchment line of the historic fortification system may have traversed. GPR did not produce any results for the center of the street. While the GPR picked up reflective areas representing anomalies under the street, the shape, contract of the amplitude, width, and depth it was all metal utility works, most likely piping. No evidence of a filled in entrenchment was found.

Modern utility pipeworks

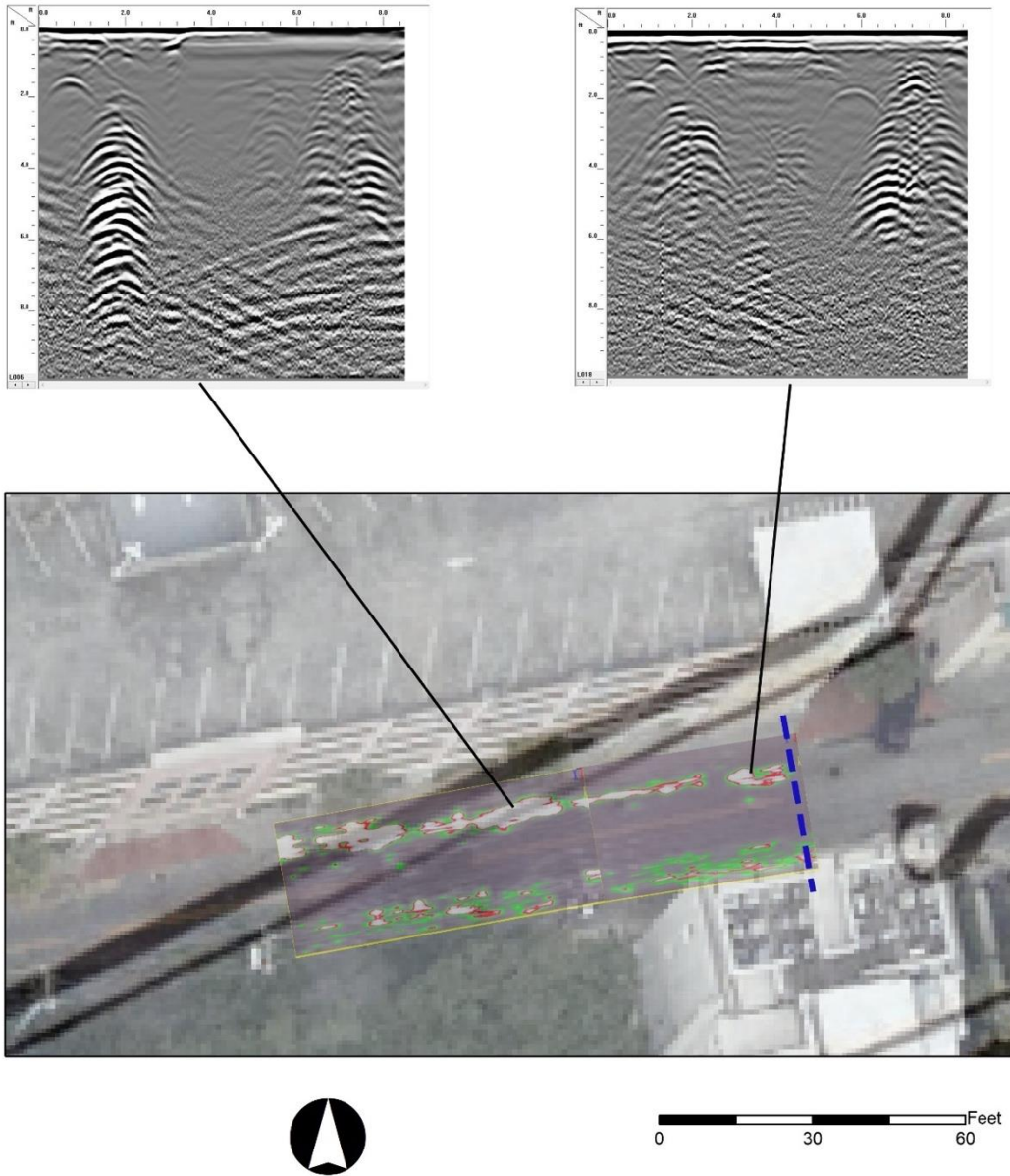
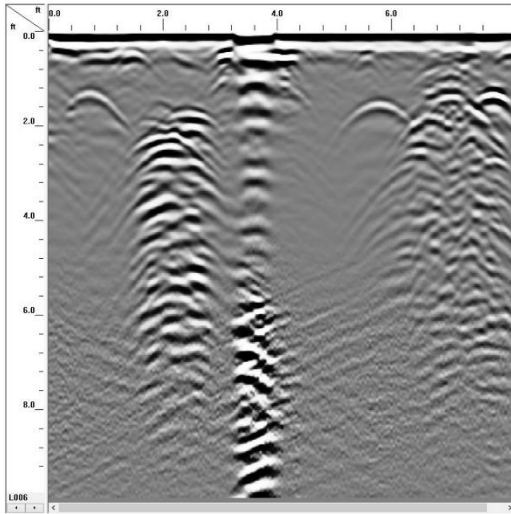


Figure 21: GPR results of the northern entrenchment wall at Cumberland Street.

GPR of Northern Entrenchment Wall at Church St

Similar results were produced from GPR at the section of Church Street predicted to have had the northern entrenchment line intersect. The highly reflective parabolas indicate a feature resembling a metal pipe. This is confirmed as the greatest reflection (seen in the middle of Church Street in Figure 21), is under a utility cover on the surface of the street. No evidence of a filled in entrenchment was found.



Utility cover and pipeworks

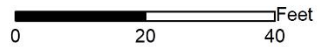


Figure 22: GPR results of the northern entrenchment wall at Church Street.

Colleton's Bastion and Western Entrenchment Wall at Meeting Street

Overlay for Colleton's Bastion and Western Entrenchment Wall at Meeting Street

A segment of the historic fortification system that has not been studied greatly is Colleton's Bastion located just south of Tradd Street on Meeting Street. Previous work by Jon Marcoux at the First Baptist Church property at that corner and of a private property on the east side of Meeting Street provided known wall locations that could be used to create a potential wall projection line (Figure 22). Together with the "Ichnography of 1739 Map", a location testing site was decided on for GPR analysis.

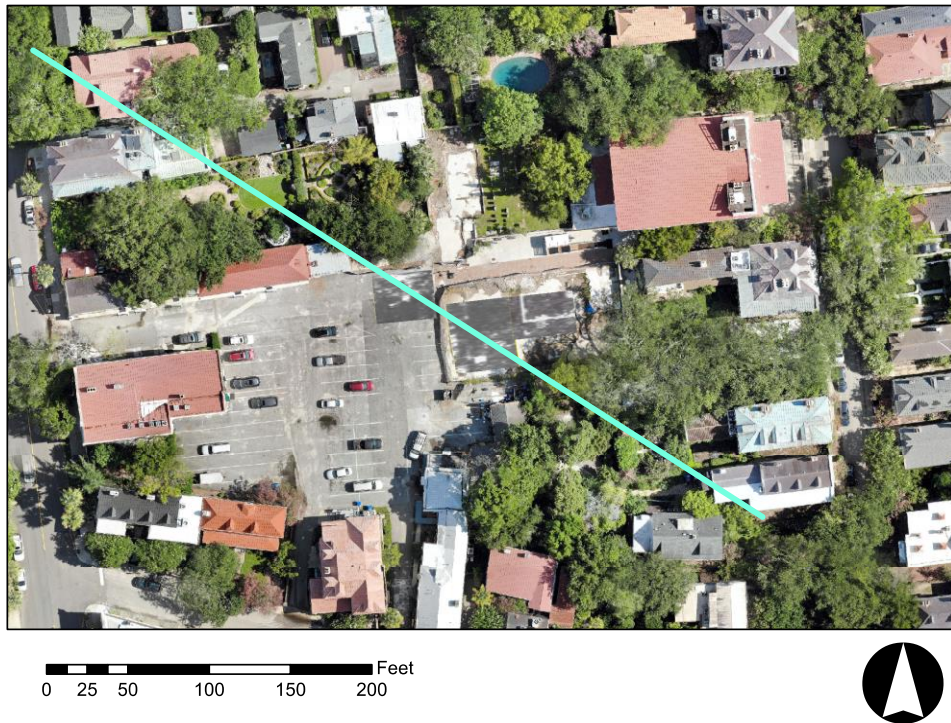


Figure 23: GPR results previously taken by Jon Marcoux on the modern streetscape of Charleston and its predicted possible southern entrenchment wall trajectory lines towards Colleton's Bastion.

GPR of Colleton's Bastion and Western Entrenchment Wall at Meeting Street

GPR results produced from the testing site at Meeting Street, next to the First Baptist Church, did not suggest any clear evidence of a former entrenchment. A highly reflective metal pipe was detected underneath a modern utility cover on the surface of the street. Other findings produced images that had faint wide parabola shapes and sections of high amplitude with jagged appearances. This is the same result one would expect when looking for in-fill. However, since Meeting Street has been replaced, in-filled and had trolley lines put in, and there is not a consistent diagonal line across the width of the street, it cannot be concluded that the bastion or entrenchment walls were detected.

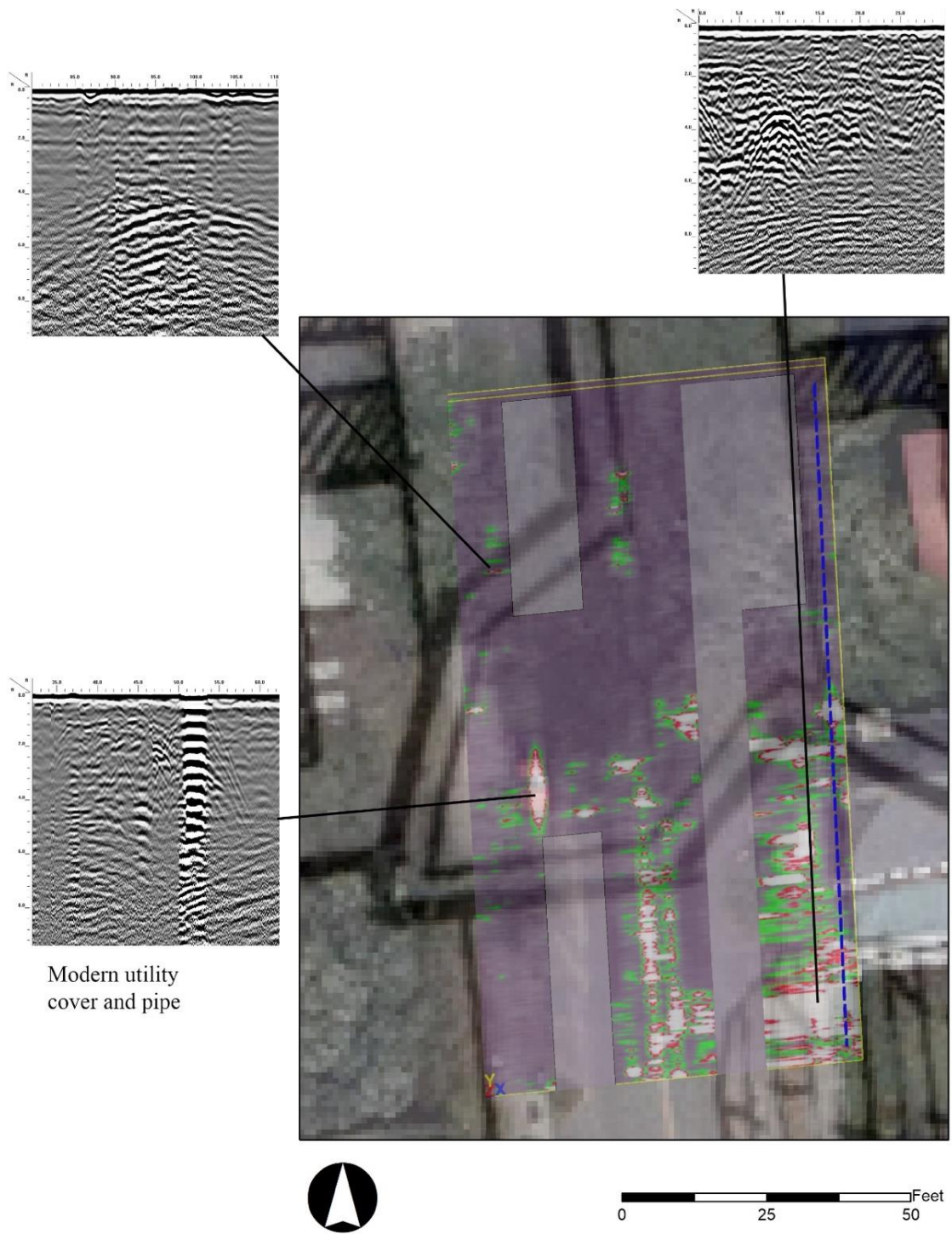


Figure 24: GPR results of Colleton's Bastion and western entrenchment wall at Meeting Street.

Tradd Street Redan at South Adger's Wharf

Overlay for Tradd Street Redan at South Adger's Wharf

The overlay of the Tradd Street Redan Plat on the referenced map, created in conjunction with the known redan point found during an archaeological excavation suggests the redan meets the curtain wall along the eastern edge of East Bay Street under the parking lane. Due to the plats great detail, descriptions, and alignment with known redan points, this plat was used for prediction of a GPR testing site.



Figure 25: Georeferenced *Tradd Street Redan Plat* overlaid on the modern streetscape of downtown Charleston zoomed in to the intersection of East Bay Street and South Adger's Wharf.

GPR of Tradd Street Redan at South Adger's Wharf

GPR was conducted at the testing site for the Tradd Street Redan in part of the street, on the sidewalk, and into the entrance of the parking lot at South Adger's Wharf. Anomalies detected can be categorized as modern utility work and as potential curtain wall features. The reflections in the middle of the street are of a high amplitude, with the width and depth of modern piping, similar to those found at Cumberland Street, Church Street and Meeting Street. The reflections south of the building that sits at the northeast corner of Tradd Street and South Adger's Wharf are consistent with those found at modern sidewalks.

Additional anomalies were reflected by GPR that resulted in images that one would expect to see when searching for a brick wall. Figure 25 shows reflections that are not as high in amplitude as metal in a flat and rectangular shape. Additionally, these features were found to be right where the curtain wall was predicted to be: on the eastern half of East Bay Street. This reflection was also detected at an angle towards the South Adger's Wharf parking lot where the redan is hypothesized to have met the curtain wall.

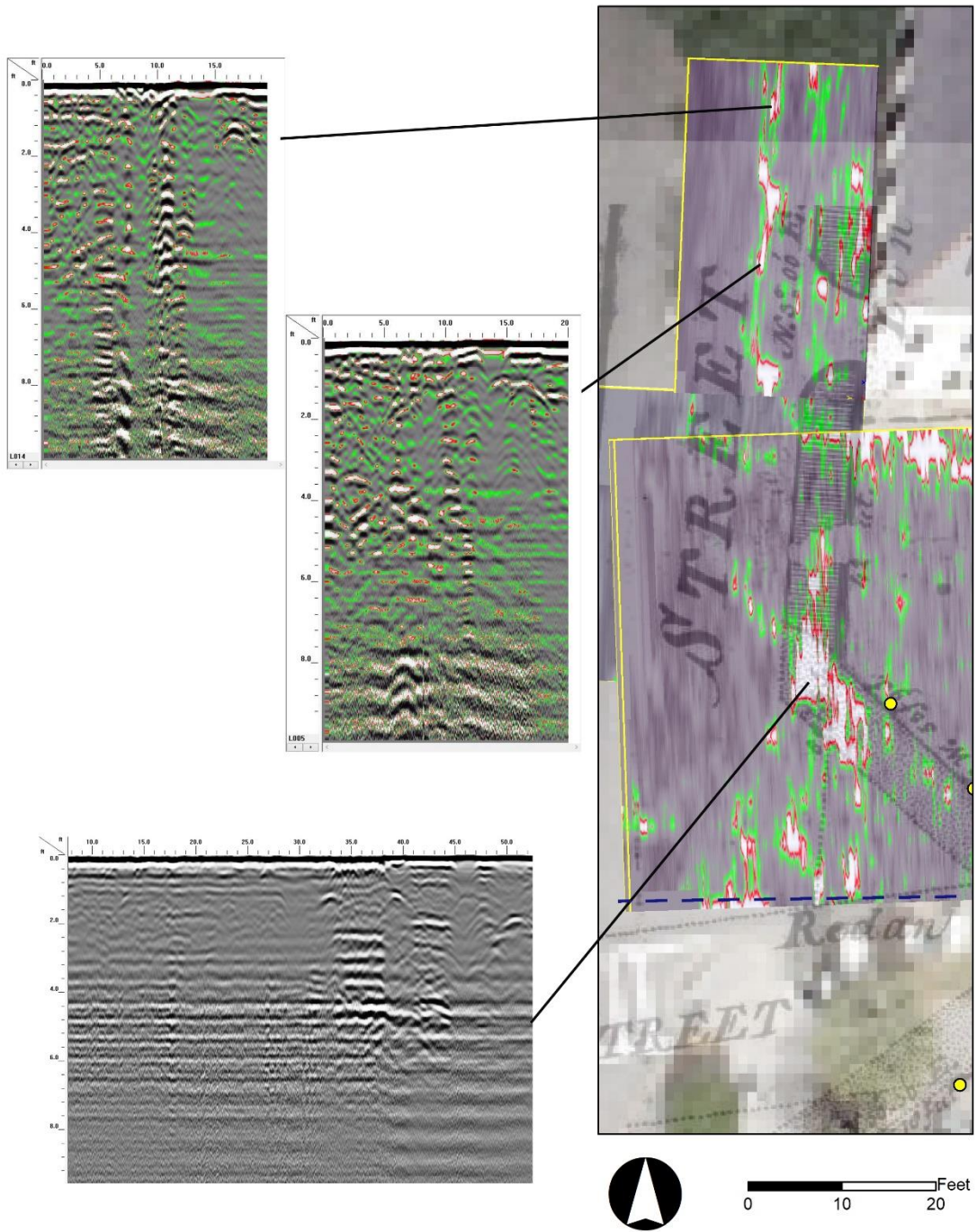


Figure 26: GPR results of the *Tradd Street Redan* at the intersection of East Bay Street and South Adger's Wharf.

Summary

In summary, results produced by the GPR survey show that while there are multiple anomalies under the sections of Cumberland Street, Church Street, and Meeting Street, they are most likely a part of modern utility pipework. Any indications of “in-fill” are most likely attributed to the reconstruction of those streets over time, and are not thought to be related to the walled city system.

GPR surveys of the area around the US Custom House at East Bay Street and Market Street and the intersection of Tradd Street at South Adger’s Wharf produced images of features that are most likely both modern utility pipework and sections of masonry rectangular structures underneath. A possible section of the north parapet wall, alongside a portion of the western wall at Craven’s Bastion may have been detected. At Tradd Street and South Adger’s Wharf, a possible curtain wall feature and corner of the Tradd Street Redan have been detected.

CHAPTER FIVE

CONCLUSION

This thesis employed a multi-tool approach in an effort to locate sections of Charleston's early 18th-century fortification system. While scholarly research and a few archaeological excavation have already been undertaken for the walled city by Charleston's Walled City Task Force, a majority of the sections of the city wall have yet to be definitively located. One important aspect to studying and searching for the walled city is the analysis of historic maps and plats. However, the accuracy of some of the most popular and important historic maps of Charleston's peninsula had yet to be determined. Once the eleven historic maps and four historic plats were georeferenced to the modern landscape through aerial imagery and residual error in feet was calculated, testing sites for surveying portions of the walled city via GPR were predicted.

Georeferencing

The different methodologies used for the georeferencing process suggest the smallest deviation in a methodology can alter the calculated residual error. For example, the residual error for every map georeferenced with street corners as control points was greater than if intersections were used as control points instead. Residual error was also greater when control points were taken within and beyond the walled city boundaries instead of just within. This suggests that the smaller the area being georeferenced, the smaller the residual error, and/or the walled city landscape (the first streets in Charleston) has remained relatively unchanged overtime compared to the modern streetscape today.

Residual error can also change drastically depending on whether or not every detail on a historic map is included in the georeferencing process or if anomalies detected through visual observation first are removed. While minimizing the visual errors before georeferencing allowed for a more accurate overlay for helping predict survey test sites, their removal alters the calculated accuracy of the entire historic map itself.

The historic maps that had the highest residual error were those created around 1780 during the British Siege of Charleston. Most of these maps were drawn by foreign soldiers with the emphasis of recording military movements on the upper peninsula. Because most of the brick eastern fortification line of the early city fortification was still standing at that time, it was included on these maps. It is clear that the fortification line with its bastions and redans were not nearly as important to the surveyors and the men they were creating them for than the American Revolution components of the landscape. The exception was the “Taylor Map” that had the lowest residual error of any map.

The “Crisp Map” and the *Port of Charles Town* were produced before the American Revolution and had residual errors that were above the average for the eleven maps. There is little detail in these two maps as their purpose was to draw the newly settled Charleston peninsula and its surrounding waters and islands.

The “Halsey Map” had the second lowest residual error, and while the residual error for the entire map was low relative to most of the others, visual observation suggests that the city wall outline was not accurate. These two conclusions are the result of it being the latest map surveyed out of the eleven used in this thesis.

The *Ichnography of Charleston* Map of 1739 had the third lowest residual error out of the eleven maps, but had the entire fortification system drawn approximately to scale based on visual observation compared to most of the other maps. Therefore, this map was chosen to be a source for predicting surveying testing sites.

The McCrady Plat 1197 and East Bay Plat used had lower residual error compared to the maps. This is not surprising as these historic plats were surveyed with great detail and measurements of both property lines and streets were taken. The Craven's Bastion Plat and Tradd Street Redan Plat were the two plats that served best for the prediction of GPR surveying test sites for those two locations. After all, these historic plats were created to specifically document their respective feature.

Ground Penetrating Radar

The four areas chosen as GPR survey testing sites included areas at the southeastern corner of Market Street and East Bay Street near today's US Custom House, the intersection of East Bay Street and South Adger's Wharf, Meeting Street south of Tradd Street adjacent to the First Baptist Church, and two sections on both Cumberland Street and Church Street (near where they intersect) near the Powder Magazine. The selection of these testing sites came from a combination of analysis of georeferenced maps, scholarly research, and Walled City Task Force member suggestions.

Results produced by the GPR survey show multiple anomalies under the sections of Cumberland Street, Church Street, and Meeting Street that are suggested to be a part of the modern utility pipework under the main city streets. Any indications of "in-fill" are

most likely attributed to the reconstruction of those streets over time, and are not thought to be related to the walled city system.

GPR surveys of the area around the US Custom House at East Bay Street and Market Street and the intersection of Tradd Street at South Adger's Wharf produced images of both modern utility pipework, but also those that suggest there are sections of masonry rectangular structures underneath. A possible section of the north parapet wall, alongside a portion of the western wall at Craven's Bastion has been detected. At Tradd Street and South Adger's Wharf, a possible curtain wall feature and corner of the Tradd Street Redan were also detected.

Future Studies and Recommendations

While GPR provides the first indication of a subterranean feature, until it is visually seen, the identification of the feature remains a hypothesis. The results for this thesis provides enough evidence to suggest where the fortifications are located at the two sites surveyed on East Bay Street. The next step to confirm these findings is to "ground truth" these locations through archaeological excavations, which is beyond the scope of this thesis.

This thesis was limited to the number of historic maps and plats drawn for the Charleston peninsula in the 18th century. While some of the most popular maps were employed in this study, only maps or plats that depicted the walled city were chosen. Therefore, a full examination of the accuracy of Charleston historic maps has only been started and is not complete. The methodology in this thesis serves as a step-by-step guide

for additional historic maps to be analyzed for accuracy, as well as for the discovery of other historic subterranean features lost to the modern world.

This thesis has already aided the Walled City Project in Charleston. The fence line that surrounds the US Custom House at the corner of South Market Street and East Bay Street has begun to deform and lose structural stability. Through visual observation and an analysis of the georeferenced maps and plats and GPR results, it has been determined that one of the corner posts near the staircase that is leaning sits partially atop a solid masonry structure. This post has begun to tilt and sink where it does not align overtop that structure. It is likely that masonry structure is part of the parapet wall that surrounded Craven's Bastion.

Results of this thesis provides a strong defense for future archaeological excavations, as well as in the importance of the walled city system to Charleston. I recommended another excavation to be conducted west (front) of the US Custom House on the sidewalk underneath the blue stone, and perhaps into the parking lane. This should unearth portions of the curtain wall and help determine where that line meets Craven's Bastion.

I also recommend that the City of Charleston work alongside the National Parks Service and the United States National Committee of the International Council on Monuments and Sites (US/ ICOMOS) to pursue designating the 62 acres that once made up the first urban area of Charleston's peninsula that were encompassed by the fortification system as an UNESCO World Heritage Listing. There are six criteria for

nominating a cultural site for the listing. The colonial walled city of Charleston can be successfully argued for the following criteria:

- The fortification system is applicable under Criteria I which states a site must “represent a masterpiece of human creative genius”⁸¹.
- As this section of Charleston stood as the urban center around the turn of the 18th century and impacted town expansion, it is applicable under Criteria II in that it “exhibit[s] an important interchange of human values, over a span of time or within a cultural area of the world, on developments in architecture or technology, monumental arts, town planning, or landscape design”⁸².
- These 62 acres of Charleston, being the only significant English walled city in the United States, and significant in the development of military defenses in the New World, is applicable under Criteria IV as it is “an outstanding example of a type of building, architectural or technological ensemble, or landscape, which illustrates (a) significant stage(s) in human history”⁸³.
- As the walled city was the urban center of Charleston where large numbers of immigrants arrived, where trade for the southern colonies prospered, including the slave trade, and the town flourished into a major

⁸¹ “A Quick Guide to the World Heritage Program in the United States”. 2021. National Parks Service International Cooperation.

⁸² Ibid.

⁸³ Ibid.

port city, it is applicable under Criteria V as “outstanding example of a traditional human settlement, land-use, or sea-use which is representative of a culture (or cultures), or human interaction with the environment especially when it has become vulnerable under the impact of irreversible change”⁸⁴.

As for the walled city itself, I suggest the Walled City Task Force continue its efforts to trace the outline of the system on the surface using a brick path like the redan near South Adger’s Wharf, at least on City property. All remnants of the masonry wall or the entrenchments remain under today’s modern streetscape, unbeknownst to the thousands of tourists that walk on the sidewalks every day. Continuing to trace the fortification system, as well as implementing more wayside signs (similar to the one located at South Adger’s Wharf), will continue to educate the public on historic military endeavors and the early years of Charleston. These efforts, in conjunction with further scholarly research and Walled City Task Force undertakings, will allow the history of this area of the peninsula to be preserved for years to come, instead of continuing to be hidden beneath the surface.

⁸⁴ Ibid.

APPENDICES

A. FIGURES OF HISTORIC MAPS AND PLATS



Figure 27: "Crisp Map".

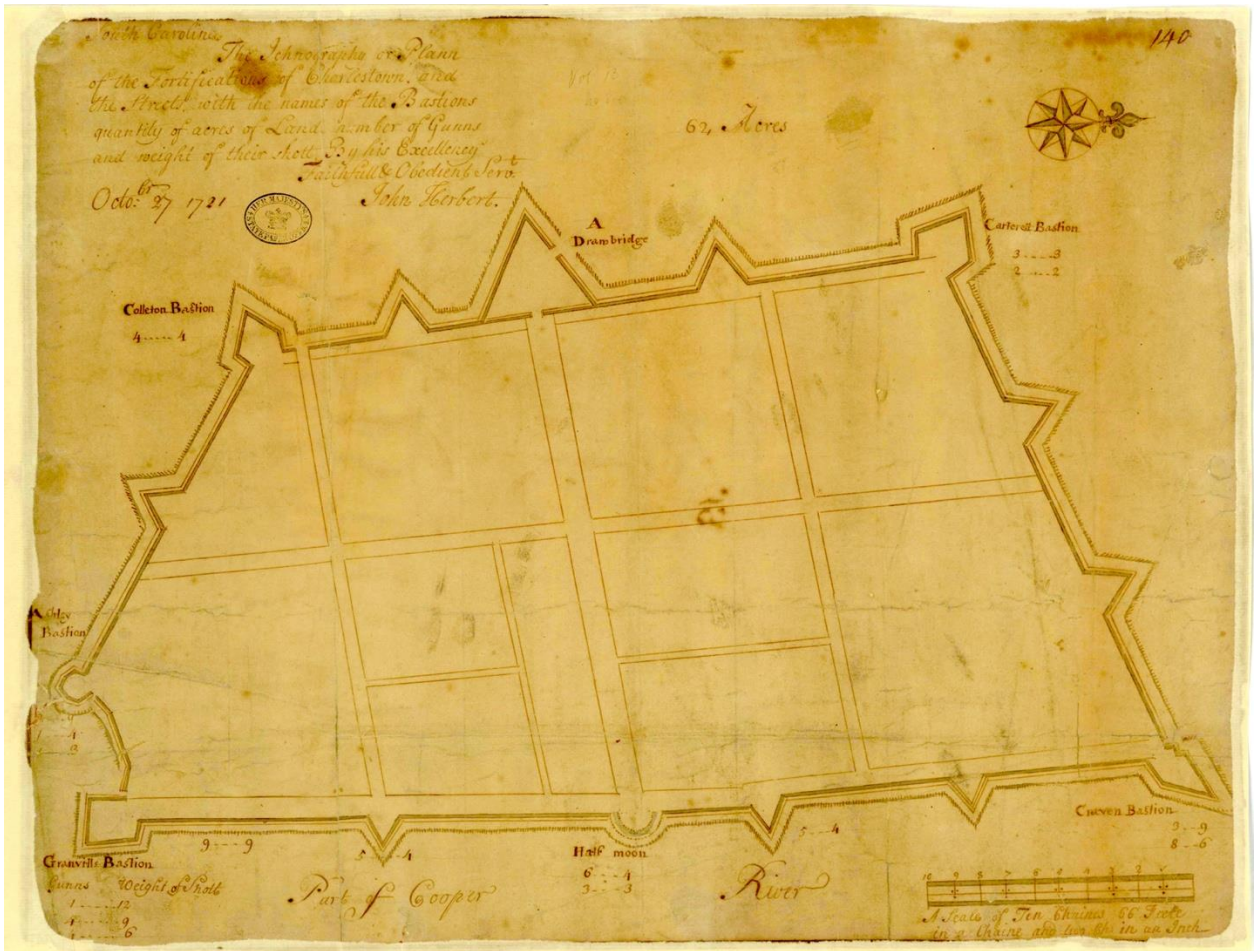


Figure 28: "Herbert Map"

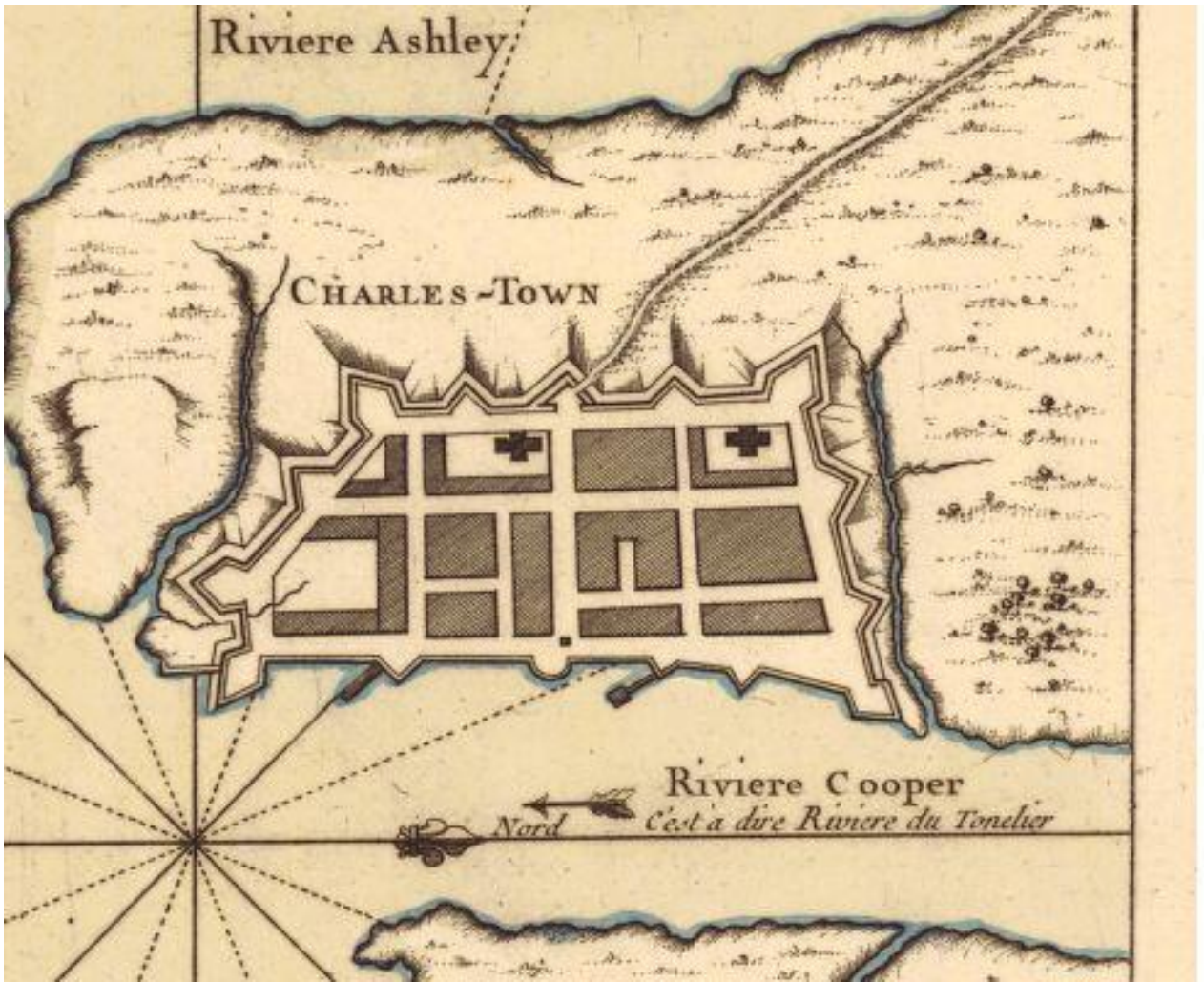


Figure 30: Port of Charles-Town.



Figure 31: “Blaskowitz Map”.



Figure 32: "Clinton Map".



Figure 33: Plan de la Ville de Charlestown.



Figure 34: Investiture of Charlestown.



Figure 35: "Taylor Map"

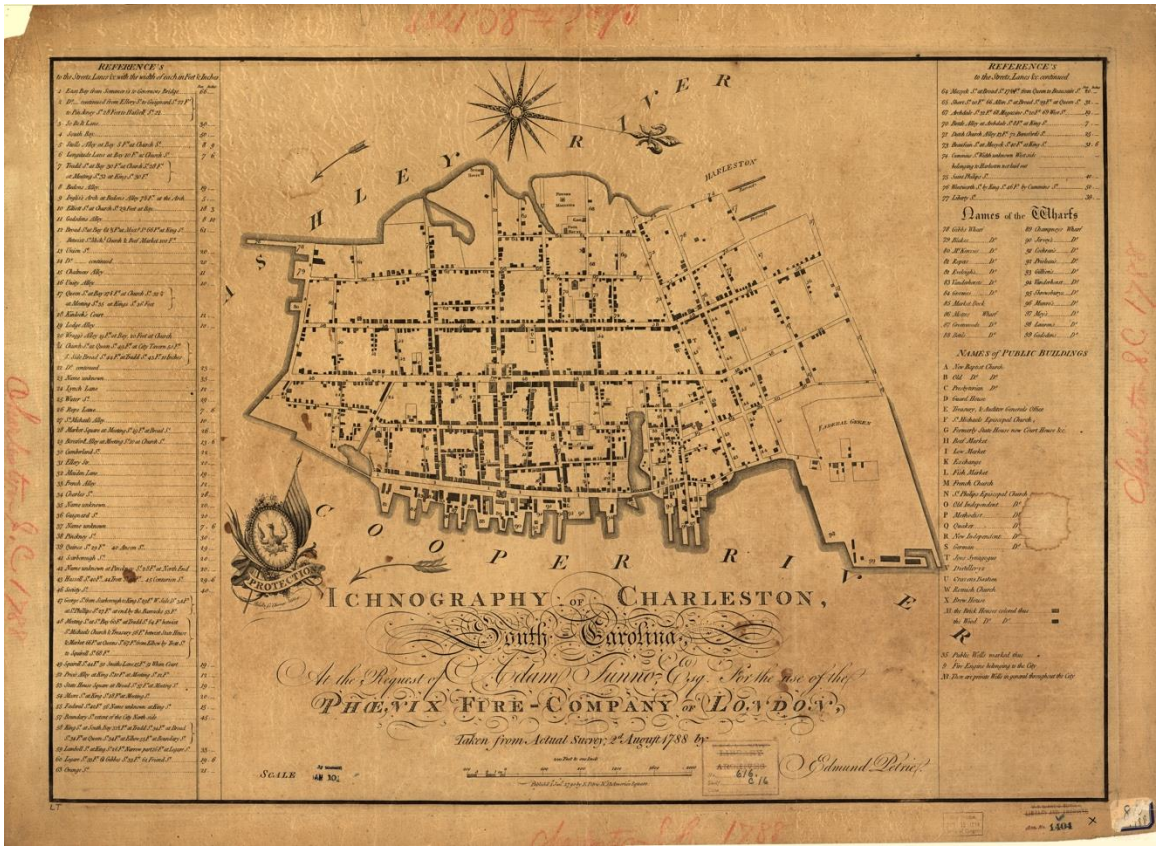


Figure 36: Ichnography of Charleston 1788.

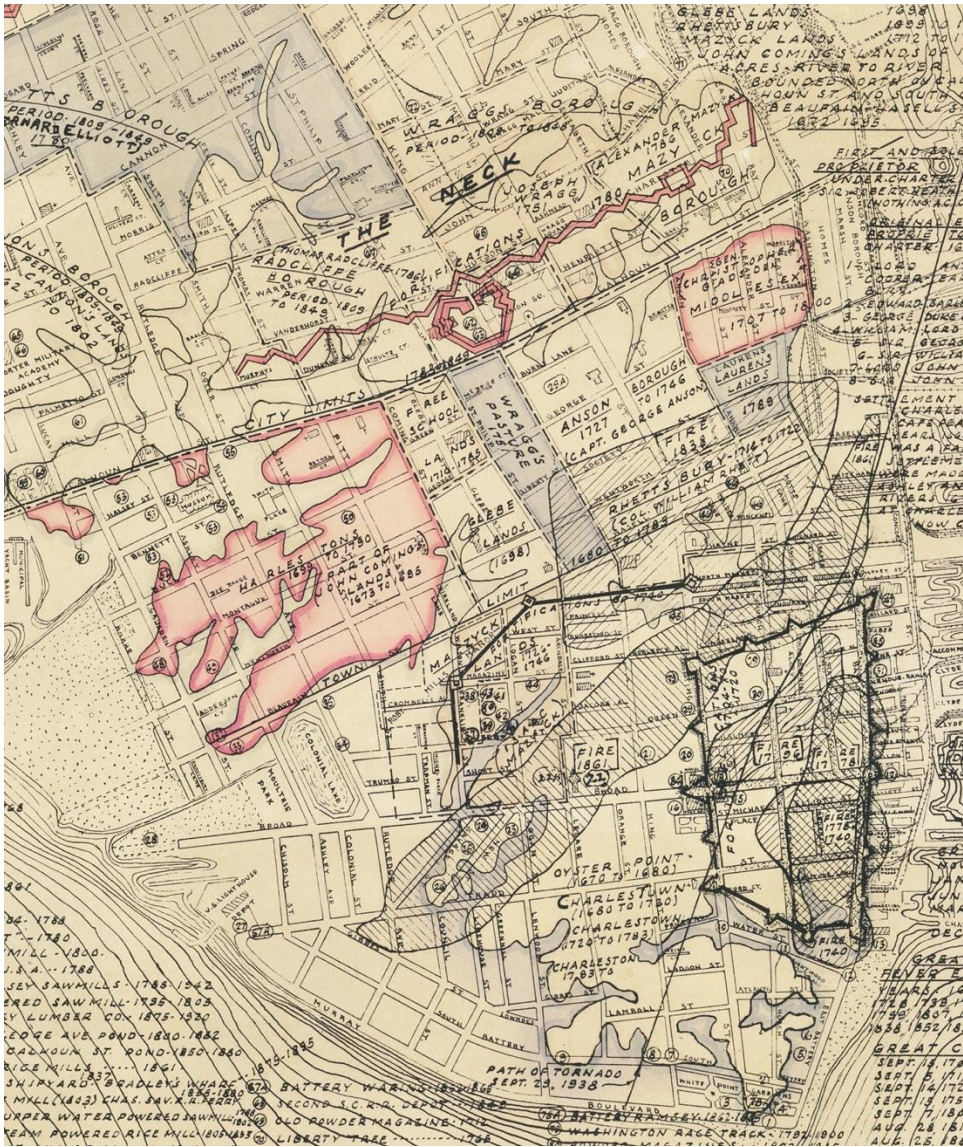


Figure 37: "Halsey Map"



Figure 38: McCrary Plat 1197.

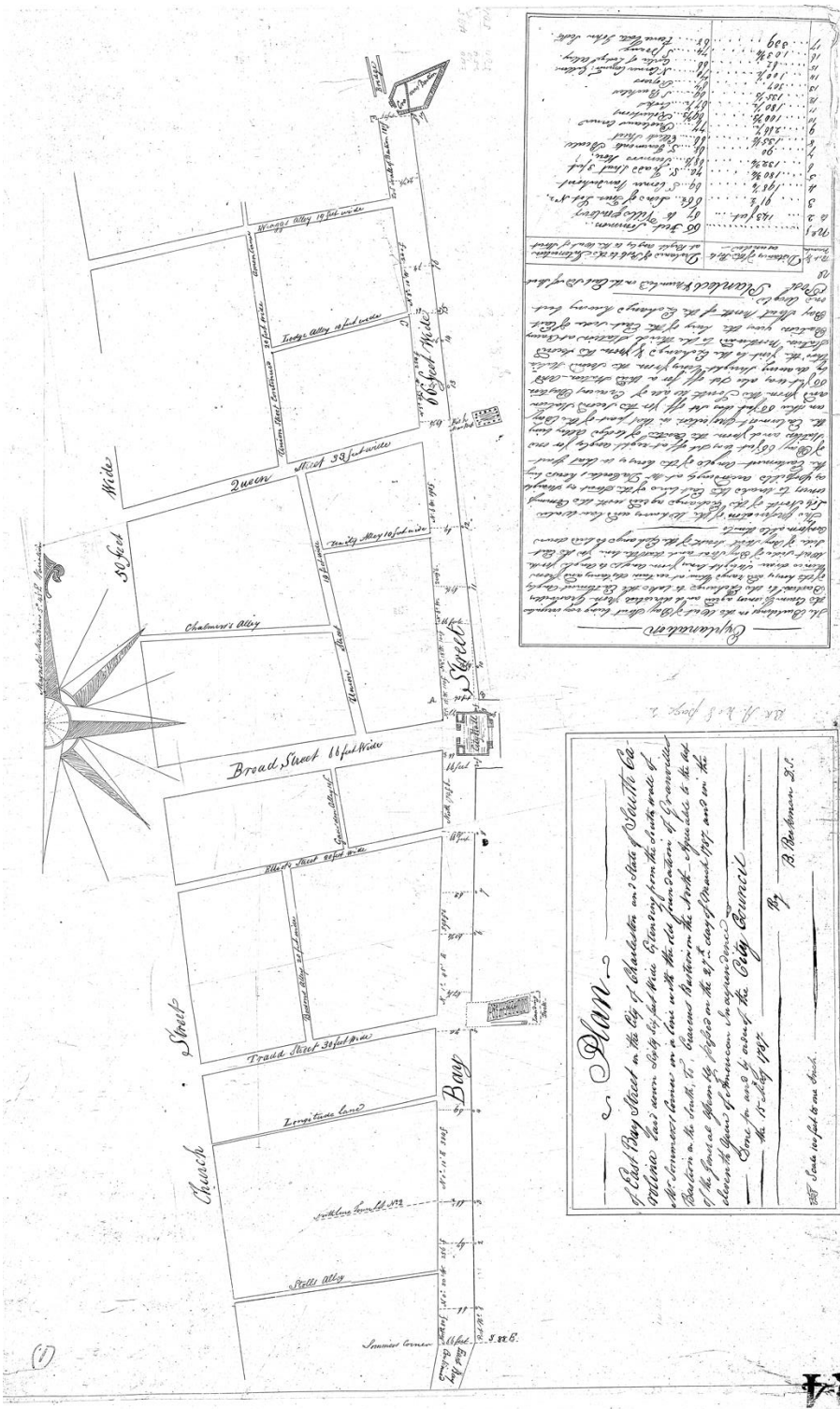


Figure 39: East Bay Street Plat.

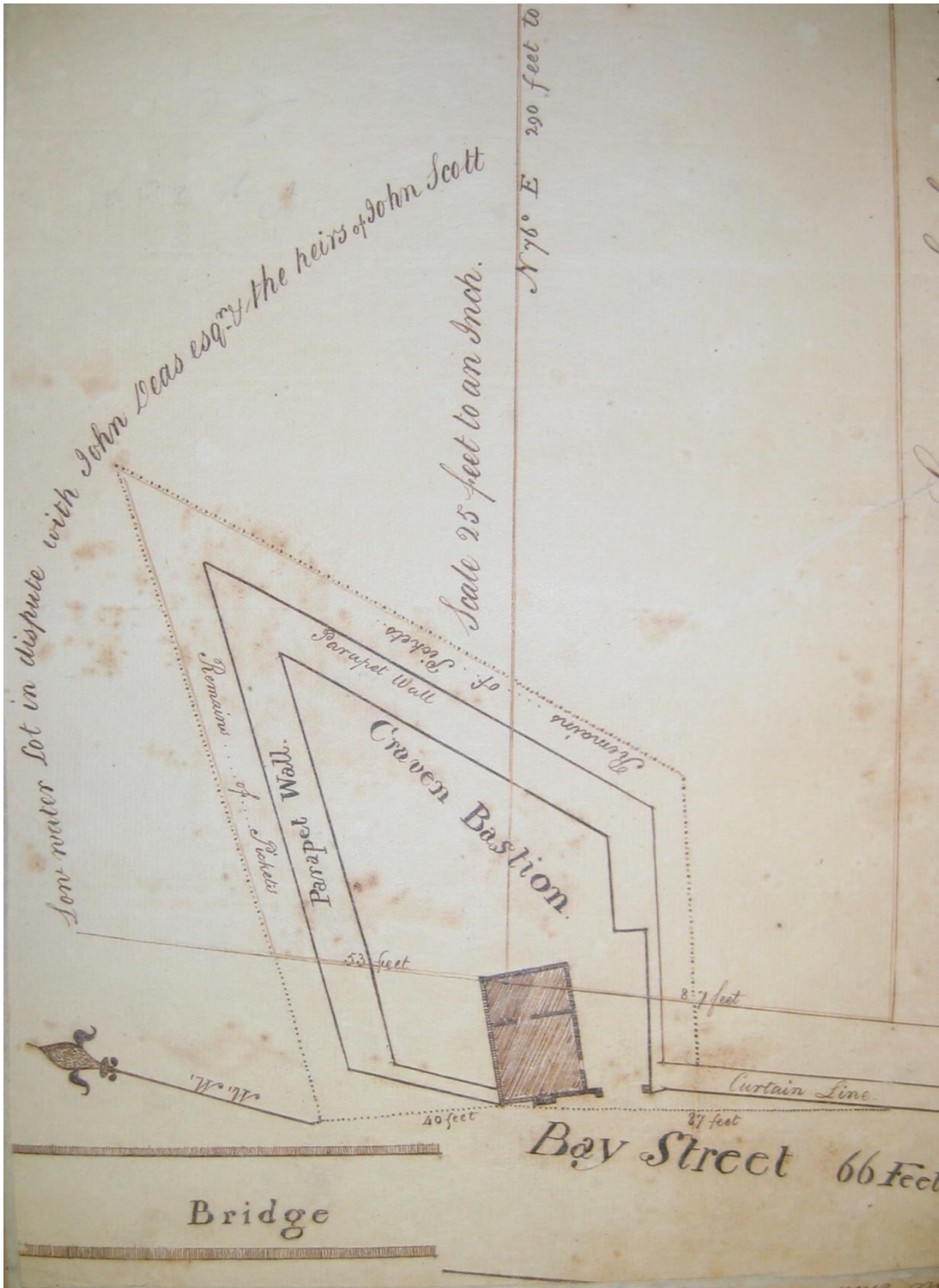


Figure 40: Craven's Bastion Plat.

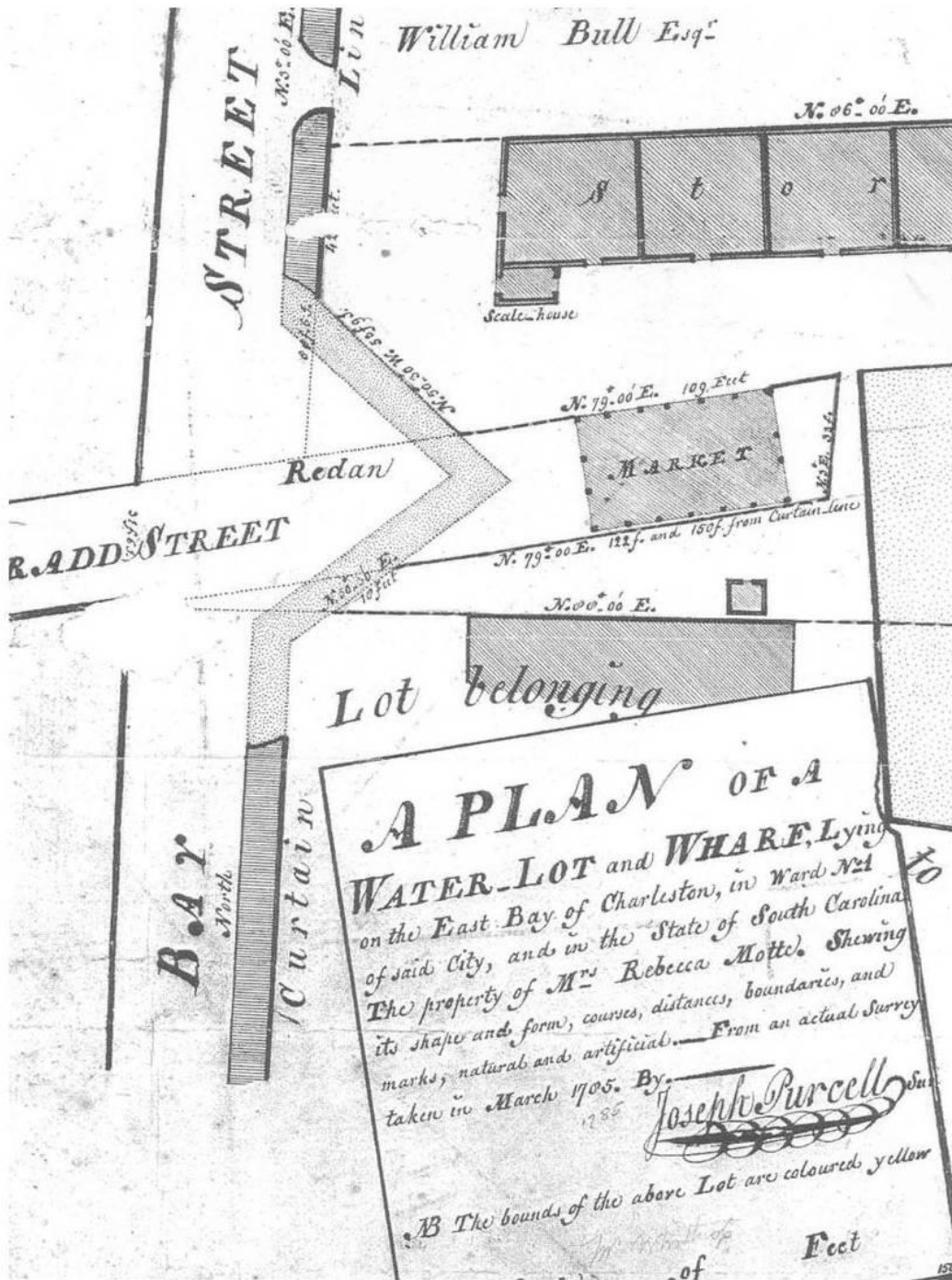


Figure 41: Tradd Street Redan Plat.

B. FIGURES OF GEOREFERENCED HISTORIC MAPS



Figure 42: Zoomed in georeferenced “Herbert Map” overlaid on the modern streetscape of downtown Charleston, showing links between control points.

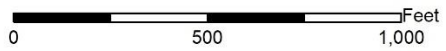


Figure 43: Georeferenced “Herbert Map” overlaid on the modern streetscape of downtown Charleston.

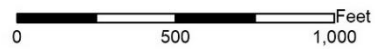


Figure 44: Georeferenced *Port of Charles-Town* overlaid on the modern streetscape of downtown Charleston.



Figure 45: Georeferenced “Blaskowitz Map” overlaid on the modern streetscape of downtown Charleston.

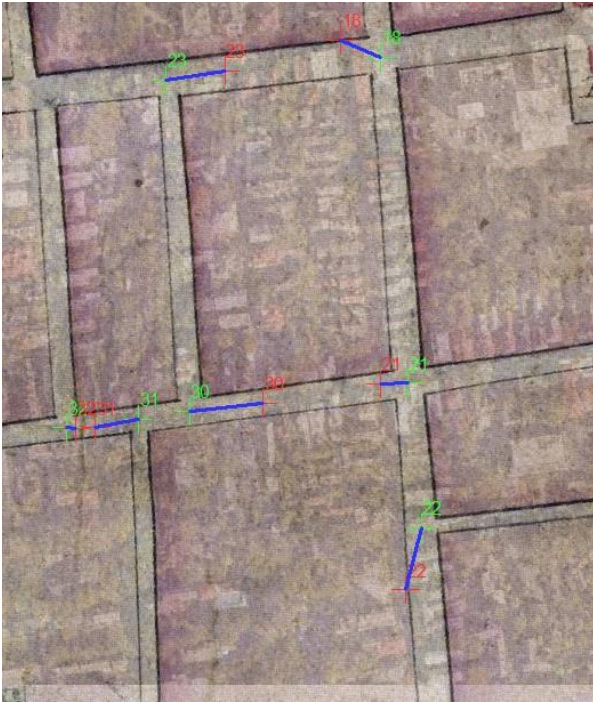


Figure 46: Zoomed-in image of the control point pair links at intersections between Broad Street and Prices Alley on the overlay of the georeferenced “Blaskowitz Map”.



Figure 47: Zoomed-in image of the intersection of Broad Street and Church Street showing control point pair links on the overlay of the georeferenced “Clinton Map”.

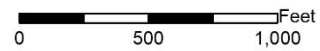


Figure 48: Georeferenced “Clinton Map” overlaid on the modern streetscape of downtown Charleston.

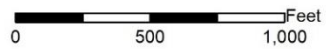
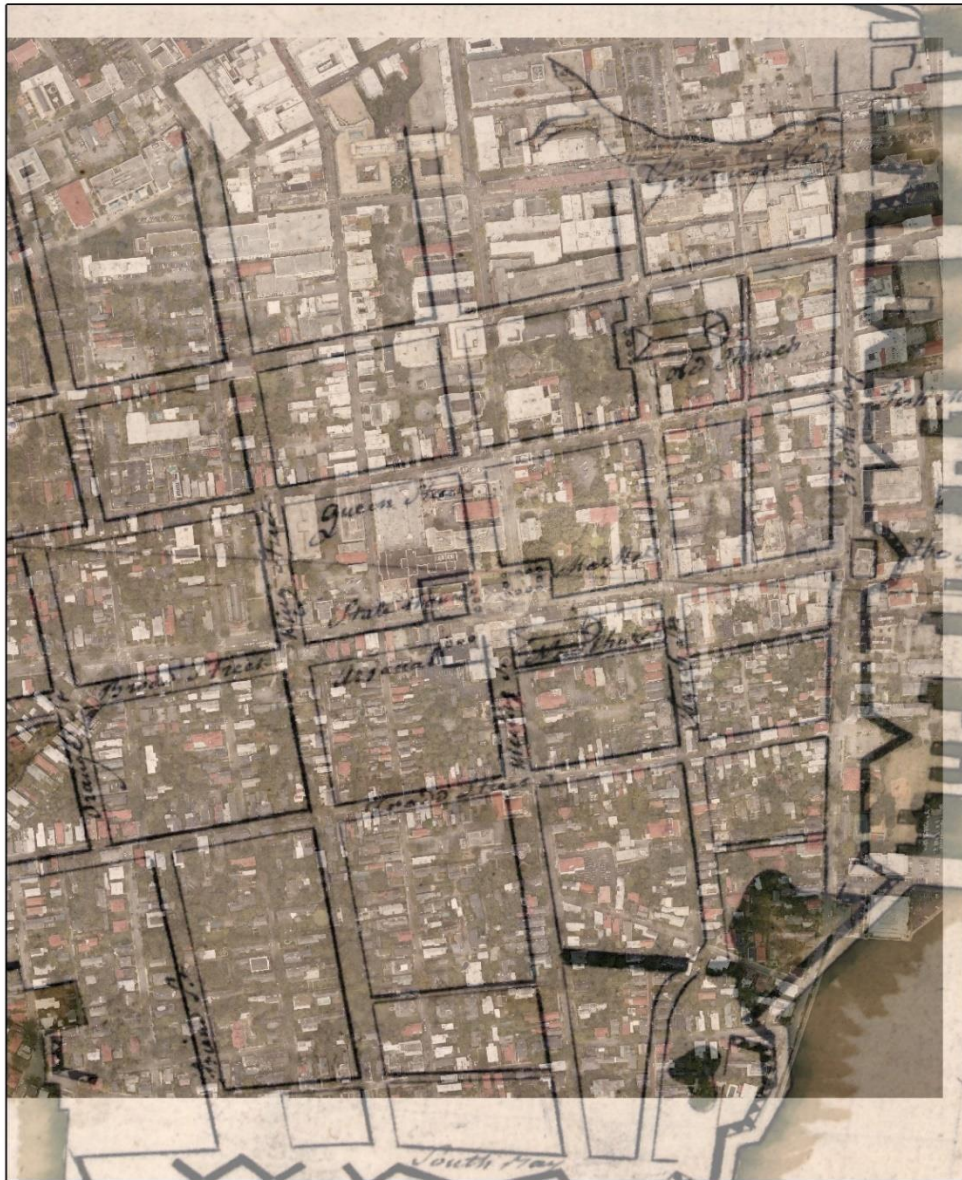


Figure 49: Georeferenced *Plan de la Ville de Charlestown* overlaid on the modern streetscape of downtown Charleston.



Figure 50: Georeferenced *Investiture of Charleston* overlaid on the modern streetscape of downtown Charleston.



Figure 51: Zoomed-in image of the intersection of Broad Street and Church Street showing control point pair links on the overlay of the georeferenced *Investiture of Charleston* Map.

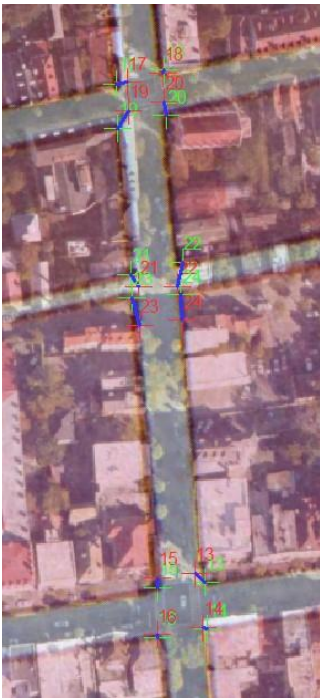


Figure 52: Zoomed-in image showing the control point pair links on Queen Street from Church Street to Broad Street on the georeferenced “Taylor Map” overlaid on the modern landscape.

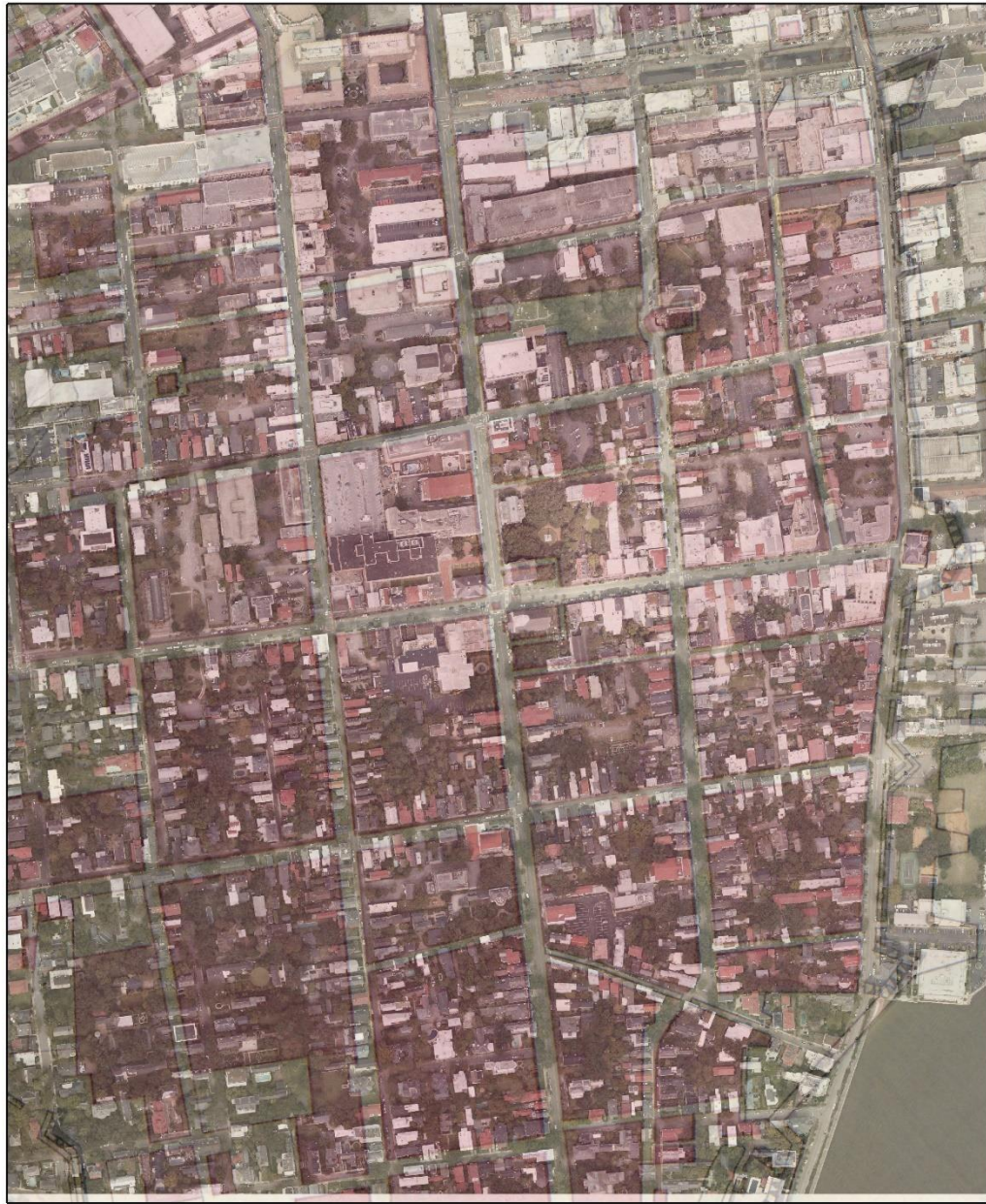


Figure 53: Georeferenced “Taylor Map” overlaid on the modern streetscape of downtown Charleston.

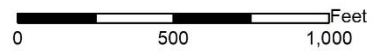
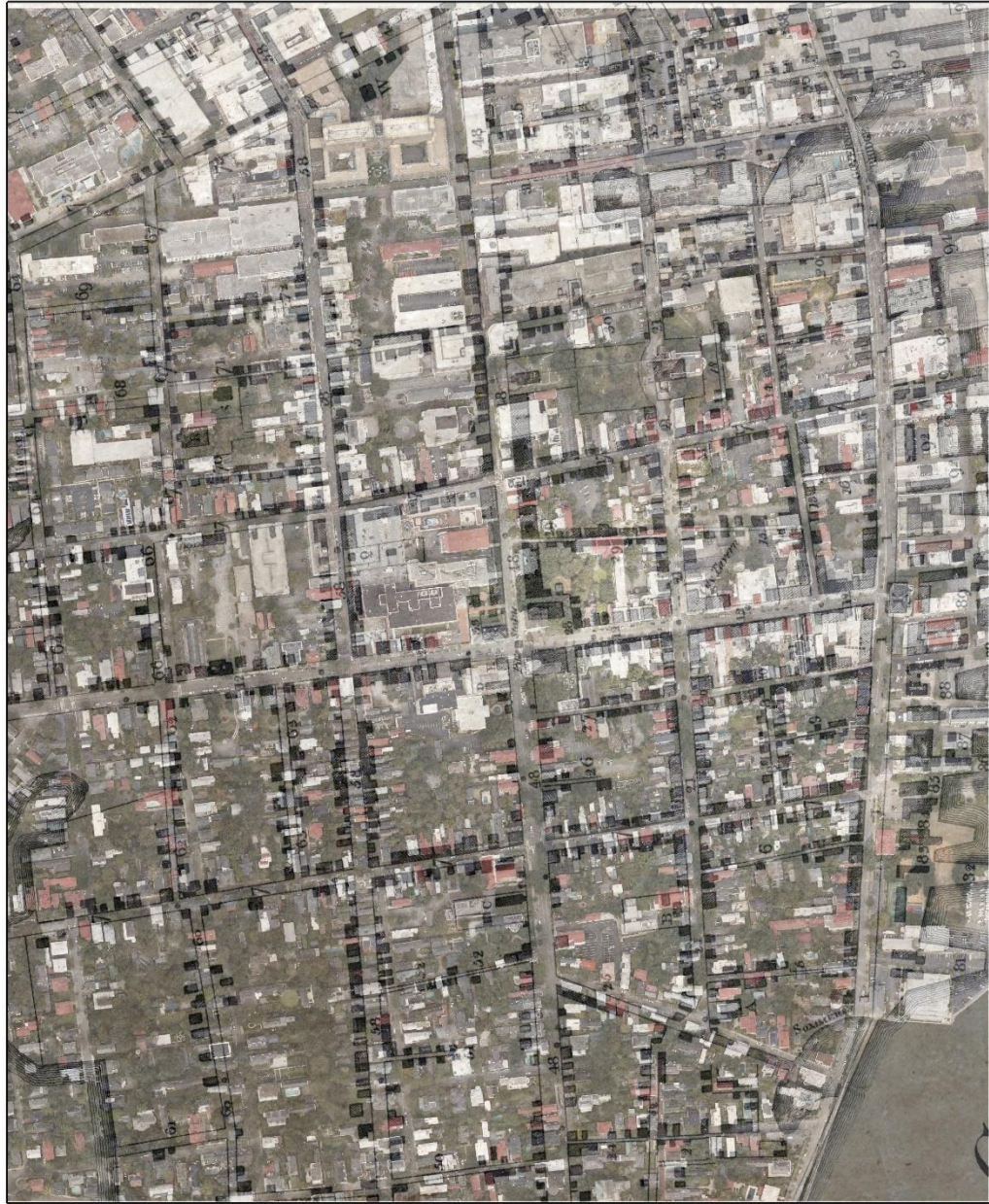


Figure 54: Georeferenced *Ichnography of Charleston* overlaid on the modern streetscape of downtown Charleston.

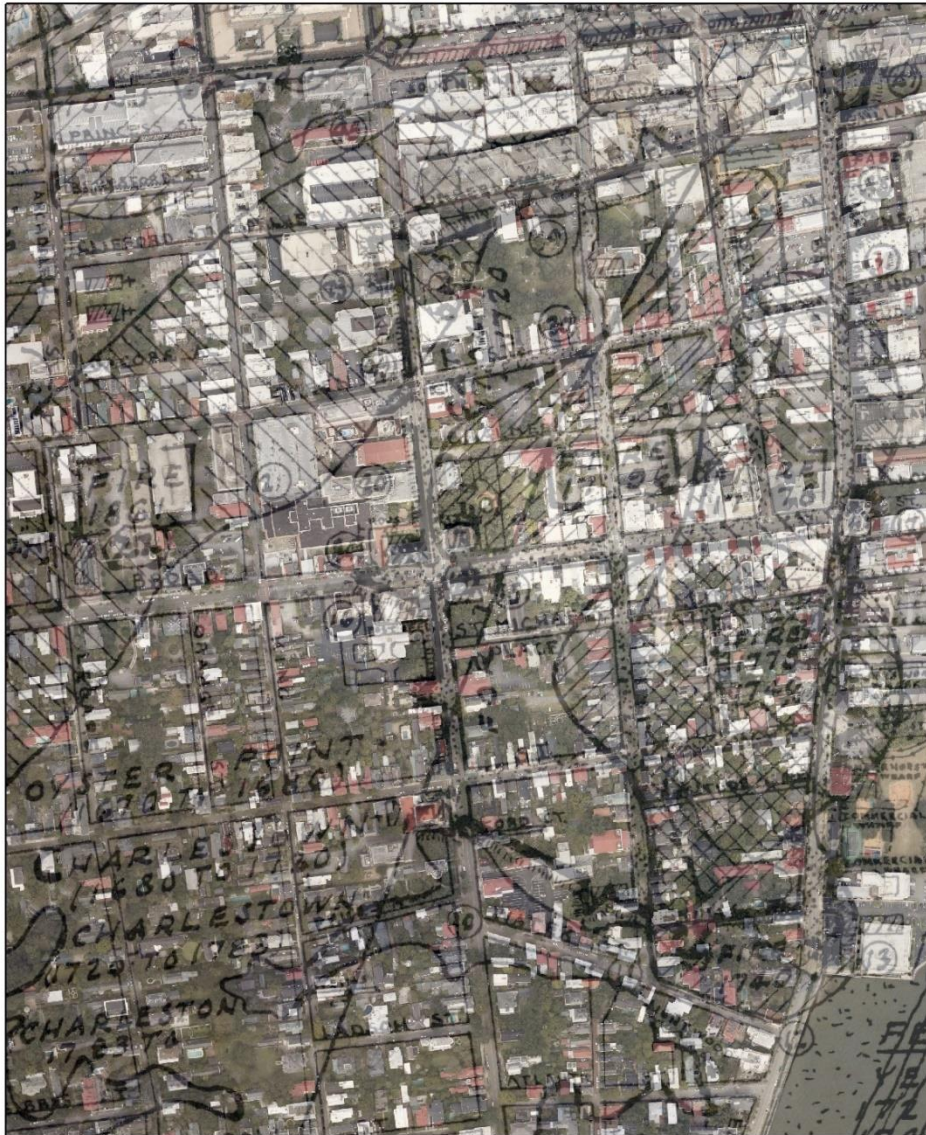


Figure 55: Georeferenced “Halsey Map” overlaid on the modern streetscape of downtown Charleston.

C. FIGURES OF OVERLAYS OF HISTORIC MAPS FOR CRAVEN’S BASTION

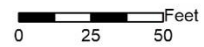


Figure 56: Georeferenced “Crisp Map” overlaid on the modern streetscape of downtown Charleston zoomed in to the intersection of East Bay Street and South Market Street



Figure 57: Georeferenced “Herbert Map” overlaid on the modern streetscape of downtown Charleston zoomed in to the intersection of East Bay Street and South Market Street.

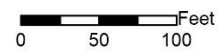


Figure 58: Georeferenced *Port of Charles-Town* overlaid on the modern streetscape of downtown Charleston zoomed in to the intersection of East Bay Street and South Market Street.

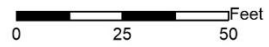
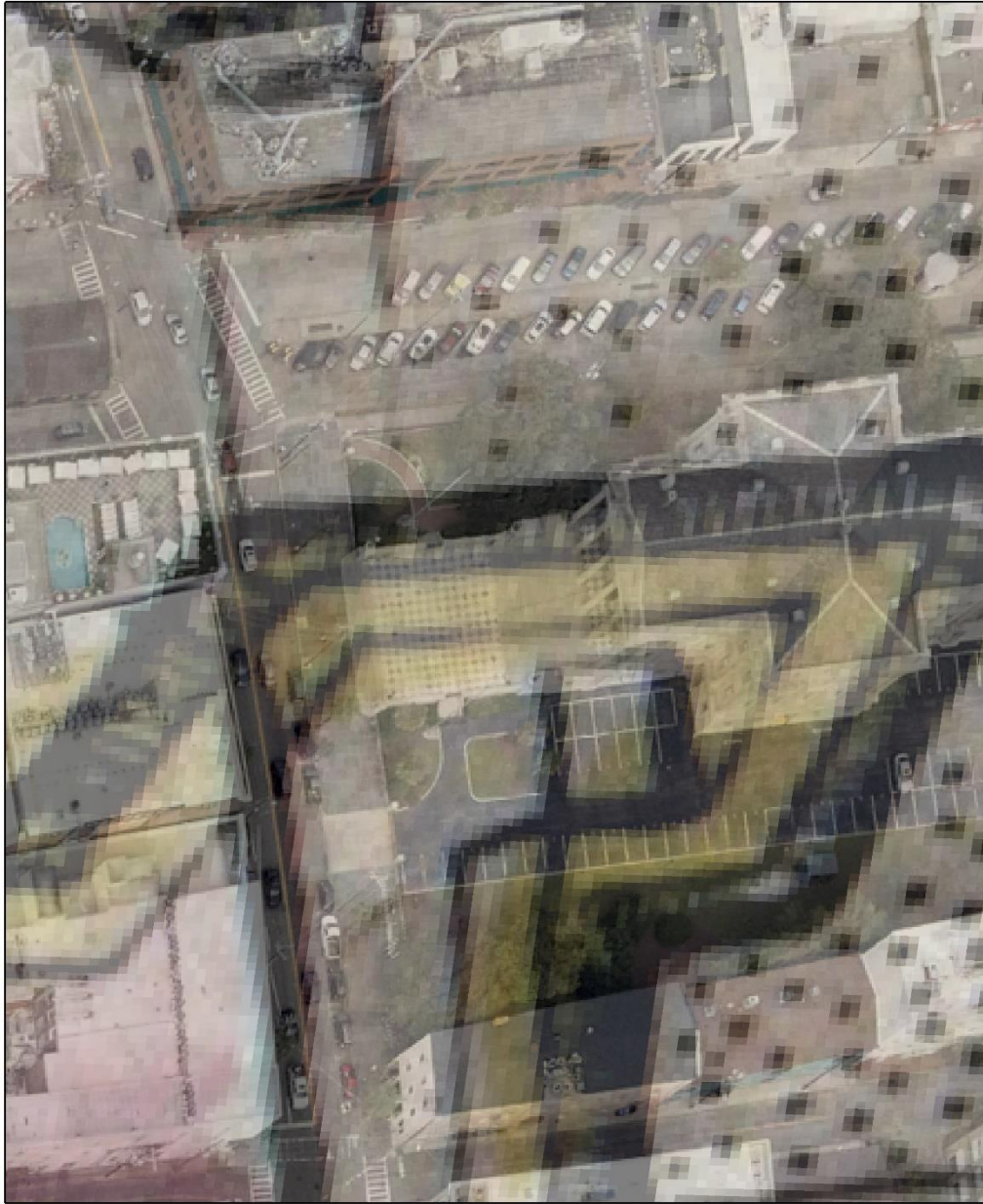
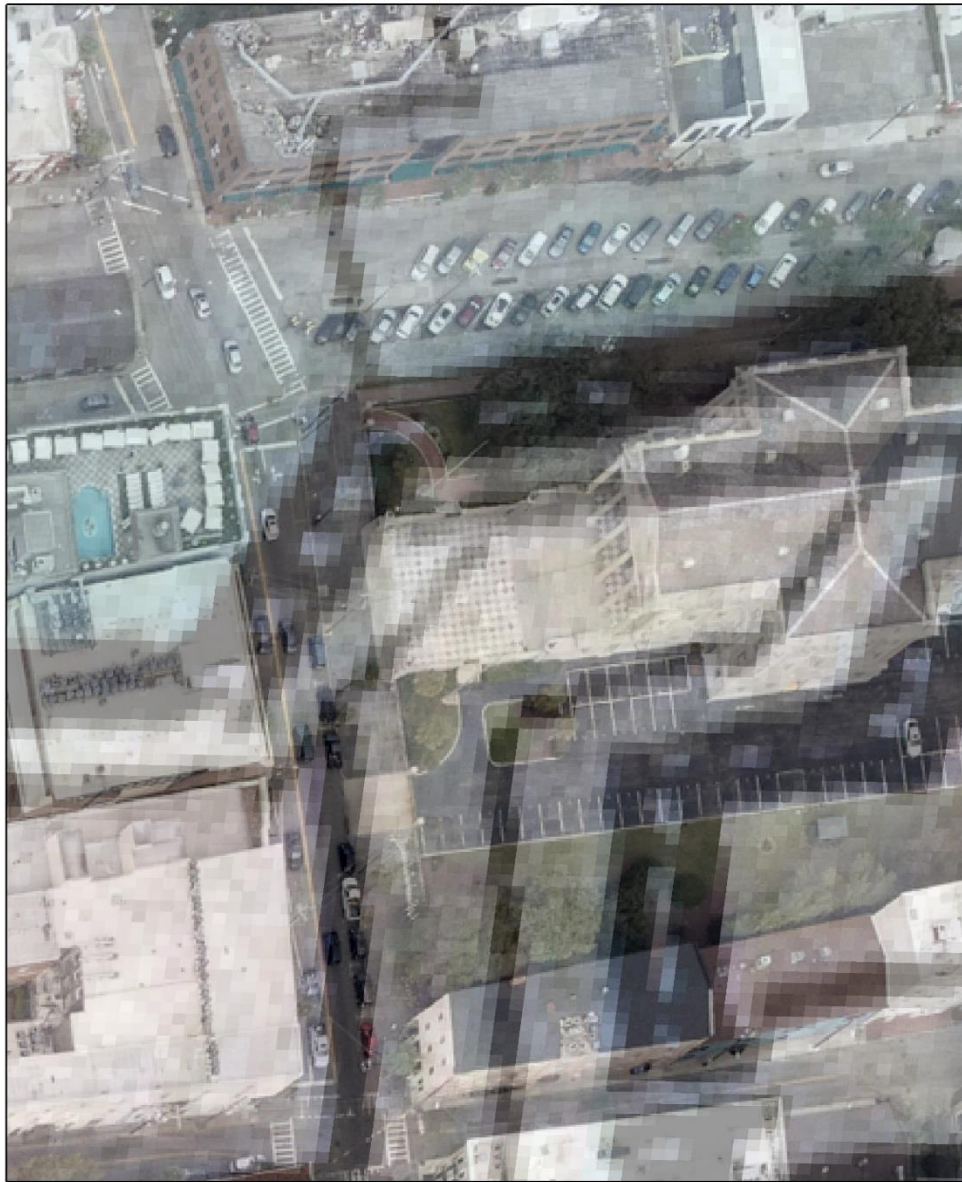


Figure 59: Georeferenced “Blaskowitz Map” overlaid on the modern streetscape of downtown Charleston zoomed in to the intersection of East Bay Street and South Market Street.



0 25 50 Feet

Figure 60: Georeferenced “Clinton Map” overlaid on the modern streetscape of downtown Charleston zoomed in to the intersection of East Bay Street and South Market Street.



0 25 50 Feet

Figure 61: Georeferenced *Investiture of Charleston* overlaid on the modern streetscape of downtown Charleston zoomed in to the intersection of East Bay Street and South Market Street.

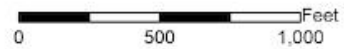


Figure 62: Georeferenced *Plan de la Ville de Charlestown* overlaid on the modern streetscape of downtown Charleston zoomed in to the intersection of East Bay Street and South Market Street.

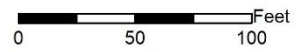
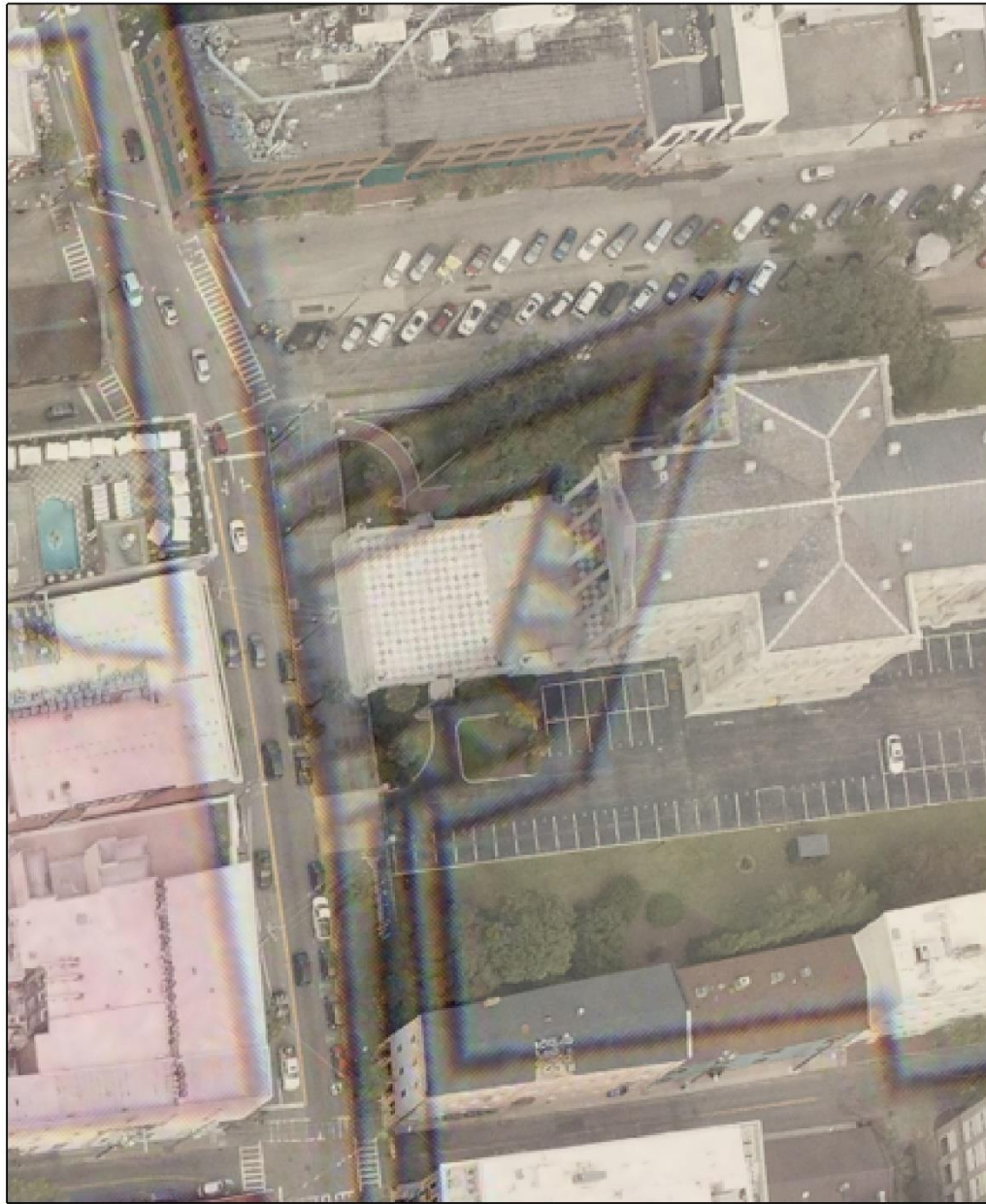


Figure 63: Georeferenced “Taylor Map” overlaid on the modern streetscape of downtown Charleston zoomed in to the intersection of East Bay Street and South Market Street.

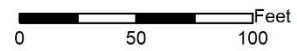


Figure 64: Georeferenced *Ichnography of Charleston* overlaid on the modern streetscape of downtown Charleston zoomed in to the intersection of East Bay Street and South Market Street.

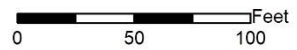


Figure 65: Georeferenced “Halsey Map” overlaid on the modern streetscape of downtown Charleston zoomed in to the intersection of East Bay Street and South Market Street.

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